Interface and Hardware Component Configuration Guide for Cisco NCS 5500 Series Routers, IOS XR Release 24.1.x, 24.2.x, 24.3.x, 24.4.x

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CONTENTS

Preface

The *Interface and Hardware Component Configuration Guide for Cisco NCS 5500 Series Routers* provides information and procedures related to router interface and hardware configuration.

The preface contains the following sections:

Changes to This Document

This table lists the technical changes made to this document since it was first released.

Table 1: Changes to This Document

Date	Summary
December 2024	Republished for Release 24.4.1
September 2024	Republished for Release 24.3.1
June 2024	Republished for Release 24.2.1
March 2024	Initial release of this document

Obtaining Documentation and Submitting a Service Request

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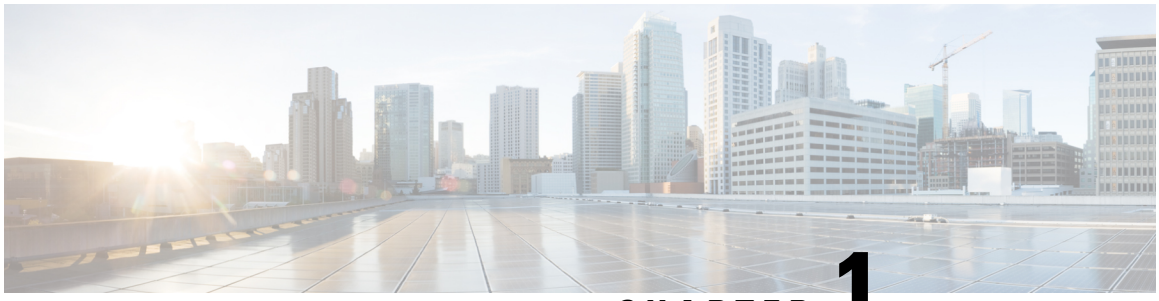


CHAPTER 1

New and Changed Feature Information

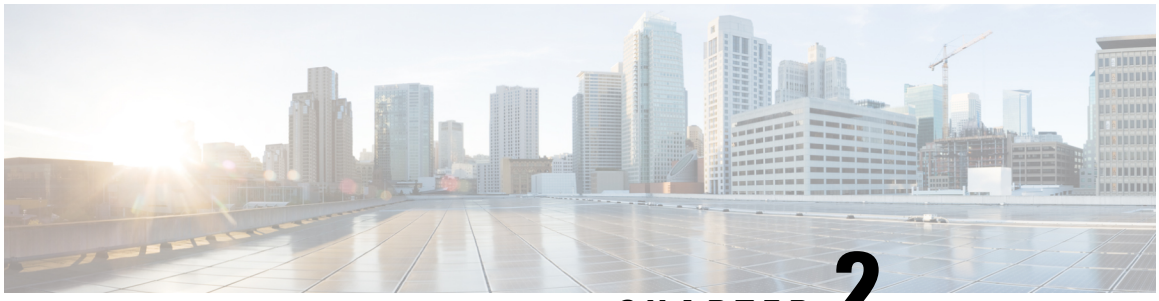
This table summarizes the new and changed feature information for the *Interface and Hardware Component Configuration Guide for Cisco NCS 5500 Series Routers*, and tells you where they are documented.

Interface and Hardware Component Features Added or Modified in IOS XR Release 24.x.x

Table 2: New and Changed Features

Feature	Description	Introduced in Release	Where Documented
Multiple SPAN ACL sessions for MPLS	This feature was introduced.	Release 24.4.1	Multiple SPAN ACL sessions for MPLS
GRE over HSRP and VRRP	This feature was introduced.	Release 24.4.1	Configuring GRE Tunnels
SPAN-to-File supports pcap and pcapng File Format for NCS 5700	This feature was introduced.	Release 24.3.1	SPAN-to-File Enhancements, on page 287
Configurable FDD and FED Alarm Threshold Values	This feature was introduced.	Release 24.3.1	Configuring FEC Alarm Threshold
Media Link-down Prefec Degrade Enablement	This feature was introduced.	Release 24.3.1	Media Link-down Prefec Degrade Enablement
Configurable Fault Recovery Attempts	This feature is introduced.	Release 24.3.1	Configurable Fault Recovery Attempts, on page 466
Support for 50Gbps Port Mode Speed on NC57 Line Cards	This feature was introduced.	Release 24.2.1	Port Mode Speed Support for NC57 Line Cards

Feature	Description	Introduced in Release	Where Documented
Carrier Delay on Physical Interfaces	This feature was introduced.	Release 24.2.1	Carrier Delay on Physical Interfaces
Carrier Delay on Physical Interfaces on NCS 5700 fixed port routers	This feature was introduced.	Release 24.2.11	Carrier Delay on Physical Interfaces
CFM over Single Pass MPLS GRE Tunnel	This feature was introduced.	Release 24.1.1	CFM over Single Pass MPLS GRE Tunnel



CHAPTER 2

YANG Data Models for Interfaces and Hardware Component Features

This chapter provides information about the YANG data models for Interface and Hardware Component features.

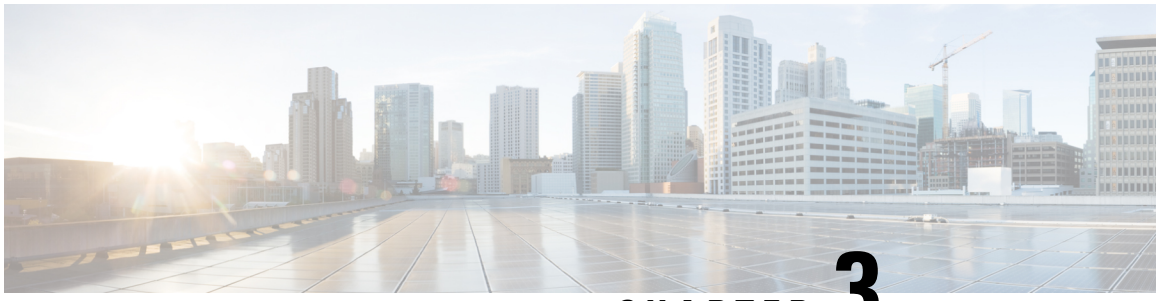
Using YANG Data Models

Cisco IOS XR supports a programmatic way of configuring and collecting operational data of a network device using YANG data models. Although configurations using CLIs are easier and human-readable, automating the configuration using model-driven programmability results in scalability.

The data models are available in the release image, and are also published in the Github repository. Navigate to the release folder of interest to view the list of supported data models and their definitions. Each data model defines a complete and cohesive model, or augments an existing data model with additional XPaths. To view a comprehensive list of the data models supported in a release, navigate to the **Available-Content.md** file in the repository.

You can also view the data model definitions using the YANG Data Models Navigator tool. This GUI-based and easy-to-use tool helps you explore the nuances of the data model and view the dependencies between various containers in the model. You can view the list of models supported across Cisco IOS XR releases and platforms, locate a specific model, view the containers and their respective lists, leaves, and leaf lists presented visually in a tree structure. This visual tree form helps you get insights into nodes that can help you automate your network.

To get started with using the data models, see the *Programmability Configuration Guide*.



CHAPTER 3

Preconfiguring Physical Interfaces

This module describes the preconfiguration of physical interfaces.

Preconfiguration is supported for these types of interfaces and controllers:

- 100-Gigabit Ethernet
- Management Ethernet

Preconfiguration allows you to configure line cards before they are inserted into the router. When the cards are inserted, they are instantly configured. The preconfiguration information is created in a different system database tree, rather than with the regularly configured interfaces. That database tree is known as the *preconfiguration directory* on the route processor.

There may be some preconfiguration data that cannot be verified unless the line card is present, because the verifiers themselves run only on the line card. Such preconfiguration data is verified when the line card is inserted and the verifiers are initiated. A configuration is rejected if errors are found when the configuration is copied from the preconfiguration area to the active area.

Note One Gigabit Ethernet interface is not supported. Only physical interfaces can be preconfigured.

Note Eight quadrature amplitude modulation (8QAM) requires V2 (or higher) CFP2 version and 5.23 (or higher) firmware.

Note From Cisco IOS XR Release 6.3.2, a six-seconds delay is introduced in error propagation from the driver to DPA for the MACSec line card and Oldcastle platforms. As a result, the BER algorithm on these platforms knows the error with a delay of 6 seconds.

Physical Interface Preconfiguration Overview

Preconfiguration is the process of configuring interfaces before they are present in the system. Preconfigured interfaces are not verified or applied until the actual interface with the matching location (rack/slot/module) is inserted into the router. When the anticipated line card is inserted and the interfaces are created, the precreated configuration information is verified and, if successful, immediately applied to the running configuration of the router.

Note When you plug the anticipated line card in, make sure to verify any preconfiguration with the appropriate **show** commands.

Use the **show run** command to see interfaces that are in the preconfigured state.

Note We recommend filling out preconfiguration information in your site planning guide, so that you can compare that anticipated configuration with the actual preconfigured interfaces when that line card is installed and the interfaces are up.

Tip Tip Use the **commit best-effort** command to save the preconfiguration to the running configuration file. The **commit best-effort** command merges the target configuration with the running configuration and commits only valid configuration (best effort). Some configuration might fail due to semantic errors, but the valid configuration still comes up.

Prerequisites for Preconfiguring Physical Interfaces

Before preconfiguring physical interfaces, ensure that this condition is met:

- Preconfiguration drivers and files are installed. Although it may be possible to preconfigure physical interfaces without a preconfiguration driver installed, the preconfiguration files are required to set the interface definition file on the router that supplies the strings for valid interface names.

Benefits of Interface Preconfiguration

Preconfigurations reduce downtime when you add new cards to the system. With preconfiguration, the new cards can be instantly configured and actively running during cards bootup.

Another advantage of performing a preconfiguration is that during a cards replacement, when the cards is removed, you can still see the previous configuration and make modifications.

How to Preconfigure Physical Interfaces

This task describes only the most basic preconfiguration of an interface.

SUMMARY STEPS

1. **configure**
2. **interface preconfigure** *type interface-path-id*
3. Use one of the following commands:
   - **ipv4 address** *ip-address subnet-mask*
   - **ipv4 address** *ip-address/prefix*
4. Configure additional interface parameters, as described in this manual in the configuration chapter that applies to the type of interface that you are configuring.
5. **end** or **commit** best-effort
6. **show running-config**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router#configure
```

Enters global configuration mode.

Step 2 **interface preconfigure** *type interface-path-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface preconfigure HundredGigE 0/3/0/2
```

Enters interface preconfiguration mode for an interface, where *type* specifies the supported interface type that you want to configure and *interface-path-id* specifies the location where the interface will be located in *rack*/*slot*/*module*/*port* notation.

Step 3 Use one of the following commands:

- **ipv4 address** *ip-address subnet-mask*
- **ipv4 address** *ip-address/prefix*

Example:

```
RP/0/RP0/CPU0:router(config-if-pre)# ipv4 address 192.168.1.2/31
```

Assigns an IP address and mask to the interface.

Step 4 Configure additional interface parameters, as described in this manual in the configuration chapter that applies to the type of interface that you are configuring.

Step 5 **end** or **commit** best-effort

Example:

```
RP/0/RP0/CPU0:router(config-if-pre)# end
```

or

```
RP/0/RP0/CPU0:router(config-if-pre)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting (yes/no/cancel)?`
- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit best-effort** command to save the configuration changes to the running configuration file and remain within the configuration session. The **commit best-effort** command merges the target configuration with the running configuration and commits only valid changes (best effort). Some configuration changes might fail due to semantic errors.

Step 6 **show running-config**

Example:

```
RP/0/RP0/CPU0:router# show running-config
```

(Optional) Displays the configuration information currently running on the router.

Example

This example shows how to preconfigure a basic Ethernet interface:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface preconfigure HundredGigE 0/3/0/24
RP/0/RP0/CPU0:router(config-if)# ipv4 address 192.168.1.2/31
RP/0/RP0/CPU0:router(config-if-pre)# commit
```

Information About Preconfiguring Physical Interfaces

From Cisco IOS XR Release 7.0.2, the NC57-18DD-SE follows the following port mapping:

- Port number 0-17 (nine pairs) and 24-29 (three pairs): They together drive 400G mode. This means that if the top port is in 400G mode, the bottom port is unusable. These ports are retimer ports.
- Port number 18-23 (six ports): They are direct connected ports and are individually capable of 400G mode.

Note There's a limitation for ports 0, 1 and 14, 15. You have to insert modules of similar speed (40G or 100G) into these pairs of ports. For example, if you insert 40G module in port 0, then 40G module must be inserted in port 1.

Note For 400G-only mode, the ports to be used are 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 19, 20, 21, 22, 23, 24, 26, and 28.

For detailed information on port mapping and usage, see the figure *NC57-18DD-SE Line Card* in chapter *NCS 5500 Series Modular Router Overview* of *Hardware Installation Guide for Cisco NCS 5500 Series Modular Routers* guide.

To control the interfaces which are created, use the `hw-module port-range mode` command with the following modes:

- 40-100: This is the default port mode. Two ports are created in 100G mode by default. Online Insertion and Removal (OIR) to 40G creates the 40G port.
- 400: The first port created is 400G. No port is created for the bottom port.
- 2x100: For 2x100 mode. This supports QDD-2X100-LR4 optics.

Port range can be in the form of n to n+1. Example: 0,1 or 6,7. The port range is valid for ports 0-17 and 24-29. To configure a port with 400G rate:

```
RP/0/RP0/CPU0:router(config)#hw-module port-range 0 1 location 0/3/CPU0 mode 400
RP/0/RP0/CPU0:router(config)#commit
Wed Feb  6 03:23:12.923 UTC
LC/0/3/CPU0:Feb  6 03:23:13.548 UTC: ifmgr[281]: %PKT_INFRA-LINK-3-UPDOWN : Interface
HundredGigE0/3/0/1, changed state to Down
LC/0/3/CPU0:Feb  6 03:23:13.548 UTC: ifmgr[281]: %PKT_INFRA-LINK-3-UPDOWN : Interface
HundredGigE0/3/0/0, changed state to Down
RP/0/RP0/CPU0:router(config)#end
RP/0/RP0/CPU0:router#show ipv4 int br location 0/3/CPU0
Wed Feb  6 03:26:07.935 UTC

Interface                      IP-Address      Status          Protocol Vrf-Name
FourHundredGigE0/3/0/0         unassigned      Shutdown        Down     default
HundredGigE0/3/0/2             unassigned      Shutdown        Down     default
HundredGigE0/3/0/3             unassigned      Shutdown        Down     default
HundredGigE0/3/0/4             unassigned      Shutdown        Down     default
HundredGigE0/3/0/5             unassigned      Shutdown        Down     default
HundredGigE0/3/0/6             unassigned      Shutdown        Down     default
```

To change a port mode:

```
RP/0/RP0/CPU0:router#conf
Thu Jan  9 05:13:02.853 UTC
RP/0/RP0/CPU0:router(config)#hw-module port-range 2 3 location 0/3/CPU0 mode 2x100
RP/0/RP0/CPU0:router(config)#commit
```

```
Thu Jan  9 05:13:11.411 UTC
LC/0/3/CPU0:Jan  9 05:13:11.469 UTC: optics_driver[196]: %PKT_INFRA-FM-3-FAULT_MAJOR :
ALARM_MAJOR :PORTMODE SPEED MISMATCH :CLEAR :0/3/CPU0:  Optics0/3/0/3
LC/0/3/CPU0:Jan  9 05:13:13.141 UTC: ifmgr[228]: %PKT_INFRA-LINK-3-UPDOWN : Interface
HundredGigE0/3/0/3, changed state to Down
LC/0/3/CPU0:Jan  9 05:13:13.141 UTC: ifmgr[228]: %PKT_INFRA-LINK-3-UPDOWN : Interface
HundredGigE0/3/0/2, changed state to Down
RP/0/RP0/CPU0:router(config)#end
RP/0/RP0/CPU0:router#show ipv4 int br location 0/3/CPU0
Thu Jan  9 05:13:24.245 UTC

Interface                      IP-Address      Status          Protocol Vrf-Name
FortyGigE0/3/0/28              unassigned      Shutdown        Down     default
HundredGigE0/3/0/29            unassigned      Shutdown        Down     default
HundredGigE0/3/0/2/0           unassigned      Down            Down     default
HundredGigE0/3/0/2/1           unassigned      Down            Down     default
HundredGigE0/3/0/3/0           unassigned      Down            Down     default
HundredGigE0/3/0/3/1           unassigned      Down            Down     default
```

Use the following commands for the newly configured image:

```
hw-module port-range 0 1 location 0/6/CPU0 mode 400
hw-module port-range 2 3 location 0/6/CPU0 mode 400
hw-module port-range 4 5 location 0/6/CPU0 mode 400
hw-module port-range 6 7 location 0/6/CPU0 mode 400
hw-module port-range 8 9 location 0/6/CPU0 mode 400
hw-module port-range 10 11 location 0/6/CPU0 mode 400
hw-module port-range 12 13 location 0/6/CPU0 mode 400
hw-module port-range 14 15 location 0/6/CPU0 mode 400
hw-module port-range 16 17 location 0/6/CPU0 mode 400
hw-module port-range 24 25 location 0/6/CPU0 mode 400
hw-module port-range 26 27 location 0/6/CPU0 mode 400
hw-module port-range 28 29 location 0/6/CPU0 mode 400
hw-module port-range 0 1 location 0/6/CPU0 mode 2x100
hw-module port-range 2 3 location 0/6/CPU0 mode 2x100
hw-module port-range 4 5 location 0/6/CPU0 mode 2x100
hw-module port-range 6 7 location 0/6/CPU0 mode 2x100
hw-module port-range 8 9 location 0/6/CPU0 mode 2x100
hw-module port-range 10 11 location 0/6/CPU0 mode 2x100
hw-module port-range 12 13 location 0/6/CPU0 mode 2x100
hw-module port-range 14 15 location 0/6/CPU0 mode 2x100
hw-module port-range 16 17 location 0/6/CPU0 mode 2x100
hw-module port-range 24 25 location 0/6/CPU0 mode 2x100
hw-module port-range 26 27 location 0/6/CPU0 mode 2x100
hw-module port-range 28 29 location 0/6/CPU0 mode 2x100
```

NCS-57B1-6D24-SYS and NCS-57B1-5DSE-SYS have the following port-mapping characteristics:

- All ports use QSFP-DD; however, the first 24 ports are 100G, and the last few ports (six for non-SE and five for SE) are 400G.
- The two port types available are "400G Direct" port and "Quad Port Group".
- Each port type supports one or more speeds and breakout modes, such as 400G/4x100G/2x100G/8x50G/100G/4x25G/40G/4x10G/10G.

Note For specific transceiver support check the optics compatibility matrix.

400G Direct Ports

Ports 24-29 for non-SE and ports 24-28 for SE are 400G direct ports, which support 400G individually.

Table 3: Possible Optics and Breakout for 400G Direct Ports

Optics	Breakout
QSFP-DD 400G	4x100G, 8x50G
QSFP56 200G	2x100G, 4x50G
QSFP28-DD 2x100G	2x(4x25G)
QSFP28 100G	4x25G
QSFP+ 40G	4x10G

Configuration Examples

The following are some configuration examples. All possible combinations are not listed here.

```
Router(config)#controller optics 0/0/0/n breakout 4x100
```

Result: Hu0/0/0/n/0-3

```
Router(config)#controller optics 0/0/0/n breakout 8x50
```

Result: Fi0/0/0/n/0-7

```
Router(config)#controller optics 0/0/0/n breakout 2x100
```

Result: Hu0/0/0/n/0-1

```
Router(config)#controller optics 0/0/0/n breakout 4x25
```

Result: TF0/0/0/n/0-3

```
Router(config)#controller optics 0/0/0/n breakout 4x10
```

Result: Te0/0/0/n/0-3

Quad Port Groups

Quad port groups have the following characteristics:

- There are six quad port groups of 4 QSFP-DD: (0,3), (4-7), (8-11), (12-15), (16-19), and (20-23).
- Each group shares 400G.
- Each port supports any combination of 40G/100G optics by default for a total of 400G per group.
- Each group has two port pairs, for example (0,1) and (2,3) for group (0,3).
- Breakout is only supported on the even (top) port of a port pair. The odd (bottom) port is automatically disabled. The odd port should be empty.
- QSA is supported only on 100G QSFP-DD ports, not on 400G QSFP-DD ports.
- Only 10G SFP+ optics are supported. There is no support for 1G.
- Linear optics not supported.
- For combinations with other optics type, see Quad Port Group table below, and consider 10G as one of the 40G optics.
- 4x25G breakout cannot co-exist with 40G or 4x10G breakout in the same port group.

Table 4: Possible Optics and Breakout for Quad Port Groups

Port N	Port N+1	Port N+2	Port N+3
100G or 40G	100G or 40G	100G or 40G	100G or 40G
4x10G	Disabled	4x10G	Disabled
4x10G	Disabled	100G or 40G	100G or 40G
100G or 40G	100G or 40G	4x10G	Disabled
4x25G	Disabled	4x25G	Disabled
4x25G	Disabled	100G	100G
100G	100G	4x25G	Disabled

Configuration Examples

The following are some configuration examples. All possible combinations are not listed here.

1. **Quad Port Group in 4x10G breakout mode**

   ```
   Router(config)#hw-module port-range n n+1 location 0/RP0/CPU0 mode 4x10
   ```

   Results:

   - Te0/0/0/n/0-3: Port n+1 will be automatically disabled.
   - Fo0/0/0/n+2~n+3 or Hu0/0/0/n+2~n+3 Ports n+2 and n+3 by default will be either 40G or 100G.
   - For breakout in port n+2, a new breakout configuration is needed for port range n+2 n+3, as only top port n+2 supports breakout (bottom port n+3 is disabled) and cannot have a mix of 4x10G and 4x25G in the same port group.

2. **Quad Port Group in 4x25G breakout mode**

   ```
   Router(config)#hw-module port-range n n+1 location 0/RP0/CPU0 mode 4x25
   ```

   Results (TF0/0/0/n/0-3 or Hu0/0/0/n+2~n+3):

   - Ports n+2 and n+3 can only be 100G.
   - For breakout in port n+2, a new breakout configuration is needed for port range n+2 n+3, as only top port n+2 supports breakout (bottom port n+3 is disabled) and cannot have a mix of 4x10G and 4x25G in the same port group.

To preconfigure interfaces, you must understand these concepts:

Use of the Interface Preconfigure Command

Interfaces that are not yet present in the system can be preconfigured with the **interface preconfigure** command in global configuration mode.

The **interface preconfigure** command places the router in interface configuration mode. Users should be able to add any possible interface commands. The verifiers registered for the preconfigured interfaces verify

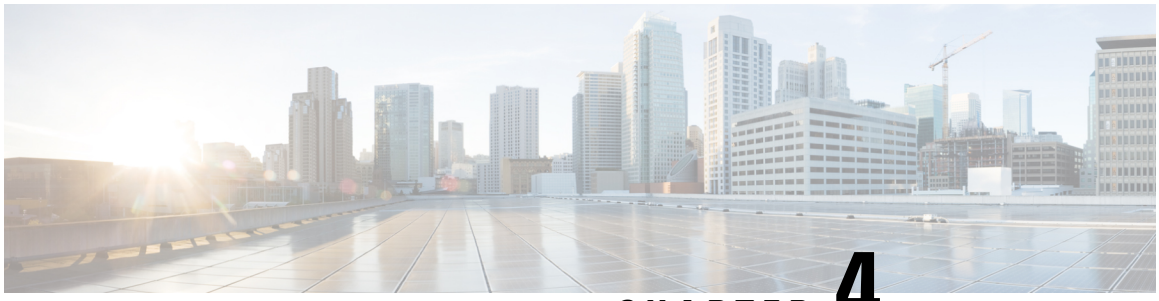
the configuration. The preconfiguration is complete when the user enters the **end** command, or any matching exit or global configuration mode command.

Note It is possible that some configurations cannot be verified until the line card is inserted.

Do not enter the **no shutdown** command for new preconfigured interfaces, because the no form of this command removes the existing configuration, and there is no existing configuration.

Users are expected to provide names during preconfiguration that will match the name of the interface that will be created. If the interface names do not match, the preconfiguration cannot be applied when the interface is created. The interface names must begin with the interface type that is supported by the router and for which drivers have been installed. However, the slot, port, subinterface number, and channel interface number information cannot be validated.

Note Specifying an interface name that already exists and is configured (or an abbreviated name like Hu0/3/0/0) is not permitted.



CHAPTER 4

Advanced Configuration and Modification of the Management Ethernet Interface

This module describes the configuration of Management Ethernet interfaces.

Before you can use Telnet to access the router through the LAN IP address, you must set up a Management Ethernet interface and enable Telnet servers.

Note Although the Management Ethernet interfaces on the system are present by default, the user must configure these interfaces to use them for accessing the router, using protocols and applications such as Simple Network Management Protocol (SNMP), HTTP, extensible markup language (XML), TFTP, Telnet, and command-line interface (CLI).

Prerequisites for Configuring Management Ethernet Interfaces

Before performing the Management Ethernet interface configuration procedures that are described in this chapter, be sure that the following tasks and conditions are met:

- You have performed the initial configuration of the Management Ethernet interface.
- You know how to apply the generalized interface name specification *rack/slot/module/port*.

Note For transparent switchover, both active and standby Management Ethernet interfaces are expected to be physically connected to the same LAN or switch.

How to Perform Advanced Management Ethernet Interface Configuration

This section contains the following procedures:

Configuring a Management Ethernet Interface

Perform this task to configure a Management Ethernet interface. This procedure provides the minimal configuration required for the Management Ethernet interface.

SUMMARY STEPS

1. **configure**
2. **interface MgmtEth** *interface-path-id*
3. **ipv4 address** *ip-address mask*
4. **mtu** *bytes*
5. **no shutdown**
6. **end** or **commit**
7. **show interfaces MgmtEth** *interface-path-id*

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface MgmtEth** *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface MgmtEth 0/RP0/CPU0/0
```

Enters interface configuration mode and specifies the Ethernet interface name and notation *rack*/*slot*/*module*/*port*.

The example indicates port 0 on the RP card that is installed in slot 0.

Step 3 **ipv4 address** *ip-address mask*

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv4 address 1.76.18.150/16 (or)
ipv4 address 1.76.18.150 255.255.0.0
```

Assigns an IP address and subnet mask to the interface.

- Replace *ip-address* with the primary IPv4 address for the interface.
- Replace *mask* with the mask for the associated IP subnet. The network mask can be specified in either of two ways:
- The network mask can be a four-part dotted decimal address. For example, 255.255.0.0 indicates that each bit equal to 1 means that the corresponding address bit belongs to the network address.
- The network mask can be indicated as a slash (/) and number. For example, /16 indicates that the first 16 bits of the mask are ones, and the corresponding bits of the address are network address.

Step 4 **mtu** *bytes*

Example:

```
RP/0/RP0/CPU0:router(config-if)# mtu 1488
```

(Optional) Sets the maximum transmission unit (MTU) byte value for the interface. The default is 1514.

- The default is 1514 bytes.
- The range for the Management Ethernet interface Interface **mtu** values is 64 to 1514 bytes.

Step 5 **no shutdown**

Example:

```
RP/0/RP0/CPU0:router(config-if)# no shutdown
```

Removes the shutdown configuration, which removes the forced administrative down on the interface, enabling it to move to an up or down state.

Step 6 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 7 **show interfaces MgmtEth** *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router# show interfaces MgmtEth 0/RP0/CPU0/0
```

(Optional) Displays statistics for interfaces on the router.

Example

This example displays advanced configuration and verification of the Management Ethernet interface on the RP:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface MgmtEth 0/RP0/CPU0/0
RP/0/RP0/CPU0:router(config-if)# ipv4 address 1.76.18.150/16

RP/0/RP0/CPU0:router(config-if)# no shutdown
RP/0/RP0/CPU0:router(config-if)# commit
RP/0/RP0/CPU0:router:Mar 26 01:09:28.685 :ifmgr[190]:%LINK-3-UPDOWN :Interface
MgmtEth0/RP0/CPU0/0, changed state to Up
RP/0/RP0/CPU0:router(config-if)# end

RP/0/RP0/CPU0:router# show interfaces MgmtEth 0/RP0/CPU0/0

MgmtEth0/RP0/CPU0/0 is up, line protocol is up
  Interface state transitions: 3
  Hardware is Management Ethernet, address is 1005.cad8.4354 (bia 1005.cad8.4354)
  Internet address is 1.76.18.150/16
  MTU 1488 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 1000Mb/s, 1000BASE-T, link type is autonegotiation
  loopback not set,
  Last link flapped 00:00:59
  ARP type ARPA, ARP timeout 04:00:00
  Last input 00:00:00, output 00:00:02
  Last clearing of "show interface" counters never
  5 minute input rate 4000 bits/sec, 3 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     21826 packets input, 4987886 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 12450 broadcast packets, 8800 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     1192 packets output, 217483 bytes, 0 total output drops
     Output 0 broadcast packets, 0 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
     3 carrier transitions

RP/0/RP0/CPU0:router# show running-config interface MgmtEth 0/RP0/CPU0/0

interface MgmtEth0/RP0/CPU0/0
 mtu 1488
 ipv4 address 1.76.18.150/16
 ipv6 address 2002::14c:125a/64
```

```
 ipv6 enable
!
```

The following example displays VRF configuration and verification of the Management Ethernet interface on the RP with source address:

```
RP/0/RP0/CPU0:router# show run interface MgmtEth 0/RP0/CPU0/0
interface MgmtEth0/RP0/CPU0/0
 vrf httpupload
 ipv4 address 10.8.67.20 255.255.0.0
 ipv6 address 2001:10:8:67::20/48
!

RP/0/RP0/CPU0:router# show run http
Wed Jan 30 14:58:53.458 UTC
http client vrf httpupload
http client source-interface ipv4 MgmtEth0/RP0/CPU0/0

RP/0/RP0/CPU0:router# show run vrf
Wed Jan 30 14:59:00.014 UTC
vrf httpupload
!
```

IPv6 Stateless Address Auto Configuration on Management Interface

Perform this task to enable IPv6 stateless auto configuration on Management interface.

SUMMARY STEPS

1. **configure**
2. **interface MgmtEth** *interface-path-id*
3. **ipv6 address autoconfig**
4. **end** or **commit**
5. **show ipv6 interfaces** *interface-path-id*

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface MgmtEth** *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface MgmtEth 0/RP0/CPU0/0
```

Enters interface configuration mode and specifies the Ethernet interface name and notation *rack*/*slot*/*module*/*port*.

The example indicates port 0 on the RP card that is installed in slot 0.

Step 3 **ipv6 address autoconfig**

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv6 address autoconfig
```

Enable IPv6 stateless address auto configuration on the management port.

Step 4 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 5 **show ipv6 interfaces** *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router# show ipv6 interfaces gigabitEthernet 0/2/0/0
```

(Optional) Displays statistics for interfaces on the router.

Example

This example displays :

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface MgmtEth 0/RP0/CPU0/0
```

```
RP/0/RP0/CPU0:router(config-if)# ipv6 address autoconfig
RP/0/RP0/CPU0:router(config-if)# commit
RP/0/RP0/CPU0:router# show ipv6 interfaces gigabitEthernet 0/2/0/0

Fri Nov  4 16:48:14.372 IST
GigabitEthernet0/2/0/0 is Up, ipv6 protocol is Up, Vrfid is default (0x60000000)
  IPv6 is enabled, link-local address is fe80::d1:1eff:fe2b:baf
  Global unicast address(es):
    5::d1:1eff:fe2b:baf [AUTO CONFIGURED], subnet is 5::/64  <<<<<<  auto configured address

  Joined group address(es): ff02::1:ff2b:baf ff02::2 ff02::1
  MTU is 1514 (1500 is available to IPv6)
  ICMP redirects are disabled
  ICMP unreachables are enabled
  ND DAD is enabled, number of DAD attempts 1
  ND reachable time is 0 milliseconds
  ND cache entry limit is 1000000000
  ND advertised retransmit interval is 0 milliseconds
  Hosts use stateless autoconfig for addresses.
  Outgoing access list is not set
  Inbound  common access list is not set, access list is not set
  Table Id is 0xe0800000
  Complete protocol adjacency: 0
  Complete glean adjacency: 0
  Incomplete protocol adjacency: 0
  Incomplete glean adjacency: 0
  Dropped protocol request: 0
  Dropped glean request: 0
```

Modifying the MAC Address for a Management Ethernet Interface

Perform this task to configure the MAC layer address of the Management Ethernet interfaces for the RPs.

SUMMARY STEPS

1. **configure**
2. **interface MgmtEth** *interface-path-id*
3. **mac-address** *address*
4. **end** or **commit**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface MgmtEth** *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface MgmtEth 0/RP0/CPU0/0
```

Enters interface configuration mode and specifies the Management Ethernet interface name and instance.

Step 3 **mac-address** *address*

Example:

```
RP/0/RP0/CPU0:router(config-if)# mac-address 0001.2468.ABCD
```

Configures the MAC layer address of the Management Ethernet interface.

Note

- To return the device to its default MAC address, use the **no mac-address** address command.

Step 4 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying Management Ethernet Interface Configuration

Perform this task to verify configuration modifications on the Management Ethernet interfaces.

SUMMARY STEPS

1. **show interfaces MgmtEth** *interface-path-id*
2. **show running-config interface MgmtEth** *interface-path-id*

DETAILED STEPS

Procedure

Step 1 **show interfaces MgmtEth** *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router# show interfaces MgmtEth 0/RP0/CPU0/0
```

Displays the Management Ethernet interface configuration.

Step 2 **show running-config interface MgmtEth** *interface-path-id*

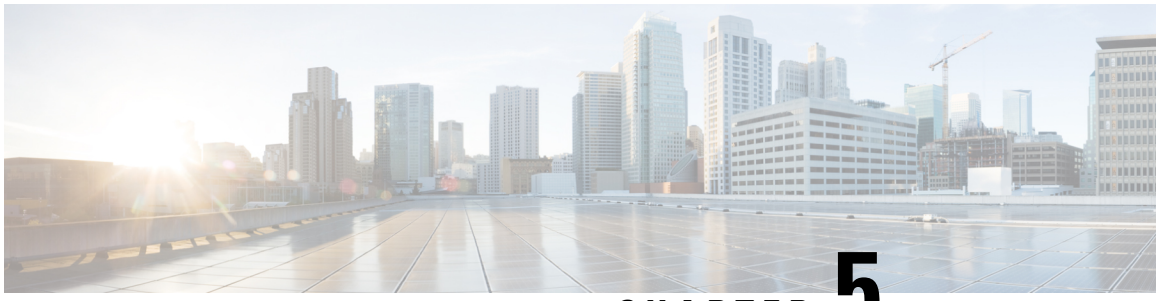
Example:

```
RP/0/RP0/CPU0:router# show running-config interface MgmtEth 0/RP0/CPU0/0
```

Displays the running configuration.

Information About Configuring Management Ethernet Interfaces

To configure Management Ethernet interfaces, you must understand the following concept:



CHAPTER 5

Configuring Ethernet Interfaces

This module describes the configuration of Ethernet interfaces.

Table 5: Feature History Table

Feature Name	Release	Description
OTN Support for NC55-MPA-12T-S MPA on Cisco NCS 5500 Series Routers.	Release 7.5.1	This release introduces support for Optical Network Transport (OTN) on NC55-MPA-12T-S Modular Port Adapter (MPA) on the following Cisco NCS 5500 Series Line cards: • NCS-55A2-MOD-S • NCS-55A2-MOD-SE-S • NCS-55A2-MOD-HX-S • NCS-55A2-MOD-SE-H-S • NCS-55A2-MOD-HD-S OTN is a superior technology that bridges the gap between next-generation IP and legacy time-division multiplexing (TDM) networks by acting as a converged transport layer for newer packet-based and existing TDM services. OTN provides robust transport services that leverage many benefits of SONET/SDH, such as resiliency and performance monitoring, while adding enhanced multi-rate capabilities in packet traffic. The Cisco NCS 5500 Series Routers support Ethernet, SONET/SDH, and OTN client interfaces with data rates from 1 to 10 Gigabits per second. To enable OTN, use the **pm otn report enable** command in the otu2e or odu2e mode.

The following distributed ethernet architecture delivers network scalability and performance, while enabling service providers to offer high-density, high-bandwidth networking solutions.

- 10-Gigabit
- 40-Gigabit
- 100-Gigabit

Tip You can programmatically configure and manage the Ethernet interfaces using `openconfig-ethernet-if.yang` and `openconfig-interfaces.yang` OpenConfig data models. To get started with using data models, see the *Programmability Configuration Guide for Cisco NCS 5500 Series Routers*.

These solutions are designed to interconnect the router with other systems in point-of-presence (POP)s, including core and edge routers and Layer 2 and Layer 3 switches.

Restrictions for Configuring Ethernet Interfaces

- Router does not support configuration of the static mac address.
- As per design, traffic logs for incoming CRC error packets don't display packets per second (PPS) and other packet-specific information, as highlighted below.

```
Router# show interface tenGigE 0/0/0/10 | include packets

5 minute input rate 541242000 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
   0 packets input, 7718374402816 bytes, 0 total input drops
   Received 0 broadcast packets, 0 multicast packets
   2952 packets output, 389664 bytes, 0 total output drops
   Output 0 broadcast packets, 2952 multicast packets
```

- To save power consumption, the router shuts down the ethernet interfaces with no configuration other than **no shutdown** after a graceful line card or system reload. To avoid ethernet interfaces going down in such scenarios, you must provide a description and the **no shutdown** configuration under the interface. You can use the **description (interface)** to add a description to an interface.
- The router doesn't support connecting a 1Gig copper cable to a 25GbE or higher speed QSFP ports.
- For 1Gig fibre cable, the router doesn't support auto-negotiation for 25GbE or higher speed QSFP ports.

- Configuring Gigabit Ethernet Interfaces, on page 27
- Information About Configuring Ethernet, on page 31
- Link Layer Discovery Protocol (LLDP), on page 42
- Carrier Delay on Physical Interfaces, on page 49
- Dense Wavelength Division Multiplexing Tunable Optics, on page 52
- Priority Flow Control (PFC) , on page 63
- Optical Transport Networks, on page 67
- How to Configure Interfaces in Breakout Mode, on page 71
- How to Configure Interfaces in Breakout Mode, on page 75

Configuring Gigabit Ethernet Interfaces

Restrictions and Important Guidelines

- NC55-MPA-12T-S supports 1G optics in eight ports. The ports are 0 to 3 and 8 to 11.
- NC55-MPA-12T-S supports 10G optics in ports 4 to 7.

Use this procedure to create a basic Ethernet interface configuration.

SUMMARY STEPS

1. **show version**
2. **show interfaces** [**GigE** | **TenGigE** | | | **HundredGigE**] *interface-path-id*
3. **configure**
4. **interface** [**GigE** | **TenGigE** | | | **HundredGigE**] *interface-path-id*
5. **ipv4 address** *ip-address mask*
6. **mtu** *bytes*
7. **no shutdown**
8. **end** or **commit**
9. **show interfaces** [**GigE TenGigE HundredGigE**] *interface-path-id*

DETAILED STEPS

Procedure

Step 1 **show version**

Example:

```
RP/0/RP0/CPU0:router# show version
```

(Optional) Displays the current software version, and can also be used to confirm that the router recognizes the line card.

Step 2 **show interfaces** [**GigE** | **TenGigE** | | | **HundredGigE**] *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router# show interface HundredGigE 0/1/0/1
```

(Optional) Displays the configured interface and checks the status of each interface port.

Step 3 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure terminal
```

Enters global configuration mode.

Step 4 **interface** [**GigE** | **TenGigE** | | | **HundredGigE**] *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface HundredGigE 0/1/0/1
```

Enters interface configuration mode and specifies the Ethernet interface name and notation *rack/slot/module/port*. Possible interface types for this procedure are:

- GigE
- 10GigE
- 100GigE

Note
- The example indicates a 100-Gigabit Ethernet interface in the line card in slot 1.

Step 5 **ipv4 address** *ip-address mask*

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv4 address 172.18.189.38 255.255.255.224
```

Assigns an IP address and subnet mask to the interface.

- Replace *ip-address* with the primary IPv4 address for the interface.
- Replace *mask* with the mask for the associated IP subnet. The network mask can be specified in either of two ways:
- The network mask can be a four-part dotted decimal address. For example, 255.0.0.0 indicates that each bit equal to 1 means that the corresponding address bit belongs to the network address.
- The network mask can be indicated as a slash (/) and number. For example, /8 indicates that the first 8 bits of the mask are ones, and the corresponding bits of the address are network address.

Step 6 **mtu** *bytes*

Example:

```
RP/0/RP0/CPU0:router(config-if)# mtu 2000
```

(Optional) Sets the MTU value for the interface.

- The configurable range for MTU values is 1514 bytes to 9646 bytes.
- The default is 1514 bytes for normal frames and 1518 bytes for 802.1Q tagged frames.

Step 7 **no shutdown**

Example:

```
RP/0/RP0/CPU0:router(config-if)# no shutdown
```

Removes the shutdown configuration, which forces an interface administratively down.

Step 8 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 9 **show interfaces** [**GigE TenGigE HundredGigE**] *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router# show interfaces HundredGigE 0/1/0/1
```

(Optional) Displays statistics for interfaces on the router.

Example

This example shows how to configure an interface for a 100-Gigabit Ethernet line card:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface HundredGigE 0/1/0/1
RP/0/RP0/CPU0:router(config-if)# ipv4 address 172.18.189.38 255.255.255.224

RP/0/RP0/CPU0:router(config-if)# mtu 2000

RP/0/RP0/CPU0:router(config-if)# no shutdown
RP/0/RP0/CPU0:router(config-if)# end
Uncommitted changes found, commit them? [yes]: yes

RP/0/RP0/CPU0:router# show interfaces HundredGigE 0/5/0/24
HundredGigE0/5/0/24 is up, line protocol is up
  Interface state transitions: 1
  Hardware is HundredGigE, address is 6219.8864.e330 (bia 6219.8864.e330)
  Internet address is 3.24.1.1/24
  MTU 9216 bytes, BW 100000000 Kbit (Max: 100000000 Kbit)
     reliability 255/255, txload 3/255, rxload 3/255
  Encapsulation ARPA,
  Full-duplex, 100000Mb/s, link type is force-up
  output flow control is off, input flow control is off
  Carrier delay (up) is 10 msec
  loopback not set,
  Last link flapped 10:05:07
  ARP type ARPA, ARP timeout 04:00:00
  Last input 00:08:56, output 00:00:00
  Last clearing of "show interface" counters never
  5 minute input rate 1258567000 bits/sec, 1484160 packets/sec
  5 minute output rate 1258584000 bits/sec, 1484160 packets/sec
     228290765840 packets input, 27293508436038 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
```

```
     Received 15 broadcast packets, 45 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     212467849449 packets output, 25733664696650 bytes, 0 total output drops
     Output 23 broadcast packets, 15732 multicast packets
     39 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
```

```
RP/0/RP0/CPU0:router# show running-config interface HundredGigE 0/5/0/24

interface HundredGigE 0/5/0/24
 mtu 9216
 service-policy input linerate
 service-policy output elinerate
 ipv4 address 3.24.1.1 255.255.255.0
 ipv6 address 3:24:1::1/64
 flow ipv4 monitor perfv4 sampler fsm ingress
!
```

Information About Configuring Ethernet

This section provides the following information sections:

Default Configuration Values for 100-Gigabit Ethernet

This table describes the default interface configuration parameters that are present when an interface is enabled on a 100-Gigabit Ethernet line card.

Note You must use the **shutdown** command to bring an interface administratively down. The interface default is **no shutdown**. When a line card is first inserted into the router, if there is no established preconfiguration for it, the configuration manager adds a shutdown item to its configuration. This shutdown can be removed only be entering the **no shutdown** command.

Table 6: 100-Gigabit Ethernet line card Default Configuration Values

Parameter	Configuration File Entry	Default Value
MTU	**mtu**	• 1514 bytes for normal frames • 1518 bytes for 802.1Q tagged frames. • 1522 bytes for Q-in-Q frames.
MAC address	**mac address**	Hardware burned-in address (BIA)

Network Interface Speed

1Gig interfaces connected through copper or fiber cable can have interface speed of either 100 Mbps or 1000 Mbps. This is applicable on 1Gig interface with a 1000Base-T module (GLC-TE). By default 1G interface has following capabilities:

- Speed—1000 Mbps for fiber cable and autonegotiate for copper cable
- Duplex—Full
- Pause—Receive Part (RX) and Transmit Part (TX)

The copper and fiber cables have same default values as mentioned above but autonegotiation is default for copper cable.

The speed can either configured or set to autonegotiate with remote end interface. When in autonegotiation mode, an interface is capable of negotiating the speed of 100 Mbps or 1000 Mbps depending on the speed at the remote end interface; and other parameters such as full duplex and pause are also autonegotiated.

Autonegotiation is an optional function of the Fast Ethernet standard that enables devices to automatically exchange information over a link about speed and duplex abilities. Autonegotiation is very useful for ports where devices with different capabilities are connected and disconnected on a regular basis.

Note Autonegotiation is disabled by default, but it's mandatory on QSFP-100G-CUxM link. You must enable autonegotiation manually when you use 100GBASE-CR4 DAC cable.

Note Starting with IOS-XR software release 24.1.1, the default value for Forward Error Correction (FEC) is set to disabled for 25G 1M and 2M copper optics.

Configuring Network Interface Speed

You can configure the network interface speed by using one of the following methods:

- Using the **speed** command
- Using the **negotiation auto** command
- Using both **speed** and **negotiation auto** command

Note Cisco recommends configuring network interface speed in autonegotiation mode.

Using the speed command

When you configure the speed of the network interface (1G) using the **speed** command, the interface speed is forced to the configured speed by limiting the speed value of the auto negotiated parameter to the configured speed.

This sample configuration forces the Gig interface speed to 100Mbps.

Note The interface speed at remote end is also set to 100Mbps.

```
#configuration
 (config)#interface GigabitEthernet 0/0/0/31
 (config-if)#speed 100
 (config-if)#commit
 (config-if)#end
```

Use the **show controller GigE** and **show interface GigE** commands to verify if the speed is configured to 100Mbps and autonegotiation is disabled:

```
#show controllers GigabitEthernet 0/0/0/31
Operational data for interface GigabitEthernet0/0/0/31:
State:
    Administrative state: enabled
    Operational state: Up
    LED state: Green On
Phy:
    Media type: Four-pair Category 5 UTP PHY, full duplex
    Optics:
        Vendor: CISCO
        Part number: SBCU-5740ARZ-CS1
        Serial number: AVC194525HW
        Wavelength: 0 nm
    Digital Optical Monitoring:
        Transceiver Temp: 0.000 C
        Transceiver Voltage: 0.000 V

        Alarms key: (H) Alarm high, (h) Warning high
                    (L) Alarm low, (l) Warning low
           Wavelength    Tx Power          Rx Power      Laser Bias
        Lane  (nm)     (dBm)     (mW)      (dBm)     (mW)       (mA)
        --   -----    ------    ------     ------    ------     ------
        0     n/a     0.0   1.0000     0.0   1.0000     0.000

        DOM alarms:
            No alarms

        Alarm                     Alarm    Warning   Warning    Alarm
        Thresholds                High      High       Low       Low
                                 -------   -------   -------   -------
        Transceiver Temp (C):      0.000     0.000     0.000     0.000
        Transceiver Voltage (V):   0.000     0.000     0.000     0.000
        Laser Bias (mA):           0.000     0.000     0.000     0.000
        Transmit Power (mW):       1.000     1.000     1.000     1.000
        Transmit Power (dBm):      0.000     0.000     0.000     0.000
        Receive Power (mW):        1.000     1.000     1.000     1.000
        Receive Power (dBm):       0.000     0.000     0.000     0.000
    Statistics:
        FEC:
            Corrected Codeword Count: 0
            Uncorrected Codeword Count: 0

MAC address information:
    Operational address: 0035.1a00.e67c
    Burnt-in address: 0035.1a00.e62c
Autonegotiation disabled.

Operational values:
```

```
    Speed: 100Mbps       /*Gig interface speed is set to 100Mbps */
    Duplex: Full Duplex
    Flowcontrol: None
    Loopback: None (or external)
    MTU: 1514
    MRU: 1514
    Forward error correction: Disabled
```

```
#show interfaces GigabitEthernet 0/0/0/31
GigabitEthernet0/0/0/31 is up, line protocol is up
  Interface state transitions: 7
  Hardware is GigabitEthernet, address is 0035.1a00.e62c (bia 0035.1a00.e62c)
  Internet address is Unknown
  MTU 1514 bytes, BW 100000 Kbit (Max: 100000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 100Mb/s, TFD, link type is force-up
  output flow control is off, input flow control is off
  Carrier delay (up) is 10 msec
  loopback not set,
  Last link flapped 00:00:30
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  30 second input rate 1000 bits/sec, 1 packets/sec
  30 second output rate 0 bits/sec, 1 packets/sec
     90943 packets input, 11680016 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 90943 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     61279 packets output, 4347618 bytes, 0 total output drops
     Output 0 broadcast packets, 8656 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
8 carrier transitions
```

In the above show output you will observe that the state of the GigabitEthernet0/0/0/31 is up, and line protocol is up. This is because the speed at both ends is 100Mbps.

Using the negotiation auto command

When you configure the network interface speed using **negotiation auto** command, the speed is autonegotiated with the remote end interface. This command enhances the speed capability to 100M or 1G to be negotiated with the peer.

This sample configuration sets the interface speed to autonegotiate:

Note The interface speed at remote end is set to 100Mbps.

Note Before Cisco IOS XR Software Release 7.3.2, the default setting for autonegotiation varied with different platforms under the NCS 5500 family. On NCS 540 and NCS 55A2, 100G autonegotiation was enabled by default.

From Cisco IOS XR Software Release 7.3.2 onwards, autonegotiation is not enabled by default. Use the **negotiation auto** command to enable autonegotiation.

Note Enabling the **negotiation auto** configuration is mandatory for the GLC-TE-specific ports to work properly on the NC57-48Q2D-S or NC57-48Q2D-SE-S line cards.

```
#configuration
 (config)#interface GigabitEthernet 0/0/0/31
 (config-if)#negotiation auto
 (config-if)#commit
 (config-if)#end
```

Use the **show controller GigE** and **show interface GigE** commands to verify if the speed is autonegotiated:

```
#show interfaces GigabitEthernet 0/0/0/31
GigabitEthernet0/0/0/31 is up, line protocol is up
  Interface state transitions: 10
  Hardware is GigabitEthernet, address is 0035.1a00.e62c (bia 0035.1a00.e62c)
  Internet address is Unknown
  MTU 1514 bytes, BW 100000 Kbit (Max: 100000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 100Mb/s, TFD, link type is autonegotiation
  output flow control is off, input flow control is off
  Carrier delay (up) is 10 msec
  loopback not set,
  Last link flapped 00:00:01
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  30 second input rate 1000 bits/sec, 1 packets/sec
  30 second output rate 0 bits/sec, 0 packets/sec
     91005 packets input, 11687850 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 91005 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     61307 packets output, 4350024 bytes, 0 total output drops
     Output 0 broadcast packets, 8668 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
     15 carrier transitions
```

In the above show output you see that GigabitEthernet0/0/0/31 is up, and line protocol is up.

```
 #show controllers GigabitEthernet 0/0/0/31
Operational data for interface GigabitEthernet0/0/0/31:

State:
    Administrative state: enabled
    Operational state: Up
    LED state: Green On
```

```
Phy:
    Media type: Four-pair Category 5 UTP PHY, full duplex
    Optics:
        Vendor: CISCO
        Part number: SBCU-5740ARZ-CS1
        Serial number: AVC194525HW
        Wavelength: 0 nm
    Digital Optical Monitoring:
        Transceiver Temp: 0.000 C
        Transceiver Voltage: 0.000 V

        Alarms key: (H) Alarm high, (h) Warning high
                    (L) Alarm low, (l) Warning low
           Wavelength    Tx Power          Rx Power      Laser Bias
        Lane  (nm)    (dBm)    (mW)     (dBm)     (mW)      (mA)
        --   -----   ------   ------    ------   ------    ------
        0     n/a     0.0   1.0000     0.0   1.0000     0.000

        DOM alarms:
            No alarms

        Alarm                     Alarm    Warning   Warning    Alarm
        Thresholds                High      High       Low       Low
                                 -------   -------   -------   -------
        Transceiver Temp (C):      0.000     0.000     0.000     0.000
        Transceiver Voltage (V):   0.000     0.000     0.000     0.000
        Laser Bias (mA):           0.000     0.000     0.000     0.000
        Transmit Power (mW):       1.000     1.000     1.000     1.000
        Transmit Power (dBm):      0.000     0.000     0.000     0.000
        Receive Power (mW):        1.000     1.000     1.000     1.000
        Receive Power (dBm):       0.000     0.000     0.000     0.000
    Statistics:
        FEC:
            Corrected Codeword Count: 0
            Uncorrected Codeword Count: 0

MAC address information:
    Operational address: 0035.1a00.e67c
    Burnt-in address: 0035.1a00.e62c

Autonegotiation enabled:
    No restricted parameters

Operational values:
    Speed: 100Mbps
    Duplex: Full Duplex
    Flowcontrol: None
    Loopback: None (or external)
    MTU: 1514
    MRU: 1514
    Forward error correction: Disabled
```

Using speed and negotiation auto command

When you configure the speed of the network interface (1G) using the **speed** and **negotiation auto** command, the interface autonegotiates all the paramets (full-duplex and pause) except speed. The speed is forced to the configured value.

This sample shows how to configures Gig interface speed to 100Mbps and autonegotiate other parameters:

Note The interface speed at remote end is set to 100Mbps.

```
#configuration
(config)#interface GigabitEthernet 0/0/0/31
(config-if)#negotiation auto
(config-if)#speed 100
(config-if)#end
```

Use the **show controller GigE** and **show interface GigE** command to verify if the link is up, speed is forced to 100Mbps and autonegotiation is enabled:

```
#show interfaces GigabitEthernet 0/0/0/31
GigabitEthernet0/0/0/31 is up, line protocol is up
  Interface state transitions: 9
  Hardware is GigabitEthernet, address is 0035.1a00.e62c (bia 0035.1a00.e62c)
  Internet address is Unknown
  MTU 1514 bytes, BW 100000 Kbit (Max: 100000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 100Mb/s, TFD, link type is autonegotiation
  output flow control is off, input flow control is off
  Carrier delay (up) is 10 msec
  loopback not set,
  Last link flapped 00:00:03
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  30 second input rate 0 bits/sec, 1 packets/sec
  30 second output rate 0 bits/sec, 0 packets/sec
     90968 packets input, 11683189 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 90968 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     61287 packets output, 4348541 bytes, 0 total output drops
     Output 0 broadcast packets, 8664 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
     12 carrier transitions
```

In the above show output you will observe that the GigabitEthernet0/0/0/31 is up, and line protocol is up This is because the speed at both ends is 100Mbps.

```
#show controllers GigabitEthernet 0/0/0/31
Operational data for interface GigabitEthernet0/0/0/31:

State:
    Administrative state: enabled
    Operational state: Up
    LED state: Green On

Phy:
    Media type: Four-pair Category 5 UTP PHY, full duplex
    Optics:
        Vendor: CISCO
        Part number: SBCU-5740ARZ-CS1
        Serial number: AVC194525HW
        Wavelength: 0 nm
    Digital Optical Monitoring:
```

```
        Transceiver Temp: 0.000 C
        Transceiver Voltage: 0.000 V

        Alarms key: (H) Alarm high, (h) Warning high
                    (L) Alarm low, (l) Warning low
           Wavelength    Tx Power          Rx Power      Laser Bias
        Lane  (nm)     (dBm)     (mW)      (dBm)      (mW)       (mA)
        --   -----    ------    ------     ------    ------     ------
        0     n/a      0.0   1.0000      0.0   1.0000      0.000

        DOM alarms:
            No alarms

        Alarm                      Alarm    Warning   Warning    Alarm
        Thresholds                 High      High       Low       Low
                                  -------   -------   -------   -------
        Transceiver Temp (C):       0.000     0.000     0.000     0.000
        Transceiver Voltage (V):    0.000     0.000     0.000     0.000
        Laser Bias (mA):            0.000     0.000     0.000     0.000
        Transmit Power (mW):        1.000     1.000     1.000     1.000
        Transmit Power (dBm):       0.000     0.000     0.000     0.000
        Receive Power (mW):         1.000     1.000     1.000     1.000
        Receive Power (dBm):        0.000     0.000     0.000     0.000
    Statistics:
        FEC:
            Corrected Codeword Count: 0
            Uncorrected Codeword Count: 0

MAC address information:
    Operational address: 0035.1a00.e67c
    Burnt-in address: 0035.1a00.e62c

Autonegotiation enabled:
    Speed restricted to: 100Mbps  /* autonegotiation is enabled and speed is forced to
100Mbps*/

Operational values:
    Speed: 100Mbps
    Duplex: Full Duplex
    Flowcontrol: None
    Loopback: None (or external)
    MTU: 1514
    MRU: 1514
    Forward error correction: Disabled
```

Ethernet MTU

The Ethernet maximum transmission unit (MTU) is the size of the largest frame, minus the 4-byte frame check sequence (FCS), that can be transmitted on the Ethernet network. Every physical network along the destination of a packet can have a different MTU.

Cisco IOS XR software supports two types of frame forwarding processes:

- Fragmentation for IPV4 packets–In this process, IPv4 packets are fragmented as necessary to fit within the MTU of the next-hop physical network.

Note IPv6 does not support fragmentation.

- MTU discovery process determines largest packet size–This process is available for all IPV6 devices, and for originating IPv4 devices. In this process, the originating IP device determines the size of the largest IPv6 or IPV4 packet that can be sent without being fragmented. The largest packet is equal to the smallest MTU of any network between the IP source and the IP destination devices. If a packet is larger than the smallest MTU of all the networks in its path, that packet will be fragmented as necessary. This process ensures that the originating device does not send an IP packet that is too large.

Note To enable hashing for L3 header only when the majority of traffic is fragmented, use the **hw-module profile load-balance algorithm L3-Only** command.

Jumbo frame support is automatically enable for frames that exceed the standard frame size. The default value is 1514 for standard frames and 1518 for 802.1Q tagged frames. These numbers exclude the 4-byte frame check sequence (FCS).

Following are the supported MTU properties on devices containing NC55 first generation line cards, NCS 5501, NCS5501-SE cards:

- Each physical port can have a different MTU.
- Main interface of each bundle can have one MTU value.
- L3 sub-interface (bundle or physical) shares MTU profiles and can have a maximum of 3 unique configured MTUs per NPU.

Note L2 sub-interface MTU is not supported.

Following are the supported MTU profiles on devices containing NC55 second generation line cards. Each profile has a limit of 7 configured MTUs per NPU.

- Port MTU profile: This is shared by bundle main interfaces and physical main interfaces.
- RIF MTU profile: This is used by the L3 sub-interface (bundle or physical) on the device.

Note L2 sub-interface MTU is not supported.

For more information about the architecture, refer to the NCS 5500 and NCS 5700 Fixed Platform Architecture white paper.

Independent MTUs for IPv4 and IPv6

Table 7: Feature History Table

Feature Name	Release Information	Description
Independent MTUs for IPv4 and IPv6	Release 7.11.1	Introduced in this release on: NCS 5700 line cards [Mode: Native] You can now ensure reduced fragmentation or packet drops by configuring separate IPv4 and IPv6 Maximum Transmission Units (MTUs). You can configure independent IPv4 and IPv6 MTUs on the physical interface and subinterface, bundle interface and subinterface, and Bridge-Group Virtual Interface (BVI). This feature introduces these changes: **CLI:** The following commands are extended to subinterface configuration mode: • **ipv4 mtu** • **ipv6 mtu** • **mtu**

Earlier, the MTU value could be configured for IP protocol only at the physical interface level. The same MTU value is considered for all subinterfaces associated with the main interface.

As IPv4 and IPv6 have different header sizes, packet overhead is correspondingly different. Therefore, a common MTU configuration for both IPv4 and IPv6 does not result in an optimum data transmission. This also results in higher fragmentation rate, further reducing the network efficiency.

You can now configure IPv4 and IPv6 MTUs separately and independent of each other for physical interface, physical sub-interface, bundle interface, bundle sub-interface, and BVI. When MTU is configured for the main interface, all sub-interfaces inherit that value as its MTU. If MTU is configured for both the main interface and the sub-interface, the minimum MTU value between the two is considered for the lower level. The possible range for MTU at all interface levels is 64 to 65535 bytes for both IPv4 and IPv6.

Following are the key benefits of using independent IPv4 and IPv6 MTU values:

- Optimal MTU configuration: By allowing independent MTU configurations, you can optimize the MTU settings for each protocol individually, considering the difference in packet overhead due to header size variation. This flexibility ensures efficient data transmission for both IPv4 and IPv6 traffic, maximizing network performance.
- Efficient MTU discovery process: MTU discovery process determines the maximum MTU size that can be transmitted without fragmentation along the entire path between source and destination. With separate MTU configurations, the process can operate independently for IPv4 and IPv6, enabling accurate discovery

of the optimal MTU for each protocol. This helps reduce fragmentation and latency, and improves overall network efficiency.

Configure Independent MTUs for IPv4 and IPv6

IP MTU can be configured in different ways. The following is an example depicting separate IPv4 and IPv6 MTU configuration on specific interface.

In this example, IPv4 MTU of interface TenGigE 0/3/0/1/0 is configured to 4500. As this is lower than the common MTU of the interface (5000), 4500 is considered as the IPv4 MTU for the interface. However, IPv6 MTU of the interface is configured to 5500, which is more than the common MTU configured for the interface. Therefore, IPv6 MTU of this interface is considered as 5000, the lower of the two values.

Note NCS 5700 line cards [Mode: Native] support a maximum MTU size of 9646.

```
Router# configure terminal
Router(config)#interface TenGigE 0/3/0/1/0
Router(config-if)#mtu 5000 /* Main interface MTU */
Router(config-if)#ipv4 mtu 4500 /* Separate IPv4 MTU configuration for the interface */
Router(config-if)#ipv6 mtu 5500 /* Separate IPv6 MTU configuration for the interface */
Router(config-if)#commit
```

Running Configuration

The following example shows the running configuration:

```
Router#show running-config interface  tenGigE 0/3/0$
interface TenGigE0/3/0/1/0
 mtu 5000
 ipv4 mtu 4500
 ipv4 address 192.3.0.1 255.255.255.0
 ipv6 mtu 5500
 ipv6 address 192:3::1/64
 lldp
 !
 load-interval 30
!
Router#
```

Verification

The following example shows how to verify the separate configuration for IPv4 and IPv6 MTUs.

```
Router#show im database interface TenGigE 0/3/0/1/0
Wed Nov  8 16:04:20.443 UTC

View: OWN - Owner, L3P - Local 3rd Party, G3P - Global 3rd Party, LDP - Local Data Plane
      GDP - Global Data Plane, RED - Redundancy, UL - UL

Node 0/3/CPU0 (0x300)

Interface TenGigE0/3/0/1/0, ifh 0x06004048 (up, 5000)
  Interface flags:          0x000000000110049f (ROOT_IS_HW|IFCONNECTOR
                            |IFINDEX|BROADCAST|CONFIG|HW|VIS|DATA|CONTROL)
  Encapsulation:            ether
  Interface type:           IFT_TENGETHERNET
  Control parent:           None
```

```
  Data parent:              None
  Views:                    GDP|LDP|L3P|OWN

  Protocol        Caps (state, mtu)
  --------        -----------------
  None            hw_oor (up, 5000)
  None            spio (up, 5000)
  None            ether (up, 5000) /* configured L2 MTU */
  arp             arp (up, 4986)
  clns            clns (up, 4986)
  ipv4            ipv4 (up, 4500) /* configured IPv4 MTU, which is less than L2 MTU */
  ipv6            ipv6_preswitch (up, 4986)
  ipv6            ipv6 (up, 4986) /* Even though configured IPv6 MTU is 5500, minimum of
L2 and IPv6 MTUs is considered. In this case, it is L2 MTU (5000)*/
  ether_sock      ether_sock (up, 4986)
```

Link Layer Discovery Protocol (LLDP)

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

To support non-Cisco devices and to allow for interoperability between other devices, it also supports the IEEE 802.1AB LLDP. LLDP is also a neighbor discovery protocol that is used for network devices to advertise information about themselves to other devices on the network. This protocol runs over the data link layer, which allows two systems running different network layer protocols to learn about each other.

With LLDP, you can also access the information about a particular physical network connection. If you use a non-Cisco monitoring tool (via SNMP,) LLDP helps you identify the Object Identifiers (OIDs) that the system supports. The following are the supported OIDs:

- 1.0.8802.1.1.2.1.4.1.1.4
- 1.0.8802.1.1.2.1.4.1.1.5
- 1.0.8802.1.1.2.1.4.1.1.6
- 1.0.8802.1.1.2.1.4.1.1.7
- 1.0.8802.1.1.2.1.4.1.1.8
- 1.0.8802.1.1.2.1.4.1.1.9
- 1.0.8802.1.1.2.1.4.1.1.10
- 1.0.8802.1.1.2.1.4.1.1.11
- 1.0.8802.1.1.2.1.4.1.1.12

Specifying User-Defined LLDP TLV Values

It is possible to override the system default values for some of the mandatory LLDP Type-Length-Values (TLVs) that are advertised by routers to their directly connected neighboring devices. While advertising their identity and capabilities, routers can assign user-defined meaningful names instead of autogenerated values. Using the following CLIs you can specify these user-defined values:

- `Router(config)#lldp tlv-select`: Choose the wire-power management (Cisco 4-wire Power via MDI TLV or IEEE 802.3 DTE Power)
- `Router(config)#lldp system-name` *system-name*
- `Router(config)#lldp system-description` *system-description*
- `Router(config)#lldp chassis-id-type` *chassis-type*
- `Router(config)#lldp chassis-id` *local-chassis-id*

Note The **chassis-id** value is configurable only when the **chassis-id-type** is set as **Local**. If there is a mismatch, you encounter a configuration failed error message.

The configured values, such as the system name, system description, chassis-id, chassis-type become part of the TLV in the LLDP packets that are sent to its neighbors. Values are transmitted only to LLDP enabled interfaces to which the router is connected.

You can assign any of the following values for the `chassis-id-type`. The chassis-id-types are objects that are part of the management information base (MIB). Depending on the selected chassis-id-type, values are assigned to these objects, and they are advertised by the router to its neighboring devices.

chassis-id-type	Description
chassis-component	Chassis identifier based on the value of entPhysicalAlias object that is defined in IETF RFC 2737.
interface-alias	Chassis identifier based on the value of ifAlias object as defined in IETF RFC 2863.
interface-name	Chassis identifier based on the name of the interface.
local	Chassis identifier based on a locally defined value.
mac-address	Chassis identifier based on the value of a unicast source address.
network-address	Chassis identifier based on a network address that is associated with a particular chassis.
port-component	Chassis identifier based on the value of entPhysicalAlias object defined in IETF RFC 2737 for a port or backplane component.

Tip You can programmatically modify default values of LLDP TLVs by using the `openconfig-lldp` OpenConfig data model. To get started with using data models, see the *Programmability Configuration Guide for Cisco NCS 5500 Series Routers*.

Configuration Example

This example shows the configuration for the LLDP TLVs that will be advertised by routers to their directly connected neighboring devices.

```
Router(config)#lldp system-name cisco-xr
Router(config)#lldp system-description cisco-xr-edge-device
Router(config)#lldp chassis-id-type local
Router(config)#lldp chassis-id ce-device9
```

Running Configuration

```
Router#show lldp
Tue Sep 13 16:03:44.550 +0530
Global LLDP information:
Status: ACTIVE
LLDP Chassis ID: ce-device9
LLDP Chassis ID Subtype: Locally Assigned Chassis Subtype
LLDP System Name: cisco-xr
LLDP advertisements are sent every 30 seconds
LLDP hold time advertised is 120 seconds
LLDP interface reinitialisation delay is 2 seconds
```

Enabling LLDP Globally

To run LLDP on the router, you must enable it globally. When you enable LLDP globally, all interfaces that support LLDP are automatically enabled for both transmit and receive operations.

You can override this default operation at the interface to disable receive or transmit operations.

The following table describes the global attributes that you can configure:

Attribute	Default	Range	Description
Holdtime	120	0-65535	Specifies the holdtime (in sec) that are sent in packets
Reinit	2	2-5	Delay (in sec) for LLDP initialization on any interface
Timer	30	5-65534	Specifies the rate at which LLDP packets are sent (in sec)

To enable LLDP globally, complete the following steps:

1. `RP/0/RSP0/CPU0:router # configure`
2. `RP/0/RSP0/CPU0:router(config) #lldp`
3. `end or commit`

Running configuration

```
RP/0/RP0/CPU0:router-5#show run lldp
Fri Dec 15 20:36:49.132 UTC
lldp
```

```
!

RP/0/RP0/CPU0:router#show lldp neighbors
Fri Dec 15 20:29:53.763 UTC
Capability codes:
        (R) Router, (B) Bridge, (T) Telephone, (C) DOCSIS Cable Device
        (W) WLAN Access Point, (P) Repeater, (S) Station, (O) Other

Device ID       Local Intf          Hold-time  Capability     Port ID
SW-NOSTG-I11-PUB.cis Mg0/RP0/CPU0/0      120        N/A             Fa0/28

Total entries displayed: 1

RP/0/RP0/CPU0:router#show lldp neighbors mgmtEth 0/RP0/CPU0/0
Fri Dec 15 20:30:54.736 UTC
Capability codes:
        (R) Router, (B) Bridge, (T) Telephone, (C) DOCSIS Cable Device
        (W) WLAN Access Point, (P) Repeater, (S) Station, (O) Other

Device ID       Local Intf          Hold-time  Capability     Port ID
SW-NOSTG-I11-PUB.cis Mg0/RP0/CPU0/0      120        N/A             Fa0/28

Total entries displayed: 1
```

Enabling LLDP Per Interface

When you enable LLDP globally, all interfaces that support LLDP are automatically enabled for both transmit and receive operations. However, if you want to enable LLDP per interface, perform the following configuration steps:

1. `RP/0/RSP0/CPU0:router(config)# int gigabitEthernet 0/2/0/0`
2. `RP/0/RSP0/CPU0:router(config-if)# no sh`
3. `RP/0/RSP0/CPU0:router(config-if)#commit`
4. `RP/0/RSP0/CPU0:router(config-if)#lldp ?`
5. `RP/0/RSP0/CPU0:router(config-if)#lldp enable`
6. `RP/0/RSP0/CPU0:router(config-if)#commit`

Running configuration

```
RP/0/RSP0/CPU0:router#sh running-config
Wed Jun 27 12:40:21.274 IST
Building configuration...
!! IOS XR Configuration 0.0.0
!! Last configuration change at Wed Jun 27 00:59:29 2018 by UNKNOWN
!
interface GigabitEthernet0/1/0/0
 shutdown
!
interface GigabitEthernet0/1/0/1
 shutdown
!
interface GigabitEthernet0/1/0/2
 shutdown
!
interface GigabitEthernet0/2/0/0
 Shutdown
!
```

```
interface GigabitEthernet0/2/0/1
 shutdown
!
interface GigabitEthernet0/2/0/2
 shutdown
!
end
```

Verification

```
Verifying the config
==================
RP/0/RSP0/CPU0:router#sh lldp interface <===== LLDP enabled only on GigEth0/2/0/0
Wed Jun 27 12:43:26.252 IST


GigabitEthernet0/2/0/0:
        Tx: enabled
        Rx: enabled
        Tx state: IDLE
        Rx state: WAIT FOR FRAME
RP/0/RSP0/CPU0:router#

RP/0/RSP0/CPU0:router# show lldp neighbors
Wed Jun 27 12:44:38.977 IST
Capability codes:
        (R) Router, (B) Bridge, (T) Telephone, (C) DOCSIS Cable Device
        (W) WLAN Access Point, (P) Repeater, (S) Station, (O) Other

Device ID       Local Intf          Hold-time  Capability     Port ID
ios             Gi0/2/0/0           120        R              Gi0/2/0/0       <====== LLDP
 enabled only on GigEth0/2/0/0 and neighborship seen for the same.

Total entries displayed: 1

RP/0/RSP0/CPU0:router#
```

Transmission of VLAN-Tagged LLDP Packets

Table 8: Feature History Table

Feature Name	Release	Description
Transmission of VLAN-Tagged LLDP Packets	Release 7.9.1	With this release, transmitting VLAN-tagged LLDP packets on the subinterfaces is supported. Earlier, if LLDP is enabled on a subinterface, the LLDP packets are sent without a VLAN tag. VLAN-tagged LLDP packets help to identify unauthorized devices on the network and discover VLANs configured on the network devices. You can monitor and enforce VLAN segregation, ensuring that devices are connected to the correct VLANs and preventing unauthorized access to sensitive network segments. You can enable VLAN tagging for LLDP packets globally or on each subinterface using these commands: • Globally: **lldp subinterfaces-tagged** • Each subinterface: **lldp tagged**

You can now transmit VLAN-tagged LLDP packets on the subinterfaces. When VLAN-tagged LLDP transmission is enabled either globally or at subinterface level, VLAN information is added to the Ethernet header of the constructed LLDP packet. For VLAN tagging, LLDP packet includes a TLV called the "Port VLAN ID TLV" to convey VLAN information. This TLV contains the VLAN ID associated with the port or interface of the sending device. It provides the receiving device with information about the VLAN membership of the transmitting port. With this, the devices can exchange VLAN information during LLDP discovery and facilitate the configuration and management of VLANs across the network.

Global VLAN-tagged LLDP Processing

You can enable VLAN tagging of LLDP packets globally on all subinterfaces after enabling LLDP on all subinterfaces.

When you enable LLDP globally, all subinterfaces are automatically enabled for both transmit and receive operations. You can override this default operation at the subinterface to disable receive or transmit operation.

Subinterface-level VLAN-tagged LLDP Processing

Instead of enabling VLAN tagging of LLDP packets on all subinterfaces on the system, you can enable it only for specific subinterfaces. You can also disable either transmit or receive on the subinterface using **lldp transmit disable** or **lldp receive disable** commands.

Configuration

You can enable transmitting tagged LLDP packets globally or on each subinterface. LLDP should be enabled on the subinterfaces before enabling Tx for VLAN-tagged LLDP packets.

Run the command **subinterfaces enable** to enable LLDP on subinterfaces.

Enable Transmission of VLAN-tagged LLDP Packets (Global)

Perform the following tasks on the router to enable transmission of VLAN-tagged LLDP packets on all subinterfaces globally:

1. Enter global configuration mode.
2. Run **lldp subinterfaces enable** command to enable LLDP on all subinterfaces.
3. Run **lldp subinterfaces-tagged** command to enable VLAN tagging on all subinterfaces.

This example shows how to enable transmission of VLAN-tagged LLDP packets on all subinterfaces globally.

```
Router(config)# lldp subinterfaces
Router(config)# lldp subinterfaces-tagged
Router(config)#!
```

Enable Transmission of VLAN-tagged LLDP Packets (Subinterface)

Perform the following tasks on the router to enable transmission of VLAN-tagged LLDP packets on a specific subinterface:

1. Enter subinterface configuration mode.
2. Run **lldp enable** command to enable LLDP on the subinterface.
3. Run **lldp tagged** command to enable VLAN tagging on the subinterface.

This example shows how to enable transmission of VLAN-tagged LLDP packets on the subinterface GigabitEthernet 0/0/0/0.1.

```
Router(config)# interface GigabitEthernet 0/0/0/0.1
Router(config-subif)# lldp enable
Router(config-subif)# lldp tagged
Router(config-subif)#!
```

Note

- You may enable LLDP globally using the **lldp subinterfaces enable** command instead of step 2 above.
- If a subinterface has double VLAN encapsulation, LLDP packets are transmitted without the VLAN tag even with the configurations mentioned here.

Verification

The following command output for **show lldp interfaces** output shows the tagged state of a subinterface with the field `Tagged`. This field is displayed only for the subinterface.

```
Router(config-subif)do show lldp interface
Thu Feb 2 16:27:12.503 IST
GigabitEthernet0/0/0/0
Tx: disabled
Rx: enabled
Tx state: IDLE
Rx state: WAIT FOR FRAME
GigabitEthernet0/0/0/0.1:
Tx: disabled
rx: enabled
Tx state: IDLE
Rx state: WAIT FOR FRAME
Tagged: true
```

The following command output for **show lldp neighbors**, shows the tagged feature for a subinterface:

```
Router(config-subif)#do show lldp neighbors
Thu Nov 3 14:02:32.041 UTC
Capabilitv codes:
        (R) Router, (B) Bridge, (T) Telephone, (C) DOCS/S Cable Device
        (W) WLAN Access Point, (P) Repeater, (S) Station, (O) Other

Device ID  Local Intf                Hold-time  Capability  Port ID
R1-ASR9k   GigabitEthernet0/0/0/0.1    150        R         GigabitEthernet0/2/0/9.1

Total entries displayed: 1
```

Carrier Delay on Physical Interfaces

Table 9: Feature History Table

Feature Name	Release Information	Feature Description
Carrier Delay on Physical Interfaces on NCS 5700 fixed port routers	Release 24.2.11	Introduced in this release on: NCS 5700 fixed port routers This feature support is now extended to NCS 5700 fixed port routers.

Feature Name	Release Information	Feature Description
Carrier Delay on Physical Interfaces	Release 24.2.1	Introduced in this release on: NCS 5500 fixed port routers; NCS 5500 modular routers (NCS 5500 line cards; NCS 5700 line cards [Mode: Compatibility; Native]) With the carrier-delay timer functionality, the Ethernet interface state remains stable for the configured delay duration, even if the hardware link state fluctuates. This prevents interface flapping and improves network reliability. If you haven't configured the timer, the default carrier delay automatically delays the hardware link-up notifications by 200 ms. This time delay ensures that a stable hardware link state is established. If you want to change the delay of the interface state change notification, you can use the **carrier-delay** command to set a different value. The feature introduces these changes: **CLI:** • **carrier-delay** • The default value of **up** keyword is implemented as 200 ms in the **carrier-delay** command.

Hardware links take time to stabilize after a state change and may experience link flaps. Link flap is a condition where a physical interface frequently fluctuates between an up and a down state.

During link flaps, the network reestablishes and updates routing paths after a disruption, which leads to resource exhaustion on routers. To overcome the problem, we recommend waiting until the link state is stable before taking action.

The carrier delay introduces a delay in processing interface link-state notifications in the router to provide enough time for the interface link to stabilize.

When there is a change in the link state, the carrier-delay timer starts. If the link state goes up, the **carrier-delay up** timer starts. Similarly, when the link state goes down, the **carrier-delay down** timer starts. During this delay period, the Ethernet interface state remains unchanged even if the link is physically restored. Setting a delay timer ensures the link state is established before the interface becomes operational again and avoids unnecessary interface state changes and associated traffic rerouting.

Guidelines and Restrictions for Setting the Carrier Delay on Physical Interfaces

The following usage guidelines and restrictions are applicable for setting the carrier delay on physical interfaces:

- You can configure carrier-delay for only link-up, only link-down, or both link-up and link-down notifications.
- If the **carrier-delay down** *milliseconds* command is configured on a physical link that fails and cannot be recovered, link down detection time increases, and it may take longer for the routing protocols to reroute the traffic around the failed link.
- If not configured, the carrier-delay up parameter defaults to 200 ms and the carrier-delay down parameter to 0 ms. When carrier-delay down is not configured, the higher-layer protocols are notified immediately when a physical link state changes.
- The **carrier-delay** command overwrites the previous configuration every time you execute the command. If any of the optional keywords is not explicitly configured, its default value is considered.

  For example, you already configured 500 ms for up timer and 300 ms for down timer. Later, if you want to change the up timer to 600 ms, you need to run **carrier-delay up 600 down 300** command. If **down** keyword is not mentioned, the default value of down timer, 0 ms, would replace the previous configuration of 300 ms.
- Loss of Signal (LOS) is not supported on carrier delay.

Configure the Carrier Delay on Physical Interfaces

Default Configuration Example

In this example, one interface is brought up to check the default value of link-up notification delay.

```
Router#configure
Router(config)#interface HundredGigE 0/0/0/0
Router(config-if)#no shutdown
Router(config-if)#commit
```

Run the **show interfaces** command to check if the carrier-delay configuration for the interface defaults to 200 ms.

```
Router#show interfaces HundredGigE 0/0/0/0 | include Carrier
Fri Mar 31 07:25:05.273 UTC
Carrier delay (up) is 200 msec
```

Configuration Example

In this example, link-up and link-down notifications are configured to be delayed by 1000 ms and 150 ms using **carrier-delay** command.

```
Router#configure
Router(config)#interface HundredGigE 0/0/0/0
Router(config-if)#carrier-delay up 1000 down 150
Router(config-if)#commit
```

Running Configuration

```
 interface HundredGigE0/0/0/0
 carrier-delay up 1000 down 150
!
```

Verification

Run the **show interfaces** command to see the current state of the carrier-delay configuration for an interface.

```
Router#show interfaces HundredGigE 0/0/0/0 | include Carrier
Fri Mar 31 07:25:05.273 UTC
Carrier delay (up) is 1000 msec, Carrier delay (down) is 150 msec
```

Dense Wavelength Division Multiplexing Tunable Optics

The Dense Wavelength-Division Multiplexing (DWDM) wavelengths of the DWDM-SFP10G-C module on the Cisco NCS 5500 Series Aggregation Services Routers is tunable. You can configure the DWDM ITU wavelengths by using the itu channel command in the interface configuration mode. The itu channel command ensures that the traffic continues to flow.

The following table contains the wavelength mapping information for the DWDM module:

Channel	Frequency (THz)	Wavelength (nm)
1	191.35	1566.723
2	191.40	1566.314
3	191.45	1565.905
4	191.50	1565.496
5	191.55	1565.087
6	191.60	1564.679
7	191.65	1564.271
8	191.70	1563.863
9	191.75	1563.455
10	191.80	1563.047
11	191.85	1562.640
12	191.90	1562.233
13	191.95	1561.826
14	192.00	1561.419
15	192.05	1561.013

Channel	Frequency (THz)	Wavelength (nm)
16	192.10	1560.606
17	192.15	1560.200
18	192.20	1559.794
19	192.25	1559.389
20	192.30	1558.983
21	192.35	1558.578
22	192.40	1558.173
23	192.45	1557.768
24	192.50	1557.363
25	192.55	1556.959
26	192.60	1556.555
27	192.65	1556.151
28	192.70	1555.747
29	192.75	1555.343
30	192.80	1554.940
31	192.85	1554.537
32	192.90	1554.134
33	192.95	1553.731
34	193.00	1553.329
35	193.05	1552.926
36	193.10	1552.524
37	193.15	1552.122
38	193.20	1551.721
39	193.25	1551.319
40	193.30	1550.918
41	193.35	1550.517
42	193.40	1550.116
43	193.45	1549.715

Channel	Frequency (THz)	Wavelength (nm)
44	193.50	1549.315
45	193.55	1548.915
46	193.60	1548.515
47	193.65	1548.115
48	193.70	1547.715
49	193.75	1547.316
50	193.80	1546.917
51	193.85	1546.518
52	193.90	1546.119
53	193.95	1545.720
54	194.00	1545.322
55	194.05	1544.924
56	194.10	1544.526
57	194.15	1544.128
58	194.20	1543.730
59	194.25	1543.333
60	194.30	1542.936
61	194.35	1542.539
62	194.40	1542.142
63	194.45	1541.746
64	194.50	1541.349
65	194.55	1540.953
66	194.60	1540.557
67	194.65	1540.162
68	194.70	1539.766
69	194.75	1539.371
70	194.80	1538.976
71	194.85	1538.581

Channel	Frequency (THz)	Wavelength (nm)
72	194.90	1538.186
73	194.95	1537.792
74	195.00	1537.397
75	195.05	1537.003
76	195.10	1536.609
77	195.15	1536.216
78	195.20	1535.822
79	195.25	1535.429
80	195.30	1535.036
81	195.35	1534.643
82	195.40	1534.250
83	195.45	1533.858
84	195.50	1533.465
85	195.55	1533.073
86	195.60	1532.681
87	195.65	1532.290
88	195.70	1531.898
89	195.75	1531.507
90	195.80	1531.116
91	195.85	1530.725
92	195.90	1530.334
93	195.95	1529.944
94	196.00	1529.553
95	196.05	1529.163
96	196.10	1528.773

Note For more information on limitations of this feature and details about optical parameters, see https://www.cisco.com/c/en/us/products/collateral/interfaces-modules/dwdm-transceiver-modules/data_sheet_c78-711186.html.

Configuring the DWDM Tunable Optics

Perform the following procedure to configure the DWDM Tunable Optics module:

1. `Router# enable //Enables the privileged EXEC mode. If prompted, enter your password.`
2. `Router# configure terminal`
3. `Router(config)# interface tengigabitethernet 4/11 // Specifies the 10-Gigabit Ethernet interface to be configured. slot/port—Specifies the location of the interface.`
4. `Router(config-if)# itu channel 28 //Sets the ITU channel. number specifies the ITU channel number. The acceptable values are from 1-96.`

Verifying the ITU Configuration

The following example shows how to use the show controller optics command to check an ITU configuration:

```
RP/0/RP0/CPU0:ios#show controllers optics 0/0/0/16
Tue Sep  5 08:25:54.127 UTC

 Controller State: Up

 Transport Admin State: In Service

 Laser State: Off

 LED State: Off

 Optics Status

         Optics Type:  SFP+ 10G DWDM Tunable
         DWDM carrier Info: C BAND, MSA ITU Channel=49, Frequency=193.75THz,
         Wavelength=1547.316nm

         Alarm Status:
         -------------
         Detected Alarms:
                 LOW-RX0-PWR

         LOS/LOL/Fault Status:

         Laser Bias Current = 0.0 mA
         Actual TX Power = 0.00 dBm
         RX Power = 0.00 dBm

         Performance Monitoring: Enable

         THRESHOLD VALUES
         ----------------

         Parameter                High Alarm  Low Alarm  High Warning  Low Warning
         -----------------------  ----------  ---------  ------------  -----------
```

```
          Rx Power Threshold(dBm)          -2.9      -30.9          -7.0        -26.9
          Tx Power Threshold(dBm)           5.9       -5.0           2.9         -1.0
          LBC Threshold(mA)               75.00      25.00         70.00        30.00
          Temp. Threshold(celsius)        75.00      -5.00         70.00         0.00
          Voltage Threshold(volt)          3.63       2.97          3.46         3.13

          Polarization parameters not supported by optics

          Temperature = 38.00 Celsius
          Voltage = 3.28 V

 Transceiver Vendor Details

        Form Factor : SFP+
        Vendor Info
        -----------
         Optics type    : SFP+ 10G DWDM Tunable
         Name           : CISCO-OCLARO
         OUI Number     : 00.0b.40
         Part Number    : TRS7080FNCCA033
         Rev Number     : 0000
         Serial Number  : ONT2038009B
         PID            : DWDM-SFP10G-C
         VID            : V01


// DWDM Channel to Frequency/Wavelength Mapping
RP/0/RP0/CPU0:ios#show controllers optics 0/0/0/16 dwdm-carrrier-map
Tue Sep  5 08:26:31.175 UTC
DWDM Carrier Band:: (null)
MSA ITU channel range supported: 1~96

DWDM Carrier Map table
------------------------------------------------------
ITU Ch   G.694.1         Frequency       Wavelength
 Num     Ch Num           (THz)             (nm)
------------------------------------------------------
     1   -35             191.35          1566.723
------------------------------------------------------
     2   -34             191.40          1566.314
------------------------------------------------------
     3   -33             191.45          1565.905
------------------------------------------------------
     4   -32             191.50          1565.496
------------------------------------------------------
     5   -31             191.55          1565.087
------------------------------------------------------
     6   -30             191.60          1564.679
------------------------------------------------------
     7   -29             191.65          1564.271
------------------------------------------------------
     8   -28             191.70          1563.863
------------------------------------------------------
     9   -27             191.75          1563.455
------------------------------------------------------
    10   -26             191.80          1563.047
------------------------------------------------------
    11   -25             191.85          1562.640
------------------------------------------------------
    12   -24             191.90          1562.233
------------------------------------------------------
    13   -23             191.95          1561.826
------------------------------------------------------
    14   -22             192.00          1561.419
```

15	-21	192.05	1561.013
16	-20	192.10	1560.606
17	-19	192.15	1560.200
18	-18	192.20	1559.794
19	-17	192.25	1559.389
20	-16	192.30	1558.983
21	-15	192.35	1558.578
22	-14	192.40	1558.173
23	-13	192.45	1557.768
24	-12	192.50	1557.363
25	-11	192.55	1556.959
26	-10	192.60	1556.555
27	-9	192.65	1556.151
28	-8	192.70	1555.747
29	-7	192.75	1555.343
30	-6	192.80	1554.940
31	-5	192.85	1554.537
32	-4	192.90	1554.134
33	-3	192.95	1553.731
34	-2	193.00	1553.329
35	-1	193.05	1552.926
36	0	193.10	1552.524
37	1	193.15	1552.122
38	2	193.20	1551.721
39	3	193.25	1551.319
40	4	193.30	1550.918
41	5	193.35	1550.517
42	6	193.40	1550.116
43	7	193.45	1549.715
44	8	193.50	1549.315
45	9	193.55	1548.915
46	10	193.60	1548.515

47	11	193.65	1548.115
48	12	193.70	1547.715
49	13	193.75	1547.316
50	14	193.80	1546.917
51	15	193.85	1546.518
52	16	193.90	1546.119
53	17	193.95	1545.720
54	18	194.00	1545.322
55	19	194.05	1544.924
56	20	194.10	1544.526
57	21	194.15	1544.128
58	22	194.20	1543.730
59	23	194.25	1543.333
60	24	194.30	1542.936
61	25	194.35	1542.539
62	26	194.40	1542.142
63	27	194.45	1541.746
64	28	194.50	1541.349
65	29	194.55	1540.953
66	30	194.60	1540.557
67	31	194.65	1540.162
68	32	194.70	1539.766
69	33	194.75	1539.371
70	34	194.80	1538.976
71	35	194.85	1538.581
72	36	194.90	1538.186
73	37	194.95	1537.792
74	38	195.00	1537.397
75	39	195.05	1537.003
76	40	195.10	1536.609
77	41	195.15	1536.216
78	42	195.20	1535.822

```
-------------------------------------------------
    79    43             195.25          1535.429
-------------------------------------------------
    80    44             195.30          1535.036
-------------------------------------------------
    81    45             195.35          1534.643
-------------------------------------------------
    82    46             195.40          1534.250
-------------------------------------------------
    83    47             195.45          1533.858
-------------------------------------------------
    84    48             195.50          1533.465
-------------------------------------------------
    85    49             195.55          1533.073
-------------------------------------------------
    86    50             195.60          1532.681
-------------------------------------------------
    87    51             195.65          1532.290
-------------------------------------------------
    88    52             195.70          1531.898
-------------------------------------------------
    89    53             195.75          1531.507
-------------------------------------------------
    90    54             195.80          1531.116
-------------------------------------------------
    91    55             195.85          1530.725
-------------------------------------------------
    92    56             195.90          1530.334
-------------------------------------------------
    93    57             195.95          1529.944
-------------------------------------------------
    94    58             196.00          1529.553
-------------------------------------------------
    95    59             196.05          1529.163
-------------------------------------------------
96    60             196.10          1528.773

// Change Frequency

RP/0/RP0/CPU0:ios#conf t
Tue Sep  5 08:34:14.312 UTC
RP/0/RP0/CPU0:ios(config)#controller optics 0/0/0/16
RP/0/RP0/CPU0:ios(config-Optics)#shutdown
RP/0/RP0/CPU0:ios(config-Optics)#dwdm-carrier 50GHz-grid frequency 19335
RP/0/RP0/CPU0:ios(config-Optics)#commit
Tue Sep  5 08:34:39.943 UTC
RP/0/RP0/CPU0:ios(config-Optics)#end
RP/0/RP0/CPU0:ios#show controllers optics 0/0/0/16
Tue Sep  5 08:34:42.824 UTC

 Controller State: Administratively Down

 Transport Admin State: Out Of Service

 Laser State: Off

 LED State: Off

 Optics Status

         Optics Type:  SFP+ 10G DWDM Tunable
         DWDM carrier Info: C BAND, MSA ITU Channel=41, Frequency=193.35THz,
         Wavelength=1550.517nm
```

```
        Alarm Status:
        -------------
        Detected Alarms:
                LOW-RX0-PWR

        LOS/LOL/Fault Status:

        Laser Bias Current = 0.0 mA
        Actual TX Power = 0.00 dBm
        RX Power = 0.00 dBm

        Performance Monitoring: Enable

        THRESHOLD VALUES
        ----------------

        Parameter                High Alarm  Low Alarm  High Warning  Low Warning
        -----------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         -2.9      -30.9          -7.0        -26.9
        Tx Power Threshold(dBm)          5.9       -5.0           2.9         -1.0
        LBC Threshold(mA)              75.00      25.00         70.00        30.00
        Temp. Threshold(celsius)       75.00      -5.00         70.00         0.00
        Voltage Threshold(volt)         3.63       2.97          3.46         3.13

        Polarization parameters not supported by optics

        Temperature = 39.00 Celsius
        Voltage = 3.28 V

 Transceiver Vendor Details

       Form Factor : SFP+
       Vendor Info
       -----------
        Optics type    : SFP+ 10G DWDM Tunable
        Name           : CISCO-OCLARO
        OUI Number     : 00.0b.40
        Part Number    : TRS7080FNCCA033
        Rev Number     : 0000
        Serial Number  : ONT2038009B
        PID            : DWDM-SFP10G-C
        VID            : V01

// Change Wavelength

RP/0/RP0/CPU0:ios#conf t
Tue Sep  5 11:27:21.614 UTC
RP/0/RP0/CPU0:ios(config)#controller optics 0/0/0/16
RP/0/RP0/CPU0:ios(config-Optics)#shutdown
RP/0/RP0/CPU0:ios(config-Optics)#dwdm-carrier 50GHz-grid wavelength 1539766
RP/0/RP0/CPU0:ios(config-Optics)#commit
Tue Sep  5 11:28:14.547 UTC
RP/0/RP0/CPU0:ios(config-Optics)#end
RP/0/RP0/CPU0:ios#show controllers optics 0/0/0/16
Tue Sep  5 11:28:30.934 UTC

 Controller State: Administratively Down

 Transport Admin State: Out Of Service

 Laser State: Off

 LED State: Off
```

```
 Optics Status

         Optics Type:  SFP+ 10G DWDM Tunable
         DWDM carrier Info: C BAND, MSA ITU Channel=68, Frequency=194.70THz,
         Wavelength=1539.766nm

         Alarm Status:
         -------------
         Detected Alarms:
                 LOW-RX0-PWR

         LOS/LOL/Fault Status:

         Laser Bias Current = 0.0 mA
         Actual TX Power = 0.00 dBm
         RX Power = 0.00 dBm

         Performance Monitoring: Enable

         THRESHOLD VALUES
         ----------------

         Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
         ------------------------  ----------  ---------  ------------  -----------
         Rx Power Threshold(dBm)         -2.9      -30.9          -7.0        -26.9
         Tx Power Threshold(dBm)          5.9       -5.0           2.9         -1.0
         LBC Threshold(mA)              75.00      25.00         70.00        30.00
         Temp. Threshold(celsius)       75.00      -5.00         70.00         0.00
         Voltage Threshold(volt)         3.63       2.97          3.46         3.13

         Polarization parameters not supported by optics

         Temperature = 38.00 Celsius
         Voltage = 3.28 V

 Transceiver Vendor Details

        Form Factor : SFP+
        Vendor Info
        -----------
         Optics type    : SFP+ 10G DWDM Tunable
         Name           : CISCO-OCLARO
         OUI Number     : 00.0b.40
         Part Number    : TRS7080FNCCA033
         Rev Number     : 0000
         Serial Number  : ONT2038009B
         PID            : DWDM-SFP10G-C
         VID            : V01
// Change Channel
RP/0/RP0/CPU0:ios#conf t
Tue Sep  5 08:29:03.648 UTC
RP/0/RP0/CPU0:ios(config)#controller optics 0/0/0/16
RP/0/RP0/CPU0:ios(config-Optics)#shutdown
RP/0/RP0/CPU0:ios(config-Optics)#dwdm-carrier 50GHz-grid ?
  frequency   Configure Frequency and Map to ITU Channel
  itu-ch      Configure the ITU 50GHz Grid ITU Channel
  wavelength  Configure Wavelength and Map to ITU Channel
RP/0/RP0/CPU0:ios(config-Optics)#dwdm-carrier 50GHz-grid itu-ch 84
RP/0/RP0/CPU0:ios(config-Optics)#commit


RP/0/RP0/CPU0:ios#show controllers optics 0/0/0/16
Tue Sep  5 08:29:54.851 UTC
```

```
Controller State: Administratively Down

Transport Admin State: Out Of Service

Laser State: Off

LED State: Off

Optics Status

        Optics Type:  SFP+ 10G DWDM Tunable
        DWDM carrier Info: C BAND, MSA ITU Channel=84, Frequency=195.50THz,
        Wavelength=1533.465nm

        Alarm Status:
        -------------
        Detected Alarms:
                LOW-RX0-PWR

        LOS/LOL/Fault Status:

        Laser Bias Current = 0.0 mA
        Actual TX Power = 0.00 dBm
        RX Power = 0.00 dBm

        Performance Monitoring: Enable

        THRESHOLD VALUES
        ----------------

        Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
        ------------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         -2.9      -30.9          -7.0        -26.9
        Tx Power Threshold(dBm)          5.9       -5.0           2.9         -1.0
        LBC Threshold(mA)              75.00      25.00         70.00        30.00
        Temp. Threshold(celsius)       75.00      -5.00         70.00         0.00
        Voltage Threshold(volt)         3.63       2.97          3.46         3.13

        Polarization parameters not supported by optics

        Temperature = 38.00 Celsius
        Voltage = 3.28 V

Transceiver Vendor Details

       Form Factor : SFP+
       Vendor Info
       -----------
        Optics type    : SFP+ 10G DWDM Tunable
        Name           : CISCO-OCLARO
        OUI Number     : 00.0b.40
        Part Number    : TRS7080FNCCA033
        Rev Number     : 0000
        Serial Number  : ONT2038009B
        PID            : DWDM-SFP10G-C
        VID            : V01
```

Priority Flow Control (PFC)

Priority flow control (PFC; IEEE 802.1Qbb), which is also referred to as Class-based Flow Control (CBFC) or Per Priority Pause (PPP), is a mechanism that prevents frame loss that is due to congestion. PFC is similar

to 802.3x Flow Control (pause frames) or link-level flow control (LLFC). However, PFC functions on a per class-of-service (CoS) basis.

During congestion, PFC sends a pause frame that indicates which CoS value needs to be paused. A PFC pause frame contains a 2-octet timer value for each CoS that indicates the length of time that the traffic needs to be paused. The unit of time for the timer is specified in pause quanta. A quanta is the time that is required for transmitting 512 bits at the speed of the port. The range is from 0 to 65535.

Note The router sends out the required amount of pause frames or pause-threshold (x-off) messages to achieve lossless queues. It also sends out resume-threshold (x-on) messages.

PFC asks the peer to stop sending frames of a particular CoS value by sending a pause frame to a well-known multicast address. This pause frame is a one-hop frame that is not forwarded when received by the peer. When the congestion is mitigated, the router stops sending the PFC frames to the upstream node.

Note

- PFC Rx traffic processing is enabled only if `hw-module profile priority-flow-control` command is enabled on the line card.
- `CISCO-PFC-EXT-MIB` is supported.

The PFC feature is only supported on the following line card or fixed chassis PIDs of the NCS5500 Series:

- NC55-36X100G
- NC55-18H18F
- NC55-24X100G-SE
- NC55-36X100G-S
- NC55-24H12F-SE
- NC55-36X100G-A-SE
- NCS-55A1-36H-SE-S
- NCS-55A1-36H-S
- NCS-55A1-24H
- NCS-55A1-48Q6H

Restrictions for PFC

PFC has the following restrictions:

- PFC for transmit is not supported for internal traffic (recycle / loopback) and non-unicast traffic (broadcast / multicast).
- PFC for receive impacts all traffic meant to go out of the port. This may cause unintended drops to both unicast and non-unicast traffic because non-unicast traffic may consume buffer descriptors, thus starving unicast traffic. Hence, PFC is incompatible with sustained high rate non-unicast traffic in the system.

- PFC configuration will enable or disable both PFC transmit and receive functionalities. There is no support to enable only transmit or receive functions.
- PFC is only supported in the non-HQoS profile. For more details on this QoS prerequisite and configuration examples, please refer to *Modular QoS Configuration Guide for Cisco NCS 5500 Series Routers*.
- Link level flow control and PFC are not supported on the same interface simultaneously.
- PFC is only qualified on 40G and 100G physical interface types. PFC is not supported on breakout ports for these interface types and is not qualified on other interface types.
- Being an Ethernet feature, PFC has to be individually configured on the member interfaces of a bundle instead of the bundle interface. The user is expected to either enable or disable PFC on all members of the bundle, as a mix isn't supported.
- Pause frames are not counted in the interface's statistical information, and the **show interfaces** command displays this counter as 0. Use the **show controllers** *Ethernet-interface-type interface-path-id* command to retrieve the PFC statistics.

Configuring Priority Flow Control

Use the following steps to configure Priority Flow Control:

Configuration:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(configure)#interface HundredGigE0/0/0/0
RP/0/RP0/CPU0:router(config)# priority-flow-control mode on
```

Running configuration:

```
*Interface Level*
interface HundredGigE0/0/0/0
priority-flow-control mode on
```

Verification:

Sample output for `show controllers hundredGigE 0/0/0/0 priority-flow-control` command is:

```
RP/0/RP1/CPU0:router#show controllers hundredGigE 0/0/0/0 priority-flow-control
Mon Oct 12 12:20:53.520 UTC

Priority flow control information for interface HundredGigE0/0/0/0:

Priority Flow Control:
    Total Rx PFC Frames: 0
    Total Tx PFC Frames: 1764273
    Rx Data Frames Dropped: 0
    CoS  Status  Rx Frames   Tx Frames
    ---  ------  ----------  ----------
      0  off              0           0
      1  off              0           0
      2  off              0           0
      3  on               0      882032
      4  on               0      882241
      5  off              0           0
      6  off              0           0
      7  off              0           0


Priority flow control watchdog configuration:
```

```
(D) : Default value
U : Unconfigured
------------------------------------------------------------------------------
       Configuration Item           Global  Interface Effective
------------------------------------------------------------------------------
    PFC watchdog state           :        U        U  Enabled(D)
    Poll interval                :        U        U      100(D)
    Shutdown multiplier          :        U        U        1(D)
    Auto-restore multiplier      :        U        U       10(D)


Priority flow control watchdog statistics:
SAR: Auto restore and shutdown
-------------------------------------------------------------------------------------------------------
Traffic Class            :       0        1        2        3        4        5        6
      7
-------------------------------------------------------------------------------------------------------
Watchdog Events          :       0        0        0        0        0        0        0
      0
Shutdown Events          :       0        0        0        0        0        0        0
      0
Auto Restore Events      :       0        0        0        0        0        0        0
      0
SAR Events               :       0        0        0        0        0        0        0
      0
SAR Instantaneous Events :       0        0        0        0        0        0        0
      0
Total Dropped Packets    :       0        0        0        0        0        0        0
      0
Dropped Packets          :       0        0        0        0        0        0        0
      0


Priority flow control watchdog state machine state:
D - Disabled
M - Monitoring
S - Waiting For Shutdown
R - Waiting to Restore
---------------------------------------------------------------
PFC Watchdog      : Enabled
Watchdog SM state :  Traffic Class
                     7 6 5 4 3 2 1 0
                     - - - D D - - -
RP/0/RP1/CPU0:router#
```

Sample output for `show controllers hundredGigE 0/0/0/0 priority-flow-control statistics` command is:

```
RP/0/RP1/CPU0:router#show controllers hundredGigE 0/0/0/0 priority-flow-control statistics

Mon Oct 12 12:22:39.362 UTC

Priority flow control information for interface HundredGigE0/0/0/0:

Priority Flow Control:
    Total Rx PFC Frames: 0
    Total Tx PFC Frames: 1764273
    Rx Data Frames Dropped: 0
    CoS  Status  Rx Frames   Tx Frames
    ---  ------  ----------  ----------
      0  off              0           0
      1  off              0           0
      2  off              0           0
      3  on               0      882032
      4  on               0      882241
```

```
      5  off              0           0
      6  off              0           0
      7  off              0           0
```

Sample output for `clear controller hundredGigE 0/0/0/0 priority-flow-control statistics [traffic-class <0-7>]` is:

```
RP/0/RP1/CPU0:router#clear controller hundredGigE 0/0/0/0 priority-flow-control statistics
 traffic-class 3
Mon Oct 12 12:22:48.778 UTC
RP/0/RP1/CPU0:router#show controllers hundredGigE 0/0/0/0  priority-flow-control statistics

Mon Oct 12 12:22:51.097 UTC

Priority flow control information for interface HundredGigE0/0/0/0:

Priority Flow Control:
    Total Rx PFC Frames: 0
    Total Tx PFC Frames: 882241
    Rx Data Frames Dropped: 0
    CoS  Status  Rx Frames   Tx Frames
    ---  ------  ----------  ----------
      0  off              0           0
      1  off              0           0
      2  off              0           0
      3  on               0           0
      4  on               0      882241
      5  off              0           0
      6  off              0           0
      7  off              0           0
RP/0/RP1/CPU0:router#
```

Optical Transport Networks

Optical Transport Network (OTN) encapsulates frames of data that allows the system to send multiple data sources on the same channel.

OTN can carry any kind of traffic and removes the restriction of the different physical network dependencies. These physical networks offer different types of services, such as Ethernet, SDH, SONET, Fiber Channel, and so on.

OTN comprises of the following switching layers:

- Time Division Multiplexing (TDM)
- Wavelength Switched Optical Network (WSON)

OTN uses the following information structures to encapsulate data:

- OTUk – where k=1/2/2e/3/3e2/4, is an information structure into which the system maps another information structure called ODUk (k=1/2/2e/3/3e2/4). The ODUk signal is the server layer signal for client signals.
- OTU2e (Data rate 11.09Gb/s) transports a 10 Gigabit Ethernet LAN PHY coming from IP/Ethernet switches and routers at full line rate (10.3 Gbit/s), as specified in G.Sup43

Restrictions and Important Guidelines

The following are some of the important guidelines and restrictions related to OTN:

- OTN is only supported on the NC55-MPA-12T-S line card.
- NC55-MPA-12T-S is supported on the following 2RU Cisco NCS 5500 Series Routers:
  - NCS-55A2-MOD-S
  - NCS-55A2-MOD-SE-S
  - NCS-55A2-MOD-HX-S
  - NCS-55A2-MOD-SE-H-S
  - NCS-55A2-MOD-HD-S
- NC55-MPA-12T-S is supported in the following Modular Line cards:
  - NC55-MOD-A-S
  - NC55-MOD-A-SE-S
- OTN isn't supported on SF_BER and SD_BER.
- OTN converts 10GE LAN PHY signal (host side) into OTU1e/OTU2e signal (line side).
- Supports 10G mapping modes
- OTU2e signal operates at 11.096 Gbps, which carries 10GE LAN PHY signal. Also known as the BMP mapping
- OTU1e signal operates at 11.049 Gbps, which carries 10GE LAN PHY signal. Also known as the BMP mapping
- Supports FEC functionality in the following modes:
  - GFEC = ITU-T G.709 / G.975, OH 7%
  - EFEC = ITU-T G.975.1 (1.4), OH 7%
  - UFEC = ITU-T G.975.1 (1.7), OH 7%
- FEC EC/UNC alarms aren't reported on NC55-MPA-12T-S.

OTN Architecture

Figure 1: OTN Architecture

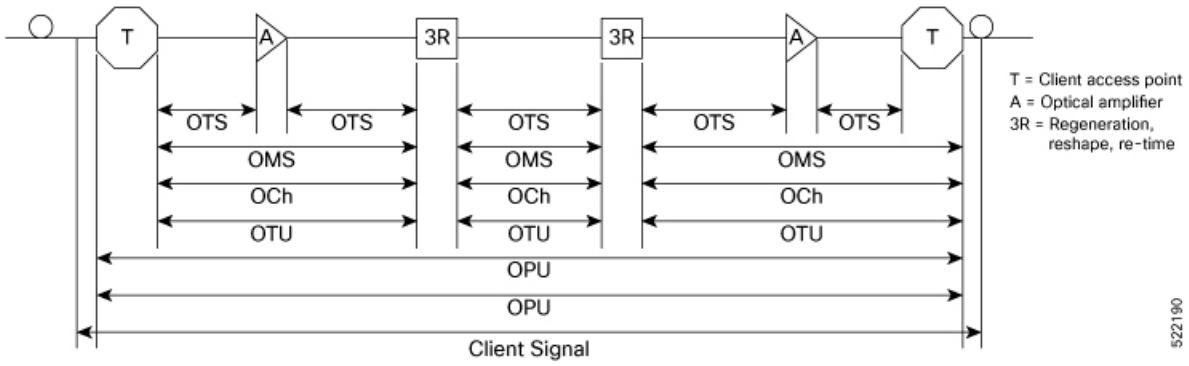
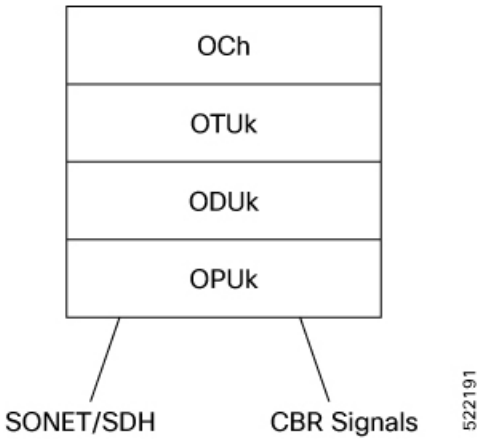


Figure 2: OTN Layers



OTN Layers and their Functions

Layer	Function	Ternimated On
Optical Transport Section (OTS)	Optical transmission. Includes fiber and optical amplifier.	Optical Amplifier
Optical Multiplex Section (OMS)	Optical multiplexing. Lambda multiplexing.	MUX/DEMUX
Optical Channel (OCh)	Client Optical Adaptation	Regenators
Optical Transport Unit (OTU)	Section Monitoring, FEC	Regenerators, Client Access Point, OTN Switch
Optical Data Unit (ODU)	Path Monitoring, Tandem Connection Monitoring	Client Access Point
Optical Channel Payload Unit (OPU)	Client Signal Adaptation	Client Access Point

Configuring OTN Interface

This section describes how you can configure OTN on an interface.

```
/* Configure “port-mode Otn framing opu2e” under controller optics of the interface. */

controller Optics0/2/1/0
port-mode Otn framing opu2e
!
```

Running Configuration

```
controller Optics0/2/1/0
port-mode Otn framing opu2e
!
```

Verification

```
RP/0/RP1/CPU0:ios#show portmode all
Sat Nov 20 21:37:01.717 UTC
Portmode Information
-------------------------------------------------
Port Name Portmode Type Framing Mapping PT type
Rate
Optics0_2_1_0 OTN OPU2e framing type None mapping type NA
None
Optics0_2_1_11 OTN OPU2e framing type None mapping type NA
None
RP/0/RP1/CPU0:ios#
```

```
RP/0/RP1/CPU0:ios#show controllers otu2e 0/2/1/0
Sat Nov 20 21:38:17.853 UTC
Port : OTU2E 0/2/1/0
Controller State : Up
Inherited Secondary State : Normal
Configured Secondary State : Normal
Derived State : In Service
Loopback mode : None
BER Thresholds : SF = 1.0E-6 SD = 1.0E-7
Performance Monitoring : Enable
Alarm Information:
LOS = 0 LOF = 0 LOM = 0
OOF = 0 OOM = 0 AIS = 0
IAE = 1 BIAE = 0 SF_BER = 0
SD_BER = 0 BDI = 0 TIM = 0
FECMISMATCH = 0 FEC-UNC = 0 FLEXO_GIDM = 0
FLEXO-MM = 0 FLEXO-LOM = 0 FLEXO-RDI = 0
FLEXO-LOF = 0
Detected Alarms : None
OTU TTI Received
FEC mode : STANDARD
```

```
RP/0/RP1/CPU0:ios#show controllers odu2e 0/2/1/0
Sat Nov 20 21:39:06.792 UTC
Port : ODU2E 0/2/1/0
Controller State : Up
Inherited Secondary state : Normal
Configured Secondary state : Maintenance
Derived State : Maintenance
Loopback mode : None
BER Thresholds : SF = 1.0E-6 SD = 1.0E-7
Performance Monitoring : Enable
Path Monitoring Mode : Non-Intrusive Monitor
PM TIM-CA state : Disable
```

```
Alarm Information:
AIS = 0 IAE = 0 BIAE = 0
SF_BER = 0 SD_BER = 0 BDI = 0
OCI = 0 LCK = 0 PTIM = 0
TIM = 0 CSF = 0 GFP LFD = 0
GFP LOCS = 0 GFP LOCCS = 0 GFP UPM = 0
Detected Alarms : None
ODU TTI Sent
ODU TTI Received
ODU TTI Expected
Owner : All
Resource State : ODU Resource Free
Private Line Emulation(PLE) supported : No
```

Supported Alarms

This table lists the supported OTN alarms:

ODU Alarms	OUT Alarms
AIS	OOF
OCI	AIS
LCK	LOF
BDI	LOM
	OOM
	BDI
	BIAE
	IAE

The following are the supported OTN PM counters:

- BIP
- BEI

How to Configure Interfaces in Breakout Mode

Table 10: Feature History Table

Feature name	Release Information	Feature Description
2x50GbE Breakout Ports on Cisco NCS-55A1-24H Routers	Release 7.5.2	You can now configure 2x50GbE breakout ports on all QSFP28 ports of the Cisco NCS-55A1-24H fixed port router.

Information About Breakout

The router supports transmission of traffic in the breakout mode. The breakout mode enables a 40GbE, 100GbE, or 400GbE port to be split into multiple GbE ports.

Breakout Mode options:

- 4x10GbE
- 4x25GbE
- 2x50GbE
- 8x50GbE
- 4x100GbE
- 3x100GbE
- 2x100GbE
- 1x100GbE

Note

- The supported breakout mode is dependent on the port and optic transceiver.
- A configuration inconsistency alarm may occur during router reload when breakout interfaces are created with ETM mode. The system automatically clears this alarm by retrying the configuration.

Configure Breakout in a Port

Note For the N540-24Q8L2DD-SYS router , before proceeding with the breakout configuration, ensure that you configure the port mode speed under the optics controller. This step is crucial to ensure that the optics controller operates at the desired speed and can properly handle the breakout settings.

For port mode speed configuration steps, refer to Configure Port Mode Speed, on page 405.

This example shows how to configuring a 4x10GbE breakout in a port:

```
RP/0/RP0/CPU0:Router# configure
RP/0/RP0/CPU0:Router(config)# controller optics 0/1/0/28
RP/0/RP0/CPU0:Router(config-Optics)# breakout 4x10
RP/0/RP0/CPU0:Router(config-Optics)# commit
RP/0/RP0/CPU0:Router(config-Optics)# end
RP/0/RP0/CPU0:Router#
```

Remove the Breakout Configuration

Removing the breakout configuration:

```
RP/0/RP0/CPU0:Router# configure
RP/0/RP0/CPU0:Router(config)# controller optics 0/1/0/28
```

```
RP/0/RP0/CPU0:Router(config-Optics)# no breakout 4x10
RP/0/RP0/CPU0:Router(config-Optics)# commit
RP/0/RP0/CPU0:uut(config-Optics)# end
```

Verify a Breakout Configuration

Verifying a breakout configuration:

```
RP/0/RP0/CPU0:Router# show running-config controller optics 0/1/0/28
controller Optics0/1/0/28
breakout 4x10
!

RP/0/RP0/CPU0:Router# show int br location 0/1/CPU0 | i Te0/1/0/28
       Te0/1/0/27/0          up          up               ARPA 10000   10000000
       Te0/1/0/27/1          up          up               ARPA 10000   10000000
       Te0/1/0/27/2          up          up               ARPA 10000   10000000
       Te0/1/0/27/3          up          up               ARPA 10000   10000000
       Te0/1/0/28/0          up          up               ARPA 10000   10000000
       Te0/1/0/28/1          up          up               ARPA 10000   10000000
       Te0/1/0/28/2          up          up               ARPA 10000   10000000
       Te0/1/0/28/3          up          up               ARPA 10000   10000000
```

1x100GbE Auto-Breakout

Table 11: Feature History Table

Feature name	Release Information	Feature Description
1x100GbE Auto-Breakout	Release 24.4.1	Introduced in this release on: NCS 5700 fixed port routers You can seamlessly switch between interface speeds with the 1x100GbE auto-breakout feature. When QDD-400G-ZRP-S optics are inserted into specified ports, 1x100GbE breakout interfaces are automatically created without manual configuration. This feature provides you the flexibility to switch between different interface speeds without manual reconfiguration. 1x100GbE auto-breakout feature is supported on the following Cisco router variant: • NCS-57B1-6D24H-S • NCS-57B1-5D24-SE

The 1x100GbE auto-breakout feature lets you seamlessly create 1x100GbE breakout interfaces using the QDD-400G-ZRP-S optical module, giving you the flexibility to switch between interface speeds without

manual configuration. When you remove the QDD-400G-ZRP-S optic, the speed stays at 1x100GbE and adjusts based on the next optics you insert.

Supported Routers

1x100GbE auto-breakout feature is supported on the following Cisco router variant:

- NCS-57B1-6D24H-S
- NCS-57B1-5D24-SE

Supported Auto-Breakout Ports

The following QSFP ports on the NCS-57B1-6D24H-S and NCS-57B1-5D24-SE platform support 1x100GbE auto-breakout:

- Even-numbered QSFP Ports: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22.

Creating Auto-Breakout Configurations

When a QDD-400G-ZRP-S module is inserted into even QSFP ports, the router automatically creates 1x100GbE breakout interfaces. The process involves:

- Inserting the optical module into the designated ports.
- System recognizing the module and creating the appropriate interfaces.
- Removing the optical module reverts the interfaces to 100GbE.

Restrictions and Usage Guidelines for Auto-breakout

- The ports are divided into six quads (0-5). Each quad consists of the following ports:
  - Quad 0 - Ports 0-3
  - Quad 1 - Ports 4-7
  - Quad 2 - Ports 8-11
  - Quad 3 - Ports 12-15
  - Quad 4 - Ports 16-19
  - Quad 5 - Ports 20-23
- 4x25GbE configuration cannot coexist with a 40G or 4x10GbE configuration in any quad.
- Different speeds cannot be configured on Quad0 simultaneously.

How to Configure Interfaces in Breakout Mode

Information About Breakout

The router supports transmission of traffic in the breakout mode. The breakout mode enables a 40GbE, 100GbE, or 400GbE port to be split into multiple GbE ports.

Breakout Mode options:

- 4x10GbE
- 4x25GbE
- 2x50GbE
- 8x50GbE
- 4x100GbE
- 3x100GbE
- 2x100GbE
- 1x100GbE

Note

- The supported breakout mode is dependent on the port and optic transceiver.
- A configuration inconsistency alarm may occur during router reload when breakout interfaces are created with ETM mode. The system automatically clears this alarm by retrying the configuration.

Configure Breakout in a Port

Note For the N540-24Q8L2DD-SYS router , before proceeding with the breakout configuration, ensure that you configure the port mode speed under the optics controller. This step is crucial to ensure that the optics controller operates at the desired speed and can properly handle the breakout settings.

For port mode speed configuration steps, refer to Configure Port Mode Speed, on page 405.

This example shows how to configuring a 4x10GbE breakout in a port:

```
RP/0/RP0/CPU0:Router# configure
RP/0/RP0/CPU0:Router(config)# controller optics 0/1/0/28
RP/0/RP0/CPU0:Router(config-Optics)# breakout 4x10
RP/0/RP0/CPU0:Router(config-Optics)# commit
RP/0/RP0/CPU0:Router(config-Optics)# end
RP/0/RP0/CPU0:Router#
```

Remove the Breakout Configuration

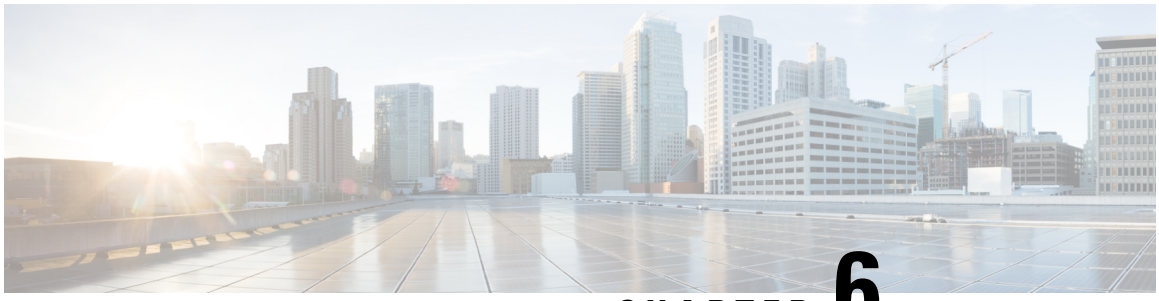
Removing the breakout configuration:

```
RP/0/RP0/CPU0:Router# configure
RP/0/RP0/CPU0:Router(config)# controller optics 0/1/0/28
RP/0/RP0/CPU0:Router(config-Optics)# no breakout 4x10
RP/0/RP0/CPU0:Router(config-Optics)# commit
RP/0/RP0/CPU0:uut(config-Optics)# end
```

Verify a Breakout Configuration

Verifying a breakout configuration:

```
RP/0/RP0/CPU0:Router# show running-config controller optics 0/1/0/28
controller Optics0/1/0/28
breakout 4x10
!

RP/0/RP0/CPU0:Router# show int br location 0/1/CPU0 | i Te0/1/0/28
       Te0/1/0/27/0          up          up               ARPA 10000   10000000
       Te0/1/0/27/1          up          up               ARPA 10000   10000000
       Te0/1/0/27/2          up          up               ARPA 10000   10000000
       Te0/1/0/27/3          up          up               ARPA 10000   10000000
       Te0/1/0/28/0          up          up               ARPA 10000   10000000
       Te0/1/0/28/1          up          up               ARPA 10000   10000000
       Te0/1/0/28/2          up          up               ARPA 10000   10000000
       Te0/1/0/28/3          up          up               ARPA 10000   10000000
```



CHAPTER 6

Configuring Ethernet OAM

This module describes the configuration of Ethernet Operations, Administration, and Maintenance (OAM) .

Table 12: Feature History Table

Release	Modification
Release 6.1.1	These features were introduced: • Ethernet Link OAM • Ethernet CFM
Release 7.1.1	Support for CFM adaptive bandwidth notifications was introduced for NCS5500 platforms.
Release 7.5.1	Support for Link Loss Forwarding (LLF) was introduced.
Release 7.5.1	Support for CFM adaptive bandwidth notifications was introduced for Cisco Network Convergence System 5700 Series routers and routers with Cisco NC57 line cards operating in native mode.

Ethernet OAM

To configure Ethernet OAM (EOAM), you should understand the following concepts:

Ethernet Link OAM

Ethernet as a Metro Area Network (MAN) or a Wide Area Network (WAN) technology benefits greatly from the implementation of Operations, Administration and Maintenance (OAM) features. Ethernet Link OAM (ELO) features allow you to monitor the quality of the connections on a MAN or a WAN. ELO operates on a single physical link, and it can be configured to monitor either side or both sides of that link.

ELO can be configured in the following ways:

- **Using an ELO profile:** An ELO profile can be configured to set the parameters for multiple interfaces. This simplifies the process of configuring Ethernet Link OAM features on multiple interfaces. An ELO profile and its features can be referenced by other interfaces, allowing them to inherit those features. This is the preferred method of configuring custom ELO settings.
- **Configuring directly on an interface:** Individual ELO features can be configured directly on an interface without being part of a profile. When an interface uses an ELO profile, specific parameters can still be overridden by configuring different values directly on the interface. In such cases, the individually configured features take precedence over the profile settings.

When an ELO packet is received on any one of the Attachment Circuit (AC) interfaces where ELO is not configured, the AC interface multicasts the received packets to other AC interfaces that are part of the Ethernet Virtual Private Network Broadcast Domain (EVPN-BD) to reach the peer. An ELO can be configured on any physical Ethernet interface, including bundle members.

These standard Ethernet Link OAM features are supported on the router:

Neighbor Discovery

Neighbor discovery enables each end of a link to learn the OAM capabilities of the other end and establish an OAM peer relationship. Each end also can require that the peer have certain capabilities before it will establish a session. You can configure certain actions to be taken if there is a capabilities conflict or if a discovery process times out, using the **action capabilities-conflict** or **action discovery-timeout** commands.

EFD

Ethernet Fault Detection (EFD) is a mechanism that allows Ethernet OAM protocols, such as CFM, to control the `line protocol` state of an interface.

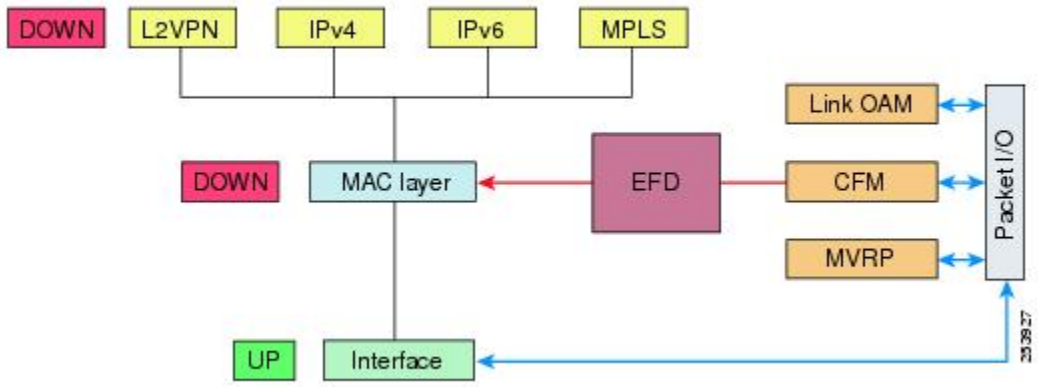
Unlike many other interface types, Ethernet interfaces do not have a line protocol, whose state is independent from that of the interface. For Ethernet interfaces, this role is handled by the physical-layer Ethernet protocol itself, and therefore if the interface is physically up, then it is available and traffic can flow.

EFD changes this to allow CFM to act as the line protocol for Ethernet interfaces. This allows CFM to control the interface state so that if a CFM defect (such as AIS or loss of continuity) is detected with an expected peer MEP, the interface can be shut down. This not only stops traffic flow, but also triggers actions in any higher-level protocols to route around the problem. For example, in the case of Layer 2 interfaces, the MAC table would be cleared and MSTP would reconverge. For Layer 3 interfaces, the ARP cache would be cleared and potentially the IGP would reconverge.

Note EFD can only be used for down MEPs. When EFD is used to shut down the interface, the CFM frames continue to flow. This allows CFM to detect when the problem has been resolved, and thus bring the interface backup automatically.

This figure shows CFM detection of an error on one of its sessions EFD signaling an error to the corresponding MAC layer for the interface. This triggers the MAC to go to a down state, which further triggers all higher level protocols (Layer 2 pseudowires, IP protocols, and so on) to go down and also trigger a reconvergence where possible. As soon as CFM detects there is no longer any error, it can signal to EFD and all protocols will once again go active.

Figure 3: CFM Error Detection and EFD Trigger



MIB Retrieval

MIB retrieval enables an OAM peer on one side of an interface to get the MIB variables from the remote side of the link. The MIB variables that are retrieved from the remote OAM peer are READ ONLY.

Miswiring Detection (Cisco-Proprietary)

Miswiring Detection is a Cisco-proprietary feature that uses the 32-bit vendor field in every Information OAMPDU to identify potential miswiring cases.

SNMP Traps

SNMP traps can be enabled or disabled on an Ethernet OAM interface.

How to Configure Ethernet OAM

This section provides these configuration procedures:

Configuring Ethernet Link OAM

Custom Ethernet Link OAM (ELO) settings can be configured and shared on multiple interfaces by creating an ELO profile in Ethernet configuration mode and then attaching the profile to individual interfaces. The profile configuration does not take effect until the profile is attached to an interface. After an ELO profile is attached to an interface, individual Ethernet Link OAM features can be configured separately on the interface to override the profile settings when desired.

This section describes how to configure an ELO profile and attach it to an interface.

Configuring an Ethernet Link OAM Profile

Perform these steps to configure an Ethernet Link OAM (ELO) profile.

Note IOS-XR CLI refers to Ethernet Link OAM as **ethernet oam** in both profile and interface configurations.

SUMMARY STEPS

1. **configure**
2. **ethernet oam profile** *profile-name*
3. **link-monitor**
4. **symbol-period window** *window*
5. **symbol-period threshold low** *threshold* **high** *threshold*
6. **frame window** *window*
7. **frame threshold low** *threshold* **high** *threshold*
8. **frame-period window** *window*
9. **frame-period threshold low***threshold* **high** *threshold*
10. **frame-seconds window** *window*
11. **frame-seconds threshold low** *threshold* **high** *threshold*
12. **exit**
13. **mib-retrieval**
14. **connection timeout** <*timeout*>
15. **hello-interval** {**100ms**|**1s**}
16. **mode** {**active**|**passive**}
17. **require-remote mode** {**active**|**passive**}
18. **require-remote mib-retrieval**
19. **action capabilities-conflict** {**disable | efd | error-disable-interface**}
20. **action critical-event** {**disable** | **error-disable-interface**}
21. **action discovery-timeout** {**disable** | **efd** | **error-disable-interface**}
22. **action dying-gasp** {**disable** | **error-disable-interface**}
23. **action high-threshold** {**error-disable-interface** | **log**}
24. **action session-down** {**disable** | **efd** | **error-disable-interface**}
25. **action session-up disable**
26. **action uni-directional link-fault** {**disable** | **efd** | **error-disable-interface**}
27. **action wiring-conflict** {**disable | efd | log**}
28. **uni-directional link-fault detection**

29. **commit**
30. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure terminal`	Enters global configuration mode.
Step 2	**ethernet oam profile** *profile-name* **Example:** `RP/0/RP0/CPU0:router(config)# ethernet oam profile Profile_1`	Creates a new Ethernet Link OAM (ELO) profile and enters Ethernet OAM configuration mode.
Step 3	**link-monitor** **Example:** `RP/0/RP0/CPU0:router(config-eoam)# link-monitor`	Enters the Ethernet OAM link monitor configuration mode.
Step 4	**symbol-period window** *window* **Example:** `RP/0/RP0/CPU0:router(config-eoam-lm)# symbol-period window 60000`	(Optional) Configures the window size (in milliseconds) for an Ethernet OAM symbol-period error event. The IEEE 802.3 standard defines the window size as a number of symbols rather than a time duration. These two formats can be converted either way by using a knowledge of the interface speed and encoding. The range is 1000 to 60000. The default value is 1000.
Step 5	**symbol-period threshold low** *threshold* **high** *threshold* **Example:** `RP/0/RP0/CPU0:router(config-eoam-lm)# symbol-period threshold ppm low 1 high 1000000`	(Optional) Configures the thresholds (in symbols) that trigger an Ethernet OAM symbol-period error event. The high threshold is optional and is configurable only in conjunction with the low threshold. The range is 0 to 60000000. The default low threshold is 1.
Step 6	**frame window** *window* **Example:** `RP/0/RP0/CPU0:router(config-eoam-lm)# frame window 6000`	(Optional) Configures the frame window size (in milliseconds) of an OAM frame error event. The range is from 1000 to 60000. The default value is 1000.

	Command or Action	Purpose
Step 7	**frame threshold low** *threshold* **high** *threshold* **Example:** `RP/0/RP0/CPU0:router(config-eoam-lm)# frame threshold low 10000000 high 60000000`	(Optional) Configures the thresholds (in symbols) that triggers an Ethernet OAM frame error event. The high threshold is optional and is configurable only in conjunction with the low threshold. The range is from 0 to 60000000. The default low threshold is 1.

Step 8	**frame-period window** *window*
	Example:
	`RP/0/RP0/CPU0:router(config-eoam-lm)# frame-period window 60000`
	`RP/0/RP0/CPU0:router(config-eoam-lm)# frame-period window milliseconds 60000`
		(Optional) Configures the window size (in milliseconds) for an Ethernet OAM frame-period error event. The IEEE 802.3 standard defines the window size as number of frames rather than a time duration. These two formats can be converted either way by using a knowledge of the interface speed. Note that the conversion assumes that all frames are of the minimum size.
		The range is from 1000 to 60000.
		The default value is 1000.
		Note
		The only accepted values are multiples of the line card interface module specific polling interval, that is, 1000 milliseconds for most line card interface modules.

Step 9	**frame-period threshold low***threshold* **high** *threshold* **Example:** `RP/0/RP0/CPU0:router(config-eoam-lm)# frame-period threshold ppm low 100 high 1000000`	(Optional) Configures the thresholds (in errors per million frames) that trigger an Ethernet OAM frame-period error event. The frame period window is defined in the IEEE specification as a number of received frames, in our implementation it is x milliseconds. The high threshold is optional and is configurable only in conjunction with the low threshold. The range is from 1 to 1000000. The default low threshold is 1. To obtain the number of frames, the configured time interval is converted to a window size in frames using the interface speed. For example, for a 1Gbps interface, the IEEE defines minimum frame size as 512 bits. So, we get a maximum of approximately 1.5 million frames per second. If the window size is configured to be 8 seconds (8000ms) then this would give us a Window of 12 million frames in the specification's definition of Errored Frame Window. The thresholds for frame-period are measured in errors per million frames. Hence, if you configure a window of 8000ms (that is a window of 12 million frames) and a high threshold of 100, then the threshold would be crossed if there are 1200 errored frames in that period (that is, 100 per million for 12 million).

	Command or Action	Purpose
Step 10	**frame-seconds window** *window* **Example:** `RP/0/RP0/CPU0:router(config-eoam-lm)# frame-seconds window 900000`	(Optional) Configures the window size (in milliseconds) for the OAM frame-seconds error event. The range is 10000 to 900000. The default value is 60000. **Note** The only accepted values are multiples of the line card interface module specific polling interval, that is, 1000 milliseconds for most line card interface modules.
Step 11	**frame-seconds threshold low** *threshold* **high** *threshold* **Example:** `RP/0/RP0/CPU0:router(config-eoam-lm)# frame-seconds threshold low 3 high 900`	(Optional) Configures the thresholds (in seconds) that trigger a frame-seconds error event. The high threshold value can be configured only in conjunction with the low threshold value. The range is 1 to 900 The default value is 1.
Step 12	**exit** **Example:** `RP/0/RP0/CPU0:router(config-eoam-lm)# exit`	Exits back to Ethernet OAM mode.
Step 13	**mib-retrieval** **Example:** `RP/0/RP0/CPU0:router(config-eoam)# mib-retrieval`	Enables MIB retrieval in an Ethernet OAM profile or on an Ethernet OAM interface.
Step 14	**connection timeout** <*timeout*> **Example:** `RP/0/RP0/CPU0:router(config-eoam)# connection timeout 30`	Configures the connection timeout period for an Ethernet OAM session. as a multiple of the hello interval. The range is 2 to 30. The default value is 5.
Step 15	**hello-interval** {**100ms**|**1s**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# hello-interval 100ms`	Configures the time interval between hello packets for an Ethernet OAM session. The default is 1 second (**1s**).
Step 16	**mode** {**active**|**passive**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# mode passive`	Configures the Ethernet OAM mode. The default is active.
Step 17	**require-remote mode** {**active**|**passive**} **Example:**	Requires that active mode or passive mode is configured on the remote end before the OAM session comes up.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config-eoam)# require-remote mode active`	
Step 18	**require-remote mib-retrieval** **Example:** `RP/0/RP0/CPU0:router(config-eoam)# require-remote mib-retrieval`	Requires that MIB-retrieval is configured on the remote end before the OAM session comes up.
Step 19	**action capabilities-conflict** {**disable** | **efd** | **error-disable-interface**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# action capabilities-conflict efd`	Specifies the action that is taken on an interface when a capabilities-conflict event occurs. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 20	**action critical-event** {**disable** | **error-disable-interface**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# action critical-event error-disable-interface`	Specifies the action that is taken on an interface when a critical-event notification is received from the remote Ethernet OAM peer. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 21	**action discovery-timeout** {**disable** | **efd** | **error-disable-interface**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# action discovery-timeout efd`	Specifies the action that is taken on an interface when a connection timeout occurs. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 22	**action dying-gasp** {**disable** | **error-disable-interface**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# action dying-gasp error-disable-interface`	Specifies the action that is taken on an interface when a dying-gasp notification is received from the remote Ethernet OAM peer. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration

	Command or Action	Purpose
		mode to override the profile setting and log the event for the interface when it occurs.
Step 23	**action high-threshold** {**error-disable-interface** | **log**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# action high-threshold error-disable-interface`	Specifies the action that is taken on an interface when a high threshold is exceeded. The default is to take no action when a high threshold is exceeded. **Note** • If you change the default, the **disable** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and take no action at the interface when the event occurs.
Step 24	**action session-down** {**disable** | **efd** | **error-disable-interface**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# action session-down efd`	Specifies the action that is taken on an interface when an Ethernet OAM session goes down. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 25	**action session-up disable** **Example:** `RP/0/RP0/CPU0:router(config-eoam)# action session-up disable`	Specifies that no action is taken on an interface when an Ethernet OAM session is established. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 26	**action uni-directional link-fault** {**disable** | **efd** | **error-disable-interface**}	Specifies the action that is taken on an interface when a link-fault notification is received from the remote Ethernet OAM peer. The default action is to create a syslog entry. **Note** • If you change the default, the **log** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and log the event for the interface when it occurs.
Step 27	**action wiring-conflict** {**disable | efd | log**} **Example:** `RP/0/RP0/CPU0:router(config-eoam)# action session-down efd`	Specifies the action that is taken on an interface when a wiring-conflict event occurs. The default is to put the interface into error-disable state. **Note**

	Command or Action	Purpose
		• If you change the default, the **error-disable-interface** keyword option is available in Interface Ethernet OAM configuration mode to override the profile setting and put the interface into error-disable state when the event occurs.
Step 28	**uni-directional link-fault detection** **Example:** `RP/0/RP0/CPU0:router(config-eoam)# uni-directional link-fault detection`	Enables detection of a local, unidirectional link fault and sends notification of that fault to an Ethernet OAM peer.
Step 29	**commit** **Example:** `RP/0/RP0/CPU0:router(config-if)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 30	**end** **Example:** `RP/0/RP0/CPU0:router(config-if)# end`	Ends the configuration session and exits to the EXEC mode.

Attaching an Ethernet Link OAM Profile to an Interface

Perform these steps to attach an Ethernet Link OAM (ELO) profile to an interface.

Note IOS-XR CLI refers to Ethernet Link OAM as **ethernet oam** in both profile and interface configurations.

SUMMARY STEPS

1. **configure**
2. **interface** [**FastEthernet** | **HundredGigE**| **TenGigE**] *interface-path-id*
3. **ethernet oam**
4. **profile** *profile-name*
5. **commit**
6. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure terminal`	Enters global configuration mode.
Step 2	**interface** [**FastEthernet** | **HundredGigE**| **TenGigE**] *interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface TenGigE 0/1/0/0`	Enters interface configuration mode and specifies the Ethernet interface name and notation *rack/slot/module/port*. **Note** • The example indicates an 8-port 10-Gigabit Ethernet interface in modular services card slot 1.
Step 3	**ethernet oam** **Example:** `RP/0/RP0/CPU0:router(config-if)# ethernet oam`	Enables Ethernet OAM and enters interface Ethernet OAM configuration mode.
Step 4	**profile** *profile-name* **Example:** `RP/0/RP0/CPU0:router(config-if-eoam)# profile Profile_1`	Attaches the specified Ethernet OAM profile (*profile-name*), and all of its configuration, to the interface.
Step 5	**commit** **Example:** `RP/0/RP0/CPU0:router(config-if)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 6	**end** **Example:** `RP/0/RP0/CPU0:router(config-if)# end`	Ends the configuration session and exits to the EXEC mode.

Configuring Ethernet Link OAM at an Interface and Overriding the Profile Configuration

Using an Ethernet Link OAM (ELO) profile is an efficient way of configuring multiple interfaces with a common ELO configuration. However, if you want to use a profile but also change the behavior of certain functions for a particular interface, then you can override the profile configuration. To override certain profile settings that are applied to an interface, you can configure that command in interface Ethernet OAM configuration mode to change the behavior for that interface.

In some cases, only certain keyword options are available in interface Ethernet OAM configuration due to the default settings for the command. For example, without any configuration of the **action** commands, several forms of the command have a default behavior of creating a syslog entry when a profile is created and applied

to an interface. Therefore, the **log** keyword is not available in Ethernet OAM configuration for these commands in the profile because it is the default behavior. However, the **log** keyword is available in Interface Ethernet OAM configuration if the default is changed in the profile configuration so you can retain the action of creating a syslog entry for a particular interface.

To see all of the default ELO configuration settings, see the Verifying the Ethernet Link OAM Configuration, on page 89 section.

To configure ELO settings at an interface and override the profile configuration, perform these steps.

Note IOS-XR CLI refers to Ethernet Link OAM as **ethernet oam** in both profile and interface configurations.

SUMMARY STEPS

1. **configure**
2. **interface** [HundredGigE | TenGigE] *interface-path-id*
3. **ethernet oam**
4. *interface-Ethernet-OAM-command*
5. **commit**
6. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure terminal`	Enters global configuration mode.
Step 2	**interface** [HundredGigE | TenGigE] *interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface TenGigE 0/1/0/0`	Enters interface configuration mode and specifies the Ethernet interface name and notation *rack/slot/module/port*. **Note** • The example indicates an 8-port 10-Gigabit Ethernet interface in modular services card slot 1.
Step 3	**ethernet oam** **Example:** `RP/0/RP0/CPU0:router(config-if)# ethernet oam`	Enables Ethernet OAM and enters interface Ethernet OAM configuration mode.
Step 4	*interface-Ethernet-OAM-command* **Example:** `RP/0/RP0/CPU0:router(config-if-eoam)# action capabilities-conflict error-disable-interface`	Configures a setting for an Ethernet OAM configuration command and overrides the setting for the profile configuration, where *interface-Ethernet-OAM-command* is

	Command or Action	Purpose
		one of the supported commands on the platform in interface Ethernet OAM configuration mode.
Step 5	**commit** **Example:** `RP/0/RP0/CPU0:router(config-if)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 6	**end** **Example:** `RP/0/RP0/CPU0:router(config-if)# end`	Ends the configuration session and exits to the EXEC mode.

Verifying the Ethernet Link OAM Configuration

Use the **show ethernet oam configuration** command to display the values for the Ethernet Link OAM (ELO) configuration for a particular interface, or for all interfaces. The following example shows the default values for ELO settings:

```
RP/0/RP0/CPU0:router# show ethernet oam configuration
Thu Aug  5 22:07:06.870 DST
GigabitEthernet0/4/0/0:
  Hello interval:                                        1s
  Mib retrieval enabled:                                  N
  Uni-directional link-fault detection enabled:           N
  Configured mode:                                   Active
  Connection timeout:                                     5
  Symbol period window:                                   0
  Symbol period low threshold:                            1
  Symbol period high threshold:                        None
  Frame window:                                        1000
  Frame low threshold:                                    1
  Frame high threshold:                                None
  Frame period window:                                 1000
  Frame period low threshold:                             1
  Frame period high threshold:                         None
  Frame seconds window:                               60000
  Frame seconds low threshold:                            1
  Frame seconds high threshold:                        None
  High threshold action:                               None
  Link fault action:                                    Log
  Dying gasp action:                                    Log
  Critical event action:                                Log
  Discovery timeout action:                             Log
  Capabilities conflict action:                         Log
  Wiring conflict action:                      Error-Disable
  Session up action:                                    Log
  Session down action:                                  Log
  Require remote mode:                               Ignore
  Require remote MIB retrieval:                           N
```

Configuration Examples for Ethernet Link OAM Interfaces

This section provides the following configuration examples:

Configuring an Ethernet Link OAM Profile Globally: Example

This example shows how to configure an Ethernet Link OAM (ELO) profile globally:

```
configure
 ethernet oam profile Profile_1
  link-monitor
   symbol-period window 60000
   symbol-period threshold ppm low 10000000 high 60000000
   frame window 60
   frame threshold ppm low 10000000 high 60000000
   frame-period window 60000
   frame-period threshold ppm low 100 high 12000000
   frame-seconds window 900000
   frame-seconds threshold low 3 high 900
   exit
  mib-retrieval
  connection timeout 30
  require-remote mode active
  require-remote mib-retrieval
  action dying-gasp error-disable-interface
  action critical-event error-disable-interface
  action discovery-timeout error-disable-interface
  action session-down error-disable-interface
  action capabilities-conflict error-disable-interface
  action wiring-conflict error-disable-interface
  action remote-loopback error-disable-interface
  commit
```

Configuring Ethernet Link OAM Features on an Individual Interface: Example

This example shows how to configure Ethernet Link OAM (ELO) features on an individual interface:

```
configure terminal
 interface TenGigE 0/1/0/0
  ethernet oam
   link-monitor
    symbol-period window 60000
    symbol-period threshold ppm low 10000000 high 60000000
    frame window 60
    frame threshold ppm low 10000000 high 60000000
    frame-period window 60000
    frame-period threshold ppm low 100 high 12000000
    frame-seconds window 900000
    frame-seconds threshold low 3 high 900
    exit
   mib-retrieval
   connection timeout 30
   require-remote mode active
   require-remote mib-retrieval
   action link-fault  error-disable-interface
   action dying-gasp error-disable-interface
   action critical-event error-disable-interface
   action discovery-timeout error-disable-interface
   action session-down error-disable-interface
   action capabilities-conflict error-disable-interface
   action wiring-conflict error-disable-interface
   action remote-loopback error-disable-interface
   commit
```

Configuring Ethernet Link OAM Features to Override the Profile on an Individual Interface: Example

This example shows the configuration of Ethernet Link OAM (ELO) features in a profile followed by an override of that configuration on an interface:

```
configure terminal
 ethernet oam profile Profile_1
  mode passive
  action dying-gasp disable
  action critical-event disable
  action discovery-timeout disable
  action session-up disable
  action session-down disable
  action capabilities-conflict disable
  action wiring-conflict disable
  action remote-loopback disable
  action uni-directional link-fault error-disable-interface
  commit

configure terminal
 interface TenGigE 0/1/0/0
  ethernet oam
   profile Profile_1
    mode active
    action dying-gasp log
    action critical-event log
    action discovery-timeout log
    action session-up log
    action session-down log
    action capabilities-conflict log
    action wiring-conflict log
    action remote-loopback log
    action uni-directional link-fault log
    uni-directional link-fault detection
    commit
```

Recovering from error-disable: Example

You can recover an error-disabled interface due to session-down using one of these methods:

- Manually clear the error-disable using the **clear** command.

  ```
  Router# configure
  Router(config)# ethernet oam profile Profile_1
  Router(config-eoam)# action
  Router(config-eoam-action)# clear session-down error-disable-interface
  ```

- Disable and then re-enable the network link using administrative shutdown commands to reset the connection.

  ```
  Router# configure
  Router(config)# interface TenGigE 0/1/0/0
  Router(config-if)# shutdown
  Router(config-if)# commit
  Router(config-if)# no shutdown
  Router(config-if)# commit
  ```

- Configure an auto-recovery timer for this error-disable reason.

  ```
  Router# configure
  Router(config)# error-disable recovery cause link-oam-session-down interval 30
  Router(config)# commit
  ```

Clearing Ethernet Link OAM Statistics on an Interface: Example

This example shows how to clear Ethernet Link OAM (ELO) statistics on an interface:

```
RP/0/RP0/CPU0:router# clear ethernet oam statistics interface gigabitethernet 0/1/5/1
```

Unidirectional Link Detection Protocol

Unidirectional Link Detection (UDLD) is a single-hop physical link protocol for monitoring an ethernet link, including both point-to-point and shared media links. This is a Cisco-proprietary protocol to detect link problems, which are not detected at the physical link layer. This protocol is specifically targeted at possible wiring errors, when using unbundled fiber links, where there can be a mismatch between the transmitting and receiving connections of a port.

Limitations

- UDLD must not be enabled on a Switched Port Analyzer (SPAN) source or a destination port.
- UDLD must not be enabled on a port that acts as a source or destination port for SPAN.

Types of Fault Detection

UDLD can detect these types of faults:

- Transmit faults — These are cases where there is a failure in transmitting packets from the local port to the peer device, but packets are being received from the peer. These faults are caused by failure of the physical link (where notification at layer 1 of unidirectional link faults is not supported by the media) as well as packet path faults on the local or peer device.
- Miswiring faults — These are cases where the receiving and transmitting sides of a port on the local device are connected to different peer ports (on the same device or on different devices). This can occur when using unbundled fibers to connect fiber optic ports.
- Loopback faults — These are cases where the receiving and transmitting sides of a port are connected to each other, creating a loopback condition. This can be an intentional mode of operation, for certain types of testing, but UDLD must not be used in these cases.
- Receive faults — The protocol includes a heartbeat signal that is transmitted at a negotiated periodic interval to the peer device. Missed heartbeats can therefore be used to detect failures on the receiving side of the link (where they do not result in interface state changes). These could be caused by a unidirectional link with a failure only affecting the receiving side, or by a link which has developed a bidirectional fault. This detection depends on reliable, regular packet transmission by the peer device. For this reason, the UDLD protocol has two (configurable) modes of operation which determine the behavior on a heartbeat timeout. These modes are described in the section UDLD Modes of Operation, on page 92.

UDLD Modes of Operation

UDLD can operate in these modes:

- **Normal mode**: In this mode, if a `Receive Fault` is detected, the user is informed and no further action is taken.
- **Aggressive mode**: In this mode, if a `Receive Fault` is detected, the user is informed and the affected port is disabled.

Note The difference of behavior between normal and aggressive modes is only seen in case of neighbor timeout. In all other cases, irrespective of the normal or aggressive mode, the system error disables a link once a unidirectional link is detected.

Configure UDLD

UDLD is configured for each interface. The interface must be a physical ethernet interface.

Perform the following steps to configure UDLD protocol on an interface:

```
RP/0/RSP0/CPU0:router# configure
RP/0/RSP0/CPU0:router(config)# interface TenGigE 0/1/0/0
```

Note The example indicates a 10-Gigabit Ethernet interface in line card slot 1.

Running Configuration

```
RP/0/RSP0/CPU0:router(config-if)# ethernet udld
RP/0/RSP0/CPU0:router(config-if-udld)# mode?
RP/0/RP0/CPU0:IOS(config)#interface tenGigE 0/0/0/0
 RP/0/RP0/CPU0:IOS(config-if)#ethernet udld
RP/0/RP0/CPU0:IOS(config-if-udld)#mode ?
   aggressive  Run UDLD in aggressive mode
   normal      Run UDLD in normal mode
 RP/0/RP0/CPU0:IOS(config-if-udld)#mode aggressive
 RP/0/RP0/CPU0:IOS(config-if-udld)#message-time ?
   <7-90>  'Mslow' message time (in seconds) to use for the UDLD protocol
 RP/0/RP0/CPU0:IOS(config-if-udld)#message-time 50
RP/0/RP0/CPU0:IOS(config-if-udld)#destination mac-address ?
   H.H.H
             A valid multicast MAC address
   cisco-l2cp           Use the Cisco L2CP MAC address (used by CDP)
   ieee-slow-protocols  Use the IEEE slow protocol destination MAC address
```

```
RP/0/RP0/CPU0:IOS(config-if-udld)#destination mac-address 0100.5e01.0101
 RP/0/RP0/CPU0:IOS(config-if-udld)#logging disable
 RP/0/RP0/CPU0:IOS(config-if-udld)#commit
 RP/0/RP0/CPU0:IOS(config-if-udld)#end
 RP/0/RP0/CPU0:IOS#sh run interface tenGigE 0/0/0/0
 interface TenGigE0/0/0/0
  ethernet udld
  mode aggressive
   message-time 50
  destination mac-address 0100.5e01.0101
   logging disable
  !
!
```

Verification

```
RP/0/RP0/CPU0:IOS# sh ethernet udld interfaces
 Device ID:               00:8a:96:e1:20:d8
 Device name:             IOS
 Interface TenGigE0/0/0/0
Port state:            Up
Main FSM state:        Advertising
Detection FSM state:   Unknown
Message interval:      7 seconds
Timeout interval:      5 seconds
Destination MAC:       01:00:5e:01:01:01

RP/0/RP0/CPU0:IOS# sh ethernet udld statistics tenGigE 0/0/0/0

Interface TenGigE0/0/0/0
Counters last cleared:               00:01:18 ago
Main FSM transitions (to each state)
Link up:     1
Detection:   0
Advertise:   1
Port shutdown: 0
```

```
UDLD inactive: 0

Detection FSM transitions (to each state)

Unknown: 0

Bidirectional: 0

Unidirectional: 0

Neighbor mismatch: 0

Loopback: 0

Rx packet counts

Probe: 0

Echo:                                        0

Flush:                                       0

Invalid packets (dropped):                   0

Tx packet counts

Probe:                                      19

Echo:                                        0

Flush:                                       0

Unable to send (dropped):                    0

RP/0/RP0/CPU0:IOS#
```

```
 RP/0/RP0/CPU0:IOS# sh ethernet udld daemon database

Interface TenGigE0/0/0/0


   Item                          Value

---------------------------  ------------------------------------------------

  Interface handle             Te0/0/0/0 (0x00000200)
  Name                         Te0/0/0/0
  Name (long internal format)  TenGigE0_0_0_0
  Configured ?                 TRUE
  Caps add in progress ?       FALSE
  Caps remove in progress ?    FALSE
  Caps added ?                 TRUE
  Protocol start pending ?     FALSE
  Protocol running ?           TRUE
  Registered for packet I/O ?  TRUE
  Aggressive mode ?            TRUE
  Logging enabled ?            FALSE
  Error disabled on start ?    FALSE
  Error disabled during ISSU ? FALSE
  Attributes read ?            TRUE
  Pending state down nfn ?     FALSE
  Message time                 50
```

Ethernet CFM

Table 13: Feature History Table

Feature Name	Release	Description
Cisco NC57 Native Mode: CFM	Release 7.3.1	This feature is now supported on routers that have the Cisco NC57 line cards installed and operate in the native mode. To enable the native mode, use the **hw-module profile npu native-mode-enable** command in the configuration mode. Ensure that you reload the router after configuring the native mode.
Cisco NC57 Compatibility Mode: CFM	Release 7.4.1	This feature is now supported on routers that have the Cisco NC57 line cards installed and operate in the compatibility mode.
Support for Link Loss Forwarding on Cisco NCS 5500 Series Routers	Release 7.5.1	This feature, now available on Cisco NCS 5500 Series Routers, enables high availability between two bridged interfaces by disabling both interfaces if any one of them fails. This functionality allows a fault detected on one side of a CFM-protected network to propagate to the other side, enabling the device to re-route around the failure at that end. In earlier releases, a failure on one bridged interface did not disable the other interface, and connected devices remained unaware of the link loss.

Ethernet Connectivity Fault Management (CFM) is a service-level OAM protocol that provides tools for monitoring and troubleshooting end-to-end Ethernet services per VLAN. This includes proactive connectivity monitoring, fault verification, and fault isolation. CFM uses standard Ethernet frames and can be run on any physical media that is capable of transporting Ethernet service frames. Unlike most other Ethernet protocols which are restricted to a single physical link, CFM frames can transmit across the entire end-to-end Ethernet network.

Note Enable a maximum of 32 VLAN ranges per NPU. Else, when you reload the device, all CFM sessions over the 802.1Q VLAN interface might go down. Also, the corresponding bundle interface might go down. If more than 32 VLAN ranges exist on an NPU, remove the additional VLAN ranges and reload the device to address the issue. This is not applicable for NCS 5700 line cards.

Note Up MEP with Cisco NC57 line cards installed and operate in the native and compatibility modes as a part of Layer 2 service. When you have have NC57 line card (compatibility mode) interface as core facing (ingress) and NC57 line card as the AC (egress) interface, the up mep CFM session does not come up.

CFM is defined in two standards:

- IEEE 802.1ag—Defines the core features of the CFM protocol.
- ITU-T Y.1731—Redefines, but maintains compatibility with the features of IEEE 802.1ag, and defines some additional features.

Ethernet CFM supports these functions of ITU-T Y.1731:

- ETH-CC, ETH-RDI, ETH-LB, ETH-LT, ETH-BNM, ETH-CSF—These are equivalent to the corresponding features defined in IEEE 802.1ag.

Note The Linktrace responder procedures defined in IEEE 802.1ag are used rather than the procedures defined in Y.1731; however, these are interoperable.

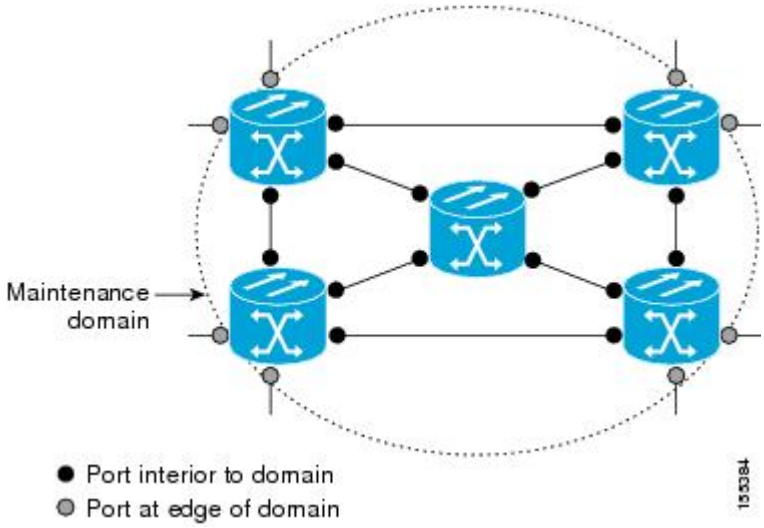
- ETH-AIS—The reception of ETH-LCK messages is also supported.

To understand how the CFM maintenance model works, you need to understand these concepts and features:

Maintenance Domains

A maintenance domain describes a management space for the purpose of managing and administering a network. A domain is owned and operated by a single entity and defined by the set of interfaces internal to it and at its boundary, as shown in this figure.

Figure 4: CFM Maintenance Domain



A maintenance domain is defined by the bridge ports that are provisioned within it. Domains are assigned maintenance levels, in the range of 0 to 7, by the administrator. The level of the domain is useful in defining the hierarchical relationships of multiple domains.

CFM maintenance domains allow different organizations to use CFM in the same network, but independently. For example, consider a service provider who offers a service to a customer, and to provide that service, they use two other operators in segments of the network. In this environment, CFM can be used in the following ways:

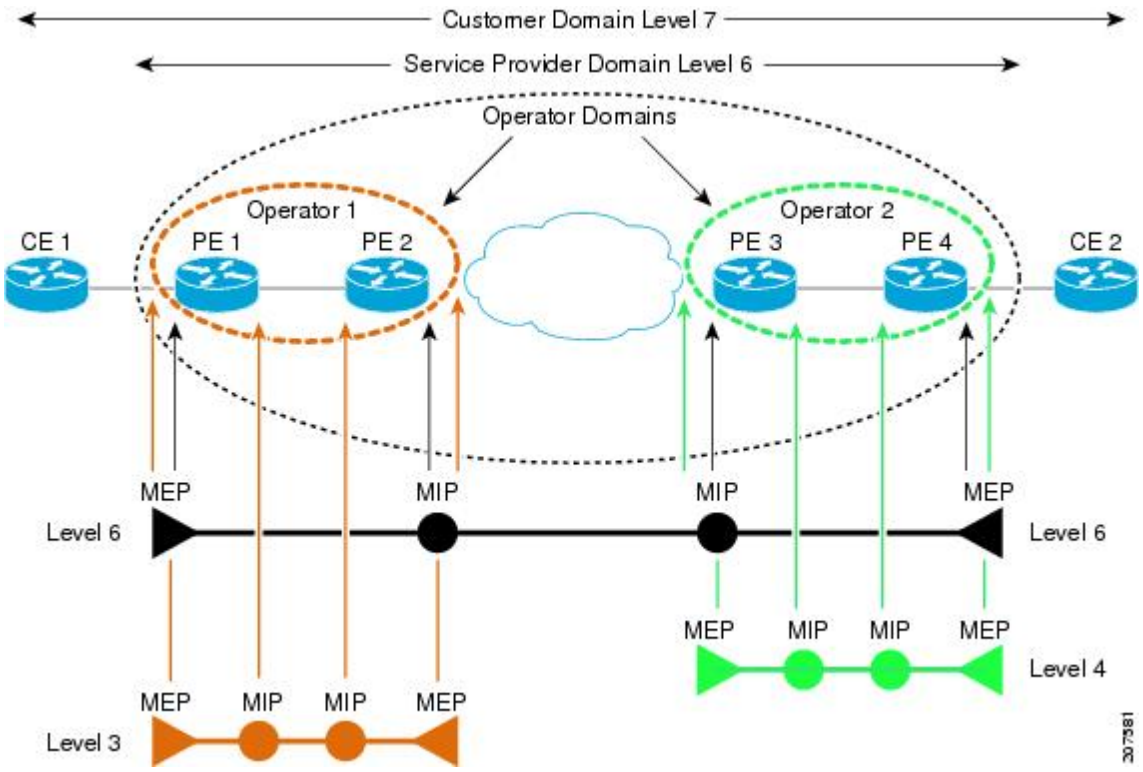
- The customer can use CFM between their CE devices, to verify and manage connectivity across the whole network.
- The service provider can use CFM between their PE devices, to verify and manage the services they are providing.
- Each operator can use CFM within their operator network, to verify and manage connectivity within their network.

Each organization uses a different CFM maintenance domain.

This figure shows an example of the different levels of maintenance domains in a network.

Note In CFM diagrams, the conventions are that triangles represent MEPs, pointing in the direction that the MEP sends CFM frames, and circles represent MIPs.

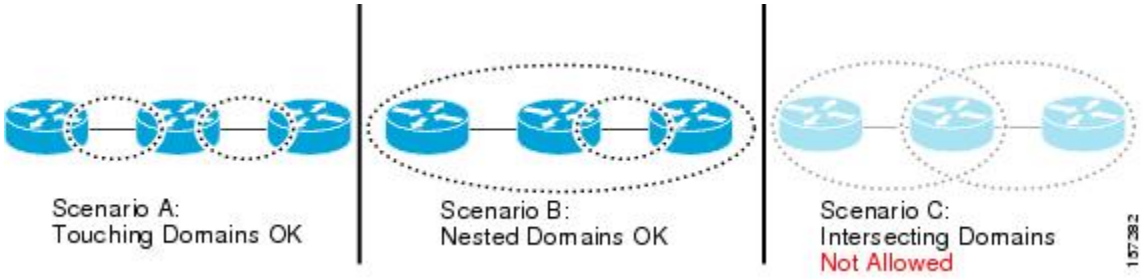
Figure 5: Different CFM Maintenance Domains Across a Network



To ensure that the CFM frames for each domain do not interfere with each other, each domain is assigned a maintenance level, between 0 and 7. Where domains are nested, as in this example, the encompassing domain must have a higher level than the domain it encloses. In this case, the domain levels must be negotiated between the organizations involved. The maintenance level is carried in all CFM frames that relate to that domain.

CFM maintenance domains may touch or nest, but cannot intersect. This figure illustrates the supported structure for touching and nested domains, and the unsupported intersection of domains.

Figure 6: Supported CFM Maintenance Domain Structure



Services

A CFM service allows an organization to partition its CFM maintenance domain, according to the connectivity within the network. For example, if the network is divided into a number of virtual LANs (VLANs), a CFM service is created for each of these. CFM can then operate independently in each service. It is important that the CFM services match the network topology, so that CFM frames relating to one service cannot be received

in a different service. For example, a service provider may use a separate CFM service for each of their customers, to verify and manage connectivity between that customer's end points.

A CFM service is always associated with the maintenance domain that it operates within, and therefore with that domain's maintenance level. All CFM frames relating to the service carry the maintenance level of the corresponding domain.

Note CFM Services are referred to as *Maintenance Associations* in IEEE 802.1ag and as *Maintenance Entity Groups* in ITU-T Y.1731.

Maintenance Points

A CFM Maintenance Point (MP) is an instance of a particular CFM service on a specific interface. CFM only operates on an interface if there is a CFM maintenance point on the interface; otherwise, CFM frames are forwarded transparently through the interface.

A maintenance point is always associated with a particular CFM service, and therefore with a particular maintenance domain at a particular level. Maintenance points generally only process CFM frames at the same level as their associated maintenance domain. Frames at a higher maintenance level are always forwarded transparently, while frames at a lower maintenance level are normally dropped. This helps enforce the maintenance domain hierarchy, and ensures that CFM frames for a particular domain cannot leak out beyond the boundary of the domain.

There are two types of MP:

- Maintenance End Points (MEPs)—Created at the edge of the domain. Maintenance end points (MEPs) are members of a particular service within a domain and are responsible for sourcing and sinking CFM frames. They periodically transmit continuity check messages and receive similar messages from other MEPs within their domain. They also transmit traceroute and loopback messages at the request of the administrator. MEPs are responsible for confining CFM messages within the domain.
- Maintenance Intermediate Points (MIPs)—Created in the middle of the domain. Unlike MEPS, MIPs do allow CFM frames at their own level to be forwarded.

MIP Creation

Unlike MEPs, MIPs are not explicitly configured on each interface. MIPs are created automatically according to the algorithm specified in the CFM 802.1ag standard. The algorithm, in brief, operates as follows for each interface:

- The bridge-domain or cross-connect for the interface is found, and all services associated with that bridge-domain or cross-connect are considered for MIP auto-creation.
- The level of the highest-level MEP on the interface is found. From among the services considered above, the service in the domain with the lowest level that is higher than the highest MEP level is selected. If there are no MEPs on the interface, the service in the domain with the lowest level is selected.
- The MIP auto-creation configuration (**mip auto-create** command) for the selected service is examined to determine whether a MIP should be created.

Note Configuring a MIP auto-creation policy for a service does not guarantee that a MIP will automatically be created for that service. The policy is only considered if that service is selected by the algorithm first.

MEP and CFM Processing Overview

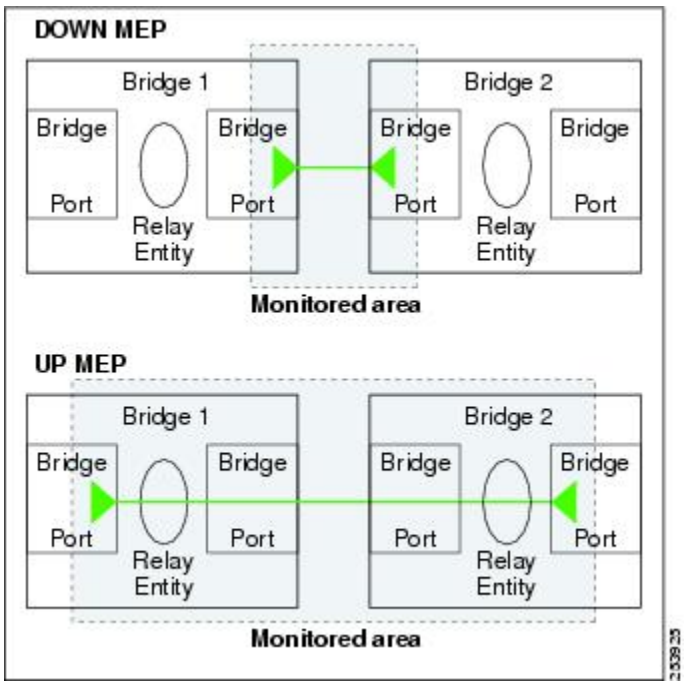
The boundary of a domain is an interface, rather than a bridge or host. Therefore, MEPs can be sub-divided into two categories:

- Down MEPs—Send CFM frames from the interface where they are configured, and process CFM frames received on that interface. Down MEPs transmit AIS messages upward (toward the cross-connect).
- Up MEPs—Send frames into the bridge relay function, as if they had been received on the interface where the MEP is configured. They process CFM frames that have been received on other interfaces, and have been switched through the bridge relay function as if they are going to be sent out of the interface where the MEP is configured. Up MEPs transmit AIS messages downward (toward the wire). However, AIS packets are only sent when there is a MIP configured on the same interface as the MEP and at the level of the MIP.

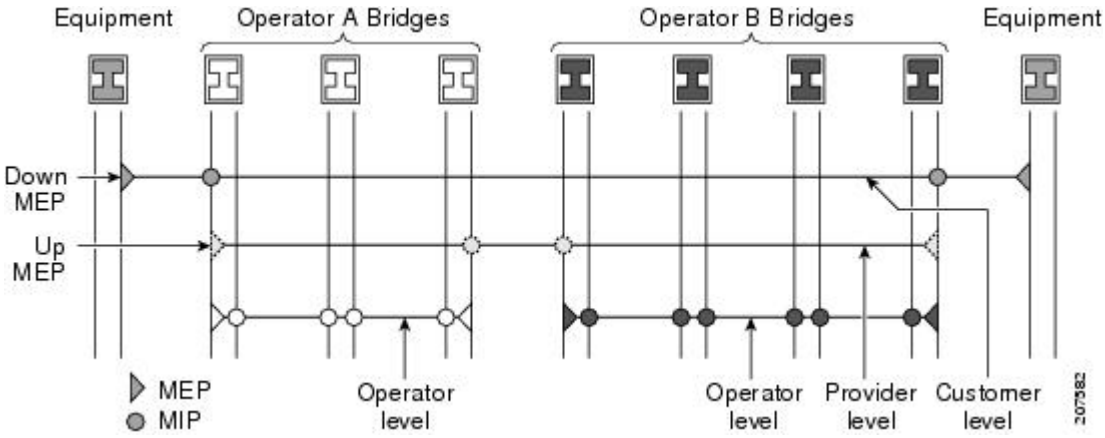
Note The terms *Down MEP* and *Up MEP* are defined in the IEEE 802.1ag and ITU-T Y.1731 standards, and refer to the direction that CFM frames are sent from the MEP. The terms should not be confused with the operational status of the MEP.

This figure illustrates the monitored areas for Down and Up MEPs.

Figure 7: Monitored Areas for Down and Up MEPs



This figure shows maintenance points at different levels. Because domains are allowed to nest but not intersect (see Supported CFM Maintenance Domain Structure), a MEP at a low level always corresponds with a MEP or MIP at a higher level. In addition, only a single MIP is allowed on any interface—this is generally created in the lowest domain that exists at the interface and that does not have a MEP.



MIPs and Up MEPs can only exist on switched (Layer 2) interfaces, because they send and receive frames from the bridge relay function. Down MEPs can be created on switched (Layer 2) interfaces.

MEPs continue to operate normally if the interface they are created on is blocked by the Spanning Tree Protocol (STP); that is, CFM frames at the level of the MEP continue to be sent and received, according to the direction of the MEP. MEPs never allow CFM frames at the level of the MEP to be forwarded, so the STP block is maintained.

MIPs also continue to receive CFM frames at their level if the interface is STP blocked, and can respond to any received frames. However, MIPs do not allow CFM frames at the level of the MIP to be forwarded if the interface is blocked.

Note A separate set of CFM maintenance levels is created every time a VLAN tag is pushed onto the frame. Therefore, if CFM frames are received on an interface which pushes an additional tag, so as to "tunnel" the frames over part of the network, the CFM frames will not be processed by any MPs within the tunnel, even if they are at the same level. For example, if a CFM MP is created on an interface with an encapsulation that matches a single VLAN tag, any CFM frames that are received at the interface that have two VLAN tags will be forwarded transparently, regardless of the CFM level.

CFM Protocol Messages

The CFM protocol consists of a number of different message types, with different purposes. All CFM messages use the CFM EtherType, and carry the CFM maintenance level for the domain to which they apply.

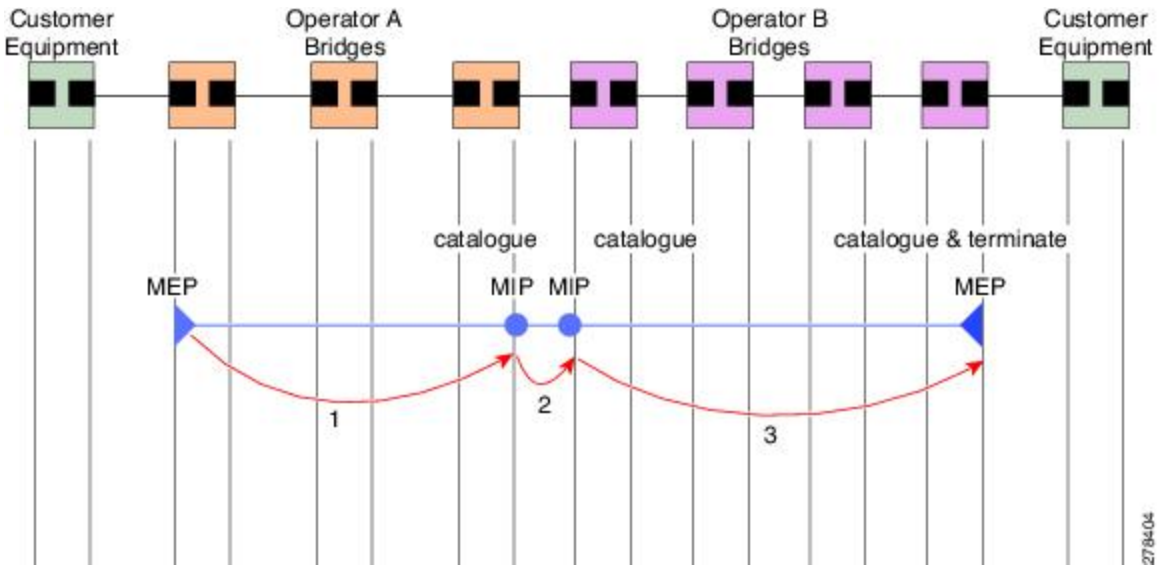
This section describes the following CFM messages:

Continuity Check (IEEE 802.1ag and ITU-T Y.1731)

Continuity Check Messages (CCMs) are "heartbeat" messages exchanged periodically between all the MEPs in a service. Each MEP sends out multicast CCMs, and receives CCMs from all the other MEPs in the service—these are referred to as *peer MEPs*. This allows each MEP to discover its peer MEPs, and to verify that there is connectivity between them.

MIPs also receive CCMs. MIPs use the information to build a MAC learning database that is used when responding to Linktrace. For more information about Linktrace, see Linktrace (IEEE 802.1ag and ITU-T Y.1731).

Figure 8: Continuity Check Message Flow



All the MEPs in a service must transmit CCMs at the same interval. The interval at which CCMs are being transmitted is called CCM interval. IEEE 802.1ag defines 7 possible intervals that can be used:

- 3.3ms
- 10ms
- 100ms
- 1s
- 10s
- 1 minute
- 10 minutes

A MEP detects a loss of connectivity with one of its peer MEPs when a certain number of CCMs have been missed. This occurs when sufficient time has passed during which a certain number of CCMs were expected, given the CCM interval. This number is called the *loss threshold*, and is usually set to 3.

CFM is supported only on interfaces which have Layer 2 transport feature enabled.

Maintenance Association Identifier (MAID)

Table 14: Feature History Table

Feature Name	Release	Description
48 byte string-based MAID support for Offloaded Endpoints	Release 7.5.1	This feature is supported on Cisco Network Convergence System 5700 Series routers and routers with the Cisco NC57 line cards operating in native mode. This feature extends MAID functionality to support the flexible format for hardware offloaded MEPs. This removes the restrictions on the type of MAID supported for sessions with less than 1 minute time intervals. To enable the feature in native mode, run the **hw-module profile oam 48byte-cfm-maid-enable** command in the System Admin Config mode, and reload the router.

Continuity Check Messages (CCM) are essential for detecting various defects in network services. They carry critical information that helps in the identification and maintenance of the service. This is a breakdown of the information contained in CCM messages:

- **Maintenance Domain Identifier (MDID):** A configured identifier unique to the domain of the transmitting Maintenance End Point (MEP). It is crucial for the identification of the maintenance domain.
- **Short MA Name (SMAN):** A configured identifier specific to the service of the transmitting MEP. It is used to identify the service within the maintenance domain.

- **Maintenance Association Identifier (MAID):** A combination of MDID and SMAN. Together, these identifiers form the MAID, which is a composite identifier that must be uniformly configured across all MEPs within the same service.

Note MDID **only** supports **null** value and SMAN supports ITU Carrier Code (ICC) or a numerical. No other values are supported.

Supported MAID Formats for Offloaded MEPs (applicable for NCS 5700 line cards only)

- No Domain Name Format
  - MD Name Format = 1-NoDomainName
  - Short MA Name Format = 3 - 2 bytes integer value
  - Short MA NAme Length = 2 - fixed length
  - Short MA Name = 2 bytes of integer
- 1731 Maid Format
  - MD Name Format = 1-NoDomainName
  - MA Name Format(MEGID Format) = 32
  - MEGID Length = 13 - fixed length
  - MEGID(ICCCode) = 6 Bytes
  - MEGID(UMC) = 7 Bytes
  - ITU Carrier Code (ICC) - Number of different configurable ICC code - 15 (for each NPU)
  - Unique MEG ID Code (UMC) - 4

These are some examples:

- Configuring domain ID null: **ethernet cfm domain SMB level 3 id null**
- Configuring SMAN: **ethernet cfm domain SMB level 3 id null service 901234AB xconnect group 99999 p2p 99999 id number 1**

This table summarizes the supported values and parameters for MDID and SMAN. This table only details the MAID restriction on the hardware offload feature. There is no MAID restriction for software offload or non-offloaded MEPs.

For Cisco NCS 5500 series routers, "id null" has to be explicitly configured for the domain ID, for hardware offloaded sessions.

Format	MDID	SMAN	Support	Comment
	No	2 byte integer	Yes	Up to 2000 entries

Format	MDID	SMAN	Support	Comment
	No	13 bytes ICCCode (6 bytes) and UMC (7 bytes)	Yes	Up to 15 unique ICC Up to 4K UMC values
48 bytes string based	1-48 bytes of MDID and SMAN		No	Most commonly used

Guidelines and Restrictions for MAID

- Configure each MEP within the service with a distinct MEP ID, which is a unique numeric identifier.
- Configure MEP CrossCheck for all MEPs with intervals of less than 10s, as Dynamic Remote MEPs are not supported for these.
- In a Remote Defect Indication (RDI), each MEP includes sequence number in the CCMs it is sending, if it has detected a defect relating to the CCMs it is receiving. This notifies all the MEPs in the service that a defect has been detected somewhere in the service. Sequence numbering is not supported for MEPs with CCM intervals of less than 10s.
- CCM Tx/Rx statistics counters are not supported for MEPs with less than 10s intervals.
- Sender TLV and Cisco Proprietary TLVs are not supported for MEPs with less than 10s intervals.
- Starting from Cisco IOS XR SoftwareRelease 7.5.1, MAID supports the flexible packet format of MEG IDs on hardware offloaded MEPs for the following Cisco NC57 line cards:
  - NC57-24DD
  - NCS-57C3-MODS-SYS

  This feature is supported only on Cisco NC57 line cards installed and operate in native mode. It removes the restrictions on the type of MAID that are supported for sessions with less than 1 minute time intervals. This helps in interoperating with the devices that already support the flexible format configuration.

  Examples:

  - Configuring domain ID: **ethernet cfm domain SMB level 3 id string** or

    ethernet cfm domain SMB level 3

  - Configuring SMAN: **ethernet cfm domain SMB level 3 id null service 901234AB xconnect group 99999 p2p 99999 id string** or

    ethernet cfm domain SMB level 3 id null service 901234AB xconnect group 99999 p2p 99999

- The status of the interface where the MEP is operating (for example, up - when the interface is up, or down - when the interface is down) should not be confused with the direction of any MEPs on the interface (Up MEPs/Down MEPs).

Defect Identification using CCM Analysis

These defects can be detected from the received CCMs:

- Interval mismatch: The CCM interval in the received CCM does not match the interval that the MEP is configured to send CCMs.
- Level mismatch: A MEP receives a CCM carrying a lower maintenance level than the MEP's own configured level.
- Loop: A CCM is received with a source MAC address that matches the MAC address of the MEP's operating interface, indicating a loop.
- Configuration error: A received CCM contains a MEP ID that duplicates the MEP ID of the receiving MEP, signaling a configuration issue.
- Cross-connect error: A CCM with a non-matching MAID is received, often pointing to a VLAN misconfiguration that causes service leakage.
- Peer interface down: A CCM is received that indicates the interface on the peer is down.
- Remote defect indication: A CCM is received carrying a remote defect indication. This does not trigger the local MEP to send out CCMs with a remote defect indication.

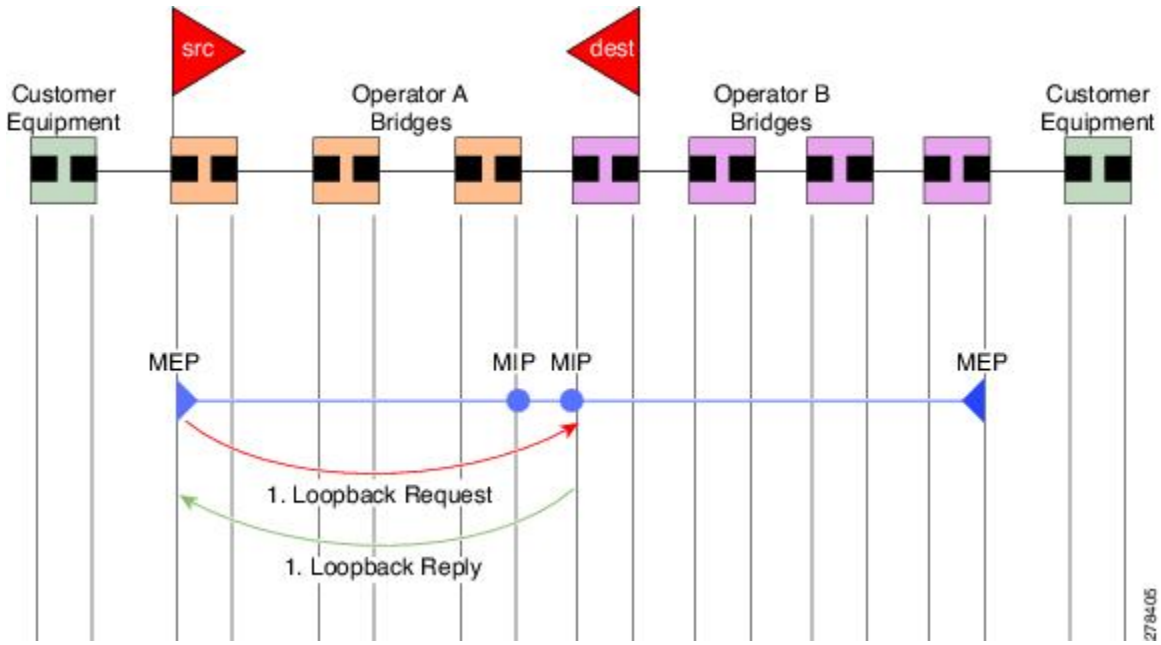
By monitoring the sequence numbers in CCMs from peer MEPs, out-of-sequence CCMs can be identified, although these are not classified as CCM defects.

Loopback (IEEE 802.1ag and ITU-T Y.1731)

Loopback Messages (LBM) and Loopback Replies (LBR) are used to verify connectivity between a local MEP and a particular remote MP. At the request of the administrator, a local MEP sends unicast LBMs to the remote MP. On receiving each LBM, the target maintenance point sends an LBR back to the originating MEP. Loopback indicates whether the destination is reachable or not—it does not allow hop-by-hop discovery of the path. It is similar in concept to an ICMP Echo (ping). Since loopback messages are destined for unicast addresses, they are forwarded like normal data traffic, while observing the maintenance levels. At each device that the loopback reaches, if the outgoing interface is known (in the bridge's forwarding database), then the frame is sent out on that interface. If the outgoing interface is not known, then the message is flooded on all interfaces.

This figure shows an example of CFM loopback message flow between a MEP and MIP.

Figure 9: Loopback Messages



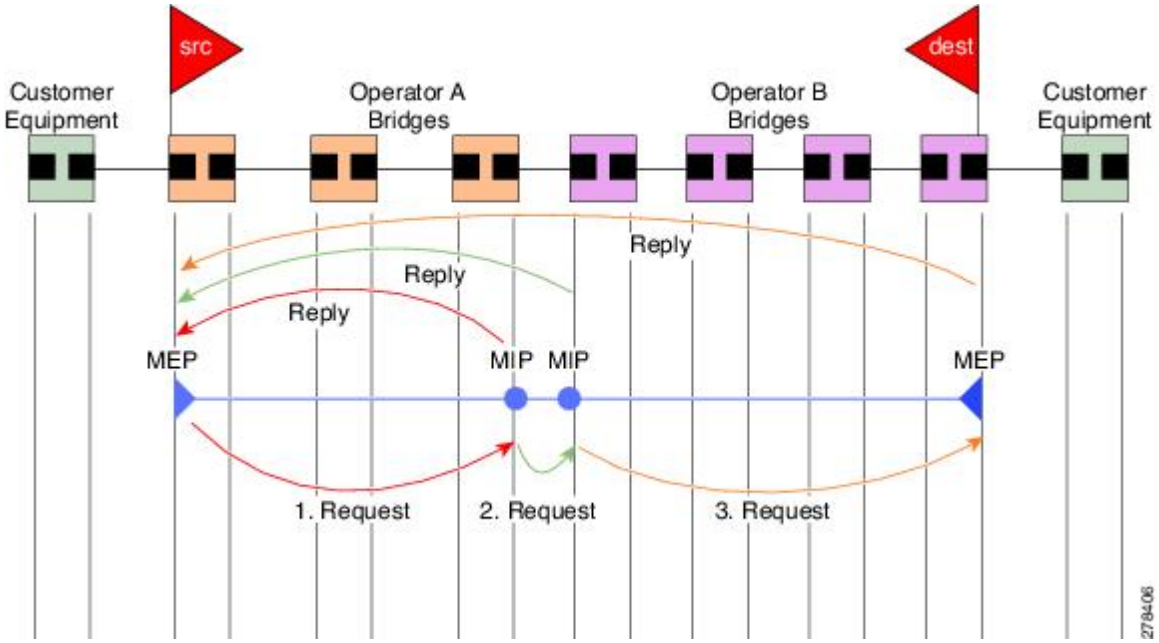
Loopback messages can be padded with user-specified data. This allows data corruption to be detected in the network. They also carry a sequence number which allows for out-of-order frames to be detected.

Linktrace (IEEE 802.1ag and ITU-T Y.1731)

Linktrace Messages (LTM) and Linktrace Replies (LTR) are used to track the path (hop-by-hop) to a unicast destination MAC address. At the request of the operator, a local MEP sends an LTM. Each hop where there is a maintenance point sends an LTR back to the originating MEP. This allows the administrator to discover connectivity data about the path. It is similar in concept to IP traceroute, although the mechanism is different. In IP traceroute, successive probes are sent, whereas CFM Linktrace uses a single LTM which is forwarded by each MP in the path. LTMs are multicast, and carry the unicast target MAC address as data within the frame. They are intercepted at each hop where there is a maintenance point, and either retransmitted or dropped to discover the unicast path to the target MAC address.

This figure shows an example of CFM linktrace message flow between MEPs and MIPs.

Figure 10: Linktrace Message Flow



The linktrace mechanism is designed to provide useful information even after a network failure. This allows it to be used to locate failures, for example after a loss of continuity is detected. To achieve this, each MP maintains a CCM Learning Database. This maps the source MAC address for each received CCM to the interface through which the CCM was received. It is similar to a typical bridge MAC learning database, except that it is based only on CCMs and it times out much more slowly—on the order of days rather than minutes.

Note In IEEE 802.1ag, the CCM Learning Database is referred to as the MIP CCM Database. However, it applies to both MIPs and MEPs.

In IEEE 802.1ag, when an MP receives an LTM message, it determines whether to send a reply using the following steps:

1. The target MAC address in the LTM is looked up in the bridge MAC learning table. If the MAC address is known, and therefore the egress interface is known, then an LTR is sent.
2. If the MAC address is not found in the bridge MAC learning table, then it is looked up in the CCM learning database. If it is found, then an LTR is sent.
3. If the MAC address is not found, then no LTR is sent (and the LTM is not forwarded).

If the target MAC has never been seen previously in the network, the linktrace operation will not produce any results.

Note IEEE 802.1ag and ITU-T Y.1731 define slightly different linktrace mechanisms. In particular, the use of the CCM learning database and the algorithm described above for responding to LTM messages are specific to IEEE 802.1ag. IEEE 802.1ag also specifies additional information that can be included in LTRs. Regardless of the differences, the two mechanisms are interoperable.

Configurable Logging

CFM supports logging of various conditions to syslog. Logging can be enabled independently for each service, and when the following conditions occur:

- New peer MEPs are detected, or loss of continuity with a peer MEP occurs.
- Changes to the CCM defect conditions are detected.
- Cross-check “missing” or “unexpected” conditions are detected.
- AIS condition detected (AIS messages received) or cleared (AIS messages no longer received).
- EFD used to shut down an interface, or bring it back up.

Flexible VLAN Tagging for CFM

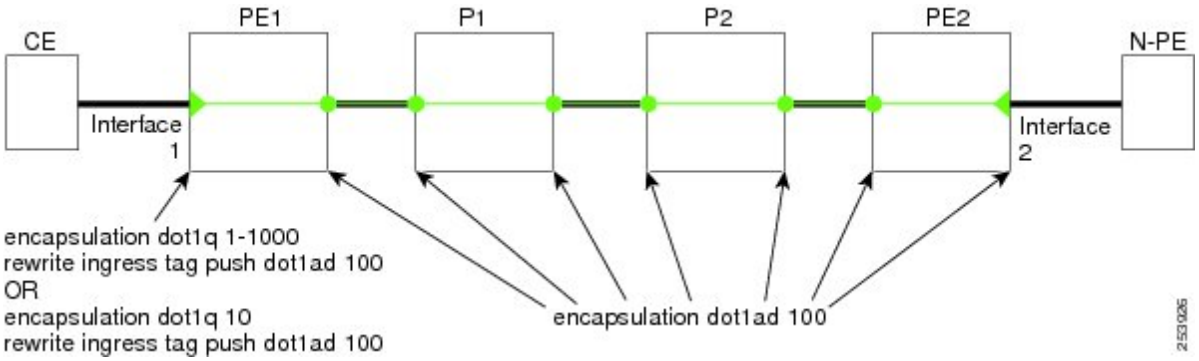
The Flexible VLAN Tagging for CFM feature ensures that CFM packets are sent with the right VLAN tags so that they are appropriately handled as a CFM packet by the remote device. When packets are received by an edge router, they are treated as either CFM packets or data packets, depending on the number of tags in the header. The system differentiates between CFM packets and data packets based on the number of tags in the packet, and forwards the packets to the appropriate paths based on the number of tags in the packet.

CFM frames are normally sent with the same VLAN tags as the corresponding customer data traffic on the interface, as defined by the configured encapsulation and tag rewrite operations. Likewise, received frames are treated as CFM frames if they have the correct number of tags as defined by the configured encapsulation and tag rewrite configuration, and are treated as data frames (that is, they are forwarded transparently) if they have more than this number of tags.

In most cases, this behavior is as desired, since the CFM frames are then treated in exactly the same way as the data traffic flowing through the same service. However, in a scenario where multiple customer VLANs are multiplexed over a single multipoint provider service (for example, N:1 bundling), a different behavior might be desirable.

This figure shows an example of a network with multiple VLANS using CFM.

Figure 11: Service Provider Network With Multiple VLANs and CFM



This figure shows a provider's access network, where the S-VLAN tag is used as the service delimiter. PE1 faces the customer, and PE2 is at the edge of the access network facing the core. N:1 bundling is used, so the interface encapsulation matches a range of C-VLAN tags. This could potentially be the full range, resulting in all:1 bundling. There is also a use case where only a single C-VLAN is matched, but the S-VLAN is nevertheless used as the service delimiter—this is more in keeping with the IEEE model, but limits the provider to 4094 services.

CFM is used in this network with a MEP at each end of the access network, and MIPs on the boxes within the network (if it is native Ethernet). In the normal case, CFM frames are sent by the up MEP on PE1 with two VLAN tags, matching the customer data traffic. This means that at the core interfaces and at the MEP on PE2, the CFM frames are forwarded as if they were customer data traffic, since these interfaces match only on the S-VLAN tag. So, the CFM frames sent by the MEP on PE1 are not seen by any of the other MPs.

Flexible VLAN tagging changes the encapsulation for CFM frames that are sent and received at Up MEPs. Flexible VLAN tagging allows the frames to be sent from the MEP on PE1 with just the S-VLAN tag that represents the provider service. If this is done, the core interfaces will treat the frames as CFM frames and they will be seen by the MIPs and by the MEP on PE2. Likewise, the MEP on PE1 should handle received frames with only one tag, as this is what it will receive from the MEP on PE2.

To ensure that CFM packets from Up MEPs are routed to the appropriate paths successfully, tags may be set to a specific number in a domain service, using the **tags** command. Currently, tags can only be set to one (1).

Configuring Ethernet CFM

To configure Ethernet CFM, perform the following tasks:

Note CFM is not supported for the following:

- L3 Interfaces and Sub-Interfaces
- Bundle Member Ports
- Bridge Domain
- CFM over BGP-VPLS is supported only for NCS 5700 line cards.

Configuring a CFM Maintenance Domain

To configure a CFM maintenance domain, perform the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **traceroute cache hold-time** *minutes* **size** *entries*
4. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
5. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet Connectivity Fault Management (CFM) configuration mode.
Step 3	**traceroute cache hold-time** *minutes* **size** *entries* **Example:** `RP/0/RP0/CPU0:router(config-cfm)# traceroute cache hold-time 1 size 3000`	(Optional) Sets the maximum limit of traceroute cache entries or the maximum time limit to hold the traceroute cache entries. The default is 100 minutes and 100 entries.
Step 4	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 5	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`

	Command or Action	Purpose
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Services for a CFM Maintenance Domain

You can configure up to 32000 CFM services for a maintenance domain. To configure services for a CFM maintenance domain, perform the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**down-meps | xconnect group** *xconnect-group-name* **m2mp | p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [[**number** *number*]
5. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet CFM configuration mode.

	Command or Action	Purpose
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations at a specified maintenance level, and enters CFM domain configuration mode. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**down-meps | xconnect group** *xconnect-group-name* **m2mp | p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [[**number** *number*] **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# service ABC xconnect group X1 p2p ADB`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Enabling and Configuring Continuity Check for a CFM Service

To configure Continuity Check for a CFM service, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**

3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [[**number** *number*]
5. **continuity-check interval** *time* [**loss-threshold** *threshold*]
6. **continuity-check archive hold-time** *minutes*
7. **continuity-check loss auto-traceroute**
8. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet Connectivity Fault Management (CFM) configuration mode.
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters the CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**down-meps	xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*]	[[**number** *number*] **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# service ABC xconnect group X1 p2p ADB`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain or xconnect where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**continuity-check interval** *time* [**loss-threshold** *threshold*] **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# continuity-check interval 100m loss-threshold 10`	(Optional) Enables Continuity Check and specifies the time interval at which CCMs are transmitted or to set the threshold limit for when a MEP is declared down.

	Command or Action	Purpose
Step 6	**continuity-check archive hold-time** *minutes* **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# continuity-check archive hold-time 100`	(Optional) Configures how long information about peer MEPs is stored after they have timed out.
Step 7	**continuity-check loss auto-traceroute** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# continuity-check loss auto-traceroute`	(Optional) Configures automatic triggering of a traceroute when a MEP is declared down.
Step 8	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Automatic MIP Creation for a CFM Service

For more information about the algorithm for creating MIPs, see the **MIP Creation** section.

To configure automatic MIP creation for a CFM service, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based***icc-string umc-string*] | [**number** *number*]
5. **mip auto-create** {**all** | **lower-mep-only**} {**ccm-learning**}

6. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router# ethernet cfm`	Enters the Ethernet Connectivity Fault Management (CFM) configuration mode.
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters the CFM domain configuration mode. The level must be specified. The only supported option is **id [null]** for less than 1min interval MEPS. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**down-meps** | **xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based***icc-string umc-string*] | [**number** *number*] **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# service ABC xconnect group X1 p2p ADB`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**mip auto-create** {**all** | **lower-mep-only**} {**ccm-learning**} **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# mip auto-create all ccm-learning`	(Optional) Enables the automatic creation of MIPs in a bridge domain. **ccm-learning** option enables CCM learning for MIPs created in this service. This must be used only in services with a relatively long CCM interval of at least 100 ms. CCM learning at MIPs is disabled by default.
Step 6	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`

	Command or Action	Purpose
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Cross-Check on a MEP for a CFM Service

To configure cross-check on a MEP for a CFM service and specify the expected set of MEPs, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]]
5. **mep crosscheck**
6. **mep-id** *mep-id-number*
7. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router# ethernet cfm`	Enters the Ethernet Connectivity Fault Management (CFM) configuration mode.

	Command or Action	Purpose
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters the CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]] **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# service Bridge_Service bridge group BD1 bridge-domain B1`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain or xconnect where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**mep crosscheck** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# mep crosscheck mep-id 10`	Enters CFM MEP crosscheck configuration mode.
Step 6	**mep-id** *mep-id-number* **Example:** `RP/0/RP0/CPU0:router(config-cfm-xcheck)# mep-id 10`	Enables cross-check on a MEP. **Note** • For non-offloaded and software-offloaded MEPs, use the **mep-id** *mep-id-number* [**mac-address** *mac-address*] command. • For hardware-offloaded MEPs, use the **mep-id** *mep-id-number* command. From Release 24.2.1, **mac-address** *mac-address* option is obsolete for hardware-offloaded MEPs. • Repeat this command for every MEP that you want included in the expected set of MEPs for cross-check.
Step 7	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-cfm-xcheck)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`

	Command or Action	Purpose
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Other Options for a CFM Service

To configure other options for a CFM service, complete the following steps:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]]
4. **service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]]
5. **maximum-meps** *number*
6. **log** {**ais**|**continuity-check errors**|**continuity-check mep changes**|**crosscheck errors**|**efd**}
7. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router# ethernet cfm`	Enters the Ethernet Connectivity Fault Management (CFM) configuration mode.

	Command or Action	Purpose
Step 3	**domain** *domain-name* **level** *level-value* [**id** [**null**] [**dns** *DNS-name*] [**mac** *H.H.H*] [**string** *string*]] **Example:** `RP/0/RP0/CPU0:router(config-cfm)# domain Domain_One level 1 id string D1`	Creates and names a container for all domain configurations and enters the CFM domain configuration mode. The level must be specified. The **id** is the maintenance domain identifier (MDID) and is used as the first part of the maintenance association identifier (MAID) in CFM frames. If the MDID is not specified, the domain name is used as the MDID by default.
Step 4	**service** *service-name* {**bridge group** *bridge-domain-group* **bridge-domain** *bridge-domain-name* | **down-meps | xconnect group** *xconnect-group-name* **p2p** *xconnect-name*}[**id** [**icc-based** *icc-string umc-string*] | [**string** *text*] | [**number** *number*] | [**vlan-id** *id-number*] | [**vpn-id** *oui-vpnid*]] **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# service Bridge_Service bridge group BD1 bridge-domain B1`	Configures and associates a service with the domain and enters CFM domain service configuration mode. You can specify that the service is used only for down MEPs, or associate the service with a bridge domain or xconnect where MIPs and up MEPs will be created. The **id** sets the short MA name.
Step 5	**maximum-meps** *number* **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# maximum-meps 1000`	(Optional) Configures the maximum number (2 to 8190) of MEPs across the network, which limits the number of peer MEPs recorded in the database.
Step 6	**log** {**ais**|**continuity-check errors**|**continuity-check mep changes**|**crosscheck errors**|**efd**} **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# log continuity-check errors`	(Optional) Enables logging of certain types of events.
Step 7	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

	Command or Action	Purpose
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring CFM MEPs

- For every subinterface configured under a Layer 3 parent interface, you must associate a unique 802.1Q or 802.1ad tag. Else, it leads to unknown network behavior.

SUMMARY STEPS

1. **configure**
2. **interface** {**HundredGigE | TenGigE**} *interface-path-id*
3. **interface** {**HundredGigE | TenGigE | Bundle-Ether**} *interface-path-id.subinterface*
4. **vrf vrf-name**
5. **interface** {**HundredGigE | TenGigE**} *interface-path-id*
6. **ethernet cfm**
7. **mep domain** *domain-name* **service** *service-name* **mep-id** *id-number*
8. **cos** *cos*
9. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface** {**HundredGigE	TenGigE**} *interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface TenGigE 0/0/0/1`	Type of Ethernet interface on which you want to create a MEP. Enter **HundredGigE** or **TenGigE** and the physical interface or virtual interface. **Note** • Use the **show interfaces** command to see a list of all interfaces currently configured on the router.
Step 3	**interface** {**HundredGigE	TenGigE	Bundle-Ether**} *interface-path-id.subinterface*	Type of Ethernet interface on which you want to create a MEP. Enter **HundredGigE, TenGigE,** or **Bundle-Ether**

	Command or Action	Purpose
	Example: `RP/0/RP0/CPU0:router(config)# interface TenGigE 0/0/0/1`	and the physical interface or virtual interface followed by the subinterface path ID. Naming convention is *interface-path-id.subinterface*. The period in front of the subinterface value is required as part of the notation.
Step 4	**vrf vrf-name** **Example:** `RP/0/RP0/CPU0:router(config-if)# vrf vrf_A`	Configures a VRF instance and enters VRF configuration mode.
Step 5	**interface** {**HundredGigE | TenGigE**} *interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# interface TenGigE 0/0/0/1`	Type of Ethernet interface on which you want to create a MEP. Enter **HundredGigE** or **TenGigE** and the physical interface or virtual interface. **Note** • Use the **show interfaces** command to see a list of all interfaces currently configured on the router.
Step 6	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router(config-if)# ethernet cfm`	Enters interface Ethernet CFM configuration mode.
Step 7	**mep domain** *domain-name* **service** *service-name* **mep-id** *id-number* **Example:** `RP/0/RP0/CPU0:router(config-if-cfm)# mep domain Dm1 service Sv1 mep-id 1`	Creates a maintenance end point (MEP) on an interface and enters interface CFM MEP configuration mode.
Step 8	**cos** *cos* **Example:** `RP/0/RP0/CPU0:router(config-if-cfm-mep)# cos 7`	(Optional) Configures the class of service (CoS) (from 0 to 7) for all CFM packets generated by the MEP on an interface. If not configured, the CoS is inherited from the Ethernet interface. **Note** For Ethernet interfaces, the CoS is carried as a field in the VLAN tag. Therefore, CoS only applies to interfaces where packets are sent with VLAN tags. If the **cos (CFM)** command is executed for a MEP on an interface that does not have a VLAN encapsulation configured, it will be ignored.
Step 9	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-if-cfm-mep)# commit`	Saves configuration changes. • When you use the **end** command, the system prompts you to commit changes:

	Command or Action	Purpose
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Y.1731 AIS

This section has the following step procedures:

Configuring AIS in a CFM Domain Service

Use the following procedure to configure Alarm Indication Signal (AIS) transmission for a CFM domain service and configure AIS logging.

The following example shows how to configure AIS on a CFM interface:

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *name* **level** *level*
4. **service** *name* **bridge group** *name* **bridge-domain** *name*
5. **service** *name* **xconnect group** *xconnect-group-name* **p2p** *xconnect-name*
6. **ais transmission** [**interval** {**1s**|**1m**}][**cos** *cos*]
7. **log ais**
8. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet CFM global configuration mode.
Step 3	**domain** *name* **level** *level* **Example:** `RP/0/RP0/CPU0:router(config-cfm)# domain D1 level 1`	Specifies the domain and domain level.
Step 4	**service** *name* **bridge group** *name* **bridge-domain** *name* **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# service S1 bridge group BG1 bridge-domain BD2`	Specifies the service, bridge group, and bridge domain.
Step 5	**service** *name* **xconnect group** *xconnect-group-name* **p2p** *xconnect-name* **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# service S1 xconnect group XG1 p2p X2`	Specifies the service and cross-connect group and name.
Step 6	**ais transmission** [**interval** {**1s**|**1m**}][**cos** *cos*] **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# ais transmission interval 1m cos 7`	Configures Alarm Indication Signal (AIS) transmission for a Connectivity Fault Management (CFM) domain service.
Step 7	**log ais** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# log ais`	Configures AIS logging for a Connectivity Fault Management (CFM) domain service to indicate when AIS or LCK packets are received.
Step 8	**end** or **commit** **Example:**	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes:

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config-sla-prof-stat-cfg)# commit`	`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring AIS on a CFM Interface

To configure AIS on a CFM interface, perform the following steps:

SUMMARY STEPS

1. **configure**
2. **interface gigabitethernet** *interface-path-id*
3. **ethernet cfm**
4. **ais transmission up interval 1m cos** *cos*
5. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**interface gigabitethernet** *interface-path-id* **Example:** `RP/0/RP0/CPU0:router# interface TenGigE 0/0/0/2`	Enters interface configuration mode.

	Command or Action	Purpose
Step 3	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet CFM interface configuration mode.
Step 4	**ais transmission up interval 1m cos** *cos* **Example:** `RP/0/RP0/CPU0:router(config-if-cfm)# ais transmission up interval 1m cos 7`	Configures Alarm Indication Signal (AIS) transmission on a Connectivity Fault Management (CFM) interface.
Step 5	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-sla-prof-stat-cfg)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes. • Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring Flexible VLAN Tagging for CFM

Use this procedure to set the number of tags in CFM packets in a CFM domain service.

SUMMARY STEPS

1. **configure**
2. **ethernet cfm**
3. **domain** *name* **level** *level*
4. **service** *name* **bridge group** *name* **bridge-domain** *name*
5. **tags** *number*
6. **end** or **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**ethernet cfm** **Example:** `RP/0/RP0/CPU0:router(config)# ethernet cfm`	Enters Ethernet CFM global configuration mode.
Step 3	**domain** *name* **level** *level* **Example:** `RP/0/RP0/CPU0:router(config-cfm)# domain D1 level 1`	Specifies the domain and domain level.
Step 4	**service** *name* **bridge group** *name* **bridge-domain** *name* **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn)# service S2 bridge group BG1 bridge-domain BD2`	Specifies the service, bridge group, and bridge domain.
Step 5	**tags** *number* **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# tags 1`	Specifies the number of tags in CFM packets. Currently, the only valid value is 1.
Step 6	**end** or **commit** **Example:** `RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# commit`	Saves configuration changes. • When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:` • Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

	Command or Action	Purpose
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes. • Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Verifying the CFM Configuration

To verify the CFM configuration, use one or more of the following commands:

show ethernet cfm configuration-errors [**domain** *domain-name*] [**interface** *interface-path-id*]	Displays information about errors that are preventing configured CFM operations from becoming active, as well as any warnings that have occurred.
show ethernet cfm local maintenance-points domain *name* [**service** *name]* | **interface** *type interface-path-id*] [**mep** | **mip**]	Displays a list of local maintenance points.

Note After you configure CFM, the error message, *cfmd[317]: %L2-CFM-5-CCM_ERROR_CCMS_MISSED : Some received CCMs have not been counted by the CCM error counters*, may display. This error message does not have any functional impact and does not require any action from you.

Troubleshooting Tips

To troubleshoot problems within the CFM network, perform these steps:

SUMMARY STEPS

1. To verify connectivity to a problematic MEP, use the **ping ethernet cfm** command as shown in this example:
2. If the results of the **ping ethernet cfm** command show a problem with connectivity to the peer MEP, use the **traceroute ethernet cfm** command to help further isolate the location of the problem as shown in the following example:

DETAILED STEPS

Procedure

Step 1 To verify connectivity to a problematic MEP, use the **ping ethernet cfm** command as shown in this example:

```
RP/0/RP0/CPU0:router# ping ethernet cfm domain D1 service S1 mep-id 16 source
interface TenGigE 0/0/0/1
```

```
Type escape sequence to abort.
Sending 5 CFM Loopbacks, timeout is 2 seconds -
Domain foo (level 2), Service foo
Source: MEP ID 1, interface TenGigE0/0/0/1
Target: 0001.0002.0003 (MEP ID 16):
  Running (5s) ...
Success rate is 60.0 percent (3/5), round-trip min/avg/max = 1251/1349/1402 ms
Out-of-sequence: 0.0 percent (0/3)
Bad data: 0.0 percent (0/3)
Received packet rate: 1.4 pps
```

Step 2 If the results of the **ping ethernet cfm** command show a problem with connectivity to the peer MEP, use the **traceroute ethernet cfm** command to help further isolate the location of the problem as shown in the following example:

```
RP/0/RP0/CPU0:router# traceroute ethernet cfm domain D1 service S1 mep-id 16 source
interface TenGigE 0/0/0/2

Traceroutes in domain D1 (level 4), service S1
Source: MEP-ID 1, interface TenGigE0/0/0/2
================================================================================
Traceroute at 2009-05-18 12:09:10 to 0001.0203.0402,
TTL 64, Trans ID 2:

Hop Hostname/Last            Ingress MAC/name       Egress MAC/Name        Relay
--- ------------------------ ---------------------- ---------------------- -----
  1 ios                      0001.0203.0400 [Down]                         FDB
      0000-0001.0203.0400    TenGigE0/0/0/2
  2 abc                                             0001.0203.0401 [Ok]    FDB
      ios                                           Not present
  3 bcd                      0001.0203.0402 [Ok]                           Hit
      abc                    TenGigE0/0
Replies dropped: 0
```

If the target was a MEP, verify that the last hop shows “Hit” in the Relay field to confirm connectivity to the peer MEP.

If the Relay field contains “MPDB” for any of the hops, then the target MAC address was not found in the bridge MAC learning table at that hop, and the result is relying on CCM learning. This result can occur under normal conditions, but it can also indicate a problem. If you used the **ping ethernet cfm** command before using the **traceroute ethernet cfm** command, then the MAC address should have been learned. If “MPDB” is appearing in that case, then this indicates a problem at that point in the network.

Configuration Examples for Ethernet CFM

This section includes the following examples:

Ethernet CFM Domain Configuration: Example

This example shows how to configure a basic domain for Ethernet CFM:

```
configure
 ethernet cfm
  traceroute cache hold-time 1 size 3000
  domain Domain_One level 1 id string D1
  commit
```

Ethernet CFM Service Configuration: Example

This example shows how to create a service for an Ethernet CFM domain:

```
service Bridge_Service bridge group BD1 bridge-domain B1
service Cross_Connect_1 xconnect group XG1 p2p X1
commit
```

Flexible Tagging for an Ethernet CFM Service Configuration: Example

This example shows how to set the number of tags in CFM packets from down MEPs in a CFM domain service:

```
configure
 ethernet cfm
  domain D1 level 1
   service S2 bridge group BG1 bridge-domain BD2
    tags 1
    commit
```

Continuity Check for an Ethernet CFM Service Configuration: Example

This example shows how to configure continuity-check options for an Ethernet CFM service:

```
   continuity-check archive hold-time 100
   continuity-check loss auto-traceroute
   continuity-check interval 100ms loss-threshold 10
   commit
```

MIP Creation for an Ethernet CFM Service Configuration: Example

This example shows how to enable MIP auto-creation for an Ethernet CFM service:

```
RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# mip auto-create all
RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# commit
```

Cross-check for an Ethernet CFM Service Configuration: Example

This example shows how to configure cross-check for MEPs in an Ethernet CFM service:

```
   mep crosscheck
    mep-id 10
    mep-id 20
    commit
```

Other Ethernet CFM Service Parameter Configuration: Example

This example shows how to configure other Ethernet CFM service options:

```
    maximum-meps 4000
    log continuity-check errors
    commit
    exit
   exit
  exit
```

MEP Configuration: Example

This example shows how to configure a MEP for Ethernet CFM on an interface:

```
interface TenGigE 0/0/0/1
 ethernet cfm
 mep domain Dm1 service Sv1 mep-id 1
 commit
```

Ethernet CFM Show Command: Examples

These examples show how to verify the configuration of Ethernet Connectivity Fault Management (CFM):

Example 1

This example shows how to display all the maintenance points that have been created on an interface:

```
RP/0/RP0/CPU0:router# show ethernet cfm local maintenance-points

Domain/Level         Service             Interface         Type   ID   MAC
-------------------- ------------------- ----------------- ------ ---- --------
fig/5                bay                 Gi0/10/0/12       Dn MEP    2 44:55:66
fig/5                bay                 Gi0/0/1/0         MIP         55:66:77
fred/3               barney              Gi0/1/0/0         Dn MEP    5 66:77:88!
```

Example 2

This example shows how to display all the CFM configuration errors on all domains:

```
RP/0/RP0/CPU0:router# show ethernet cfm configuration-errors

Domain fig (level 5), Service bay
* MIP creation configured using bridge-domain blort, but bridge-domain blort does not exist.

 * An Up MEP is configured for this domain on interface TenGigE0/0/0/3 and an Up MEP is
also configured for domain blort, which is at the same level (5).
 * A MEP is configured on interface TenGigE0/0/0/1 for this domain/service, which has CC
interval 100ms, but the lowest interval supported on that interface is 1s
```

Example 3

This example shows how to display operational state for local maintenance end points (MEPs):

```
RP/0/RP0/CPU0:router# show ethernet cfm local meps

 A - AIS received                I - Wrong interval
 R - Remote Defect received      V - Wrong Level
 L - Loop (our MAC received)     T - Timed out (archived)
 C - Config (our ID received)    M - Missing (cross-check)
 X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
 P - Peer port down

Domain foo (level 6), Service bar
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
  100 Gi1/1/0/1 (Up)       Up     0/0   N  A       L7

Domain fred (level 5), Service barney
```

```
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
    2 Gi0/1/0/0 (Up)       Up     3/2   Y  RPC     L6
Domain foo (level 6), Service bar
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
  100 Gi1/1/0/1 (Up)       Up     0/0   N  A

Domain fred (level 5), Service barney
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
    2 Gi0/1/0/0 (Up)       Up     3/2   Y  RPC
```

Example 4

This example shows how to display operational state of other maintenance end points (MEPs) detected by a local MEP:

```
RP/0/RP0/CPU0:router# show ethernet cfm peer meps

Flags:
 > - Ok                            I - Wrong interval
 R - Remote Defect received        V - Wrong level
 L - Loop (our MAC received)       T - Timed out
 C - Config (our ID received)      M - Missing (cross-check)
 X - Cross-connect (wrong MAID)    U - Unexpected (cross-check)

Domain fred (level 7), Service barney
Down MEP on TenGigE0/0/0/1, MEP-ID 2
==============================================================================
St     ID MAC address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ------------ --------- ------ ----- -----
 >      1 0011.2233.4455 Up      00:00:01         1234      0     0     0
R>      4 4455.6677.8899 Up      1d 03:04         3456      0   234     0
L       2 1122.3344.5566 Up      3w 1d 6h         3254      0     0  3254
C       2 7788.9900.1122 Test    00:13            2345      6    20  2345
X       3 2233.4455.6677 Up      00:23              30      0     0    30
I       3 3344.5566.7788 Down    00:34           12345      0   300  1234
V       3 8899.0011.2233 Blocked 00:35              45      0     0    45
 T      5 5566.7788.9900         00:56              20      0     0     0
M       6                                           0      0     0     0
U>      7 6677.8899.0011 Up      00:02             456      0     0     0

Domain fred (level 7), Service fig
Down MEP on TenGigE0/0/0/12, MEP-ID 3
==============================================================================
St     ID MAC address    Port    Up/Downtime  CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ------------ -------- ------ ----- -----
 >      1 9900.1122.3344 Up      03:45           4321      0     0     0
```

Example 5

This example shows how to display operational state of other maintenance end points (MEPs) detected by a local MEP with details:

```
RP/0/RP0/CPU0:router#  show ethernet cfm peer meps detail
Domain dom3 (level 5), Service ser3
Down MEP on TenGigE0/0/0/1 MEP-ID 1
==============================================================================
Peer MEP-ID 10, MAC 0001.0203.0403
   CFM state: Wrong level, for 00:01:34
```

```
   Port state: Up
   CCM defects detected:    V - Wrong Level
   CCMs received: 5
     Out-of-sequence:             0
     Remote Defect received:      5
     Wrong Level:                 0
     Cross-connect (wrong MAID):  0
     Wrong Interval:              5
     Loop (our MAC received):     0
     Config (our ID received):    0
Last CCM received 00:00:06 ago:
     Level: 4, Version: 0, Interval: 1min
     Sequence number: 5, MEP-ID: 10
     MAID: String: dom3, String: ser3
     Port status: Up, Interface status: Up


Domain dom4 (level 2), Service ser4
Down MEP on TenGigE0/0/0/2 MEP-ID 1
================================================================================
Peer MEP-ID 20, MAC 0001.0203.0402
   CFM state: Ok, for 00:00:04
   Port state: Up
   CCMs received: 7
     Out-of-sequence:             1
     Remote Defect received:      0
     Wrong Level:                 0
     Cross-connect (wrong MAID):  0
     Wrong Interval:              0
     Loop (our MAC received):     0
  Config (our ID received):    0
Last CCM received 00:00:04 ago:
     Level: 2, Version: 0, Interval: 10s
     Sequence number: 1, MEP-ID: 20
     MAID: String: dom4, String: ser4
     Chassis ID: Local: ios; Management address: 'Not specified'
     Port status: Up, Interface status: Up

Peer MEP-ID 21, MAC 0001.0203.0403
   CFM state: Ok, for 00:00:05
   Port state: Up
   CCMs received: 6
     Out-of-sequence:             0
     Remote Defect received:      0
     Wrong Level:                 0
     Cross-connect (wrong MAID):  0
     Wrong Interval:              0
     Loop (our MAC received):     0
     Config (our ID received):    0
Last CCM received 00:00:05 ago:
     Level: 2, Version: 0, Interval: 10s
     Sequence number: 1, MEP-ID: 21
     MAID: String: dom4, String: ser4
     Port status: Up, Interface status: Up


Peer MEP-ID 601, MAC 0001.0203.0402
   CFM state: Timed Out (Standby), for 00:15:14, RDI received
   Port state: Down
   CCM defects detected:    Defects below ignored on local standby MEP
                            I - Wrong Interval
                            R - Remote Defect received
                            T - Timed Out
                            P - Peer port down
```

```
CCMs received: 2
  Out-of-sequence:             0
  Remote Defect received:      2
  Wrong Level:                 0

  Wrong Interval:              2
  Loop (our MAC received):     0
  Config (our ID received):    0
Last CCM received 00:15:49 ago:
  Level: 2, Version: 0, Interval: 10s
  Sequence number: 1, MEP-ID: 600
  MAID: DNS-like: dom5, String: ser5
  Chassis ID: Local: ios; Management address: 'Not specified'
  Port status: Up, Interface status: Down
```

Ethernet CFM Command for flexible packet format: Examples

The flexible packet format supports the following two types of formats:

- MDID String format
- MDID Invalid format

Note To enable the feature in native mode, use the **hw-module profile oam 48byte-cfm-maid-enable** command in the System Admin Config mode. Ensure that you reload the router after configuring the native mode.

```
Router(config)#hw-module profile oam ?
  48byte-cfm-maid-enable  Enable 48byte cfm maid feature
  sat-enable              enable SAT feature
Router(config)#hw-module profile oam 48byte-cfm-maid-enable
In order to make the oam profile take effect, the router must be manually reloaded.
Router(config)#commit

Router(config)#hw-module profile npu native-mode-enable
Tue Nov 16 06:48:34.027 UTC
In order to activate this new npu profile, you must manually reload the chassis
Router(config)#commit
```

MDID String format: Example

Configuration

```
Router(config)#ethernet cfm
Router(config-cfm)#domain test level 3 id string test_domain
Router(config-cfm-dmn)#service test down-meps id string test_service
Router(config-cfm-dmn-svc)#mep crosscheck mep-id 4
Router(config-cfm-dmn-svc)#log continuity-check mep changes
Router(config-cfm-dmn-svc)#continuity-check interval 10ms
Router(config-cfm-dmn-svc)#commit
Router(config-cfm-dmn-svc)#root
Router(config)#interface TenGigE0/0/0/0.1 l2tr


Router(config-subif)#encapsulation dot1q 1


Router(config-subif)#ethernet cfm
```

```
Router(config-if-cfm)#mep domain test service test mep-id 3
Router(config-if-cfm-mep)#commit
```

Verification

```
Router#show ethernet cfm peer meps

Tue Nov 16 06:46:13.859 UTC
Flags:
> - Ok                          I - Wrong interval
R - Remote Defect received      V - Wrong level
L - Loop (our MAC received)     T - Timed out
C - Config (our ID received)    M - Missing (cross-check)
X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
* - Multiple errors received    S - Standby

Domain test (level 3), Service test
Down MEP on TenGigE0/0/0/0.1 MEP-ID 3
==============================================================================
St     ID MAC Address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ------------ --------- ------ ----- -----
>      4 d46a.355c.b814 Up      00:02:30            0      0     0     0

Router#show ethernet cfm peer meps detail
Tue Nov 16 06:46:29.169 UTC
Domain test (level 3), Service test
Down MEP on TenGigE0/0/0/0.1 MEP-ID 3
==============================================================================
Peer MEP-ID 4, MAC d46a.355c.b814
   CFM state: Ok, for 00:02:46
   Received CCM handling offloaded to hardware
   Port state: Up
   CCMs received: 0
     Out-of-sequence:             0
     Remote Defect received:      0
     Wrong level:                 0
     Cross-connect (wrong MAID):  0
     Wrong interval:              0
     Loop (our MAC received):     0
     Config (our ID received):    0
   Last CCM received:
     Level: 3, Version: 0, Interval: 10ms
     Sequence number: 0, MEP-ID: 4
     MAID: String: test_domain, String: test_service
     Port status: Up, Interface status: Up


Router#show ethernet cfm local meps verbose
Tue Nov 16 06:46:41.783 UTC
Domain test (level 3), Service test
Down MEP on TenGigE0/0/0/0.1 MEP-ID 3
==============================================================================
  Interface state: Up      MAC address: b0c5.3cff.c080
  Peer MEPs: 1 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 0 missing, 0 unexpected

  CCM generation enabled:  Yes, 10ms (Remote Defect detected: No)
                           CCM processing offloaded to hardware
  AIS generation enabled:  No
  Sending AIS:             No
  Receiving AIS:           No
  Sending CSF:             No
  Receiving CSF:           No
```

```
  No packets sent/received


Router#
Router#show run interface tenGigE 0/0/0/0.1
Tue Nov 16 06:47:09.035 UTC
interface TenGigE0/0/0/0.1 l2transport
encapsulation dot1q 1
ethernet cfm
  mep domain test service test mep-id 3
  !
!
!

Router#show run ethernet cfm
Tue Nov 16 06:47:23.800 UTC
ethernet cfm
domain test level 3 id string test_domain
  service test down-meps id string test_service
   continuity-check interval 10ms
   mep crosscheck
    mep-id 4
   !
   log continuity-check mep changes
  !
!
!
------------------------------------------------------------------------
```

MDID Invalid format: Example

Configuration

```
Router#show run ethernet cfm

Tue Nov 16 06:57:14.099 UTC

ethernet cfm
domain test level 3
  service test down-meps
   continuity-check interval 10ms
   mep crosscheck
    mep-id 4
   !
   log continuity-check mep changes
  !
!
!
```

Verification

```
Router#show ethernet  cfm peer meps
Tue Nov 16 06:57:19.027 UTC
Flags:
> - Ok                          I - Wrong interval
R - Remote Defect received      V - Wrong level
L - Loop (our MAC received)     T - Timed out
C - Config (our ID received)    M - Missing (cross-check)
X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
* - Multiple errors received    S - Standby

Domain test (level 3), Service test
```

```
Down MEP on TenGigE0/0/0/0.1 MEP-ID 3
==============================================================================
St     ID MAC Address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ------------ --------- ------ ----- -----
>      4 d46a.355c.b814 Up      00:00:24            0      0     0     0
```

```
Router#show ethernet cfm peer meps detail
Tue Nov 16 06:57:23.567 UTC
Domain test (level 3), Service test
Down MEP on TenGigE0/0/0/0.1 MEP-ID 3
==============================================================================
Peer MEP-ID 4, MAC d46a.355c.b814
   CFM state: Ok, for 00:00:29
   Received CCM handling offloaded to hardware
   Port state: Up
   CCMs received: 0
     Out-of-sequence:             0
     Remote Defect received:      0
     Wrong level:                 0
     Cross-connect (wrong MAID):  0
     Wrong interval:              0
     Loop (our MAC received):     0
     Config (our ID received):    0
   Last CCM received:
     Level: 3, Version: 0, Interval: 10ms
     Sequence number: 0, MEP-ID: 4
     MAID: String: test, String: test
     Port status: Up, Interface status: Up
```

```
Router#show ethernet cfm local meps
Tue Nov 16 06:57:36.672 UTC
Defects (from at least one peer MEP):
A - AIS received                I - Wrong interval
R - Remote Defect received      V - Wrong level
L - Loop (our MAC received)     T - Timed out
C - Config (our ID received)    M - Missing (cross-check)
X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
P - Peer port down              F - CSF received


Domain test (level 3), Service test
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ----------------------- --- -------- -- ------- ---
    3 Te0/0/0/0.1 (Up)         Dn     1/0   N
```

```
Router#show ethernet cfm local meps verbose
Tue Nov 16 06:57:39.015 UTC
Domain test (level 3), Service test
Down MEP on TenGigE0/0/0/0.1 MEP-ID 3
==============================================================================
  Interface state: Up      MAC address: b0c5.3cff.c080
  Peer MEPs: 1 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 0 missing, 0 unexpected

  CCM generation enabled:  Yes, 10ms (Remote Defect detected: No)
                           CCM processing offloaded to hardware
  AIS generation enabled:  No
  Sending AIS:             No
  Receiving AIS:           No
  Sending CSF:             No
  Receiving CSF:           No

  No packets sent/received
Router#
```

AIS for CFM Configuration: Examples

Example 1

This example shows how to configure Alarm Indication Signal (AIS) transmission for a CFM domain service:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# ethernet cfm
RP/0/RP0/CPU0:router(config-cfm)# domain D1 level 1
RP/0/RP0/CPU0:router(config-cfm-dmn)# service S1 bridge group BG1 bridge-domain BD2
RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# ais transmission interval 1m cos 7

RP/0/RP0/CPU0:routerconfigure
RP/0/RP0/CPU0:router(config)# ethernet cfm
RP/0/RP0/CPU0:router(config-cfm)# domain D1 level 1
RP/0/RP0/CPU0:router(config-cfm-dmn)# service Cross_Connect_1 xconnect group XG1 p2p X1
RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# ais transmission interval 1m cos 7
```

Example 2

This example shows how to configure AIS logging for a Connectivity Fault Management (CFM) domain service to indicate when AIS or LCK packets are received:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# ethernet cfm
RP/0/RP0/CPU0:router(config-cfm)# domain D1 level 1
RP/0/RP0/CPU0:router(config-cfm-dmn)# service S2 bridge group BG1 bridge-domain BD2
RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# log ais

RP/0/RP0/CPU0:routerconfigure
RP/0/RP0/CPU0:router(config)# ethernet cfm
RP/0/RP0/CPU0:router(config-cfm)# domain D1 level 1
RP/0/RP0/CPU0:router(config-cfm-dmn)# service Cross_Connect_1 xconnect group XG1 p2p X1
RP/0/RP0/CPU0:router(config-cfm-dmn-svc)# log ais
```

This example shows how to configure AIS transmission on a CFM interface.

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface TenGigE 0/1/0/2
RP/0/RP0/CPU0:router(config-if)# ethernet cfm
RP/0/RP0/CPU0:router(config-if-cfm)# ais transmission up interval 1m cos 7
```

AIS for CFM Show Commands: Examples

This section includes the following examples:

show ethernet cfm interfaces ais Command: Example

This example shows how to display the information published in the Interface AIS table:

```
RP/0/RP0/CPU0:router# show ethernet cfm interfaces ais

Defects (from at least one peer MEP):
 A - AIS received                I - Wrong interval
 R - Remote Defect received      V - Wrong Level
 L - Loop (our MAC received)     T - Timed out (archived)
 C - Config (our ID received)    M - Missing (cross-check)
```

```
 X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
 P - Peer port down              D - Local port down

                            Trigger                  Transmission
                       AIS  ---------    Via    --------------------------
Interface (State)      Dir  L Defects  Levels   L Int Last started  Packets
---------------------- ---  - -------  -------  - --- ------------ --------
TenGigE0/0/0/0 (Up)     Dn   5 RPC      6        7 1s  01:32:56 ago     5576
TenGigE0/0/0/0 (Up)     Up   0 M        2,3      5 1s  00:16:23 ago      983
TenGigE0/0/0/1 (Dn)     Up     D                7 60s 01:02:44 ago     3764
TenGigE0/0/0/2 (Up)     Dn   0 RX       1!
```

show ethernet cfm local meps Command: Examples

Example 1: Default

This example shows how to display statistics for local maintenance end points (MEPs):

```
RP/0/RP0/CPU0:router# show ethernet cfm local meps

 A - AIS received                I - Wrong interval
 R - Remote Defect received      V - Wrong Level
 L - Loop (our MAC received)     T - Timed out (archived)
 C - Config (our ID received)    M - Missing (cross-check)
 X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
 P - Peer port down

Domain foo (level 6), Service bar
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
  100 Gi1/1/0/1 (Up)       Up     0/0   N  A       7

Domain fred (level 5), Service barney
   ID Interface (State)        Dir MEPs/Err RD Defects AIS
----- ------------------------ --- -------- -- ------- ---
    2 Gi0/1/0/0 (Up)       Up     3/2   Y  RPC     6
```

Example 2: Domain Service

This example shows how to display statistics for MEPs in a domain service:

```
RP/0/RP0/CPU0:router# show ethernet cfm local meps domain foo service bar detail

Domain foo (level 6), Service bar
Down MEP on TenGigE0/0/0/1, MEP-ID 100
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 0 up, 0 with errors, 0 timed out (archived)

  CCM generation enabled:  No
  AIS generation enabled:  Yes (level: 7, interval: 1s)
  Sending AIS:             Yes (started 01:32:56 ago)
  Receiving AIS:           Yes (from lower MEP, started 01:32:56 ago)

Domain fred (level 5), Service barney
Down MEP on TenGigE0/0/0/1, MEP-ID 2
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 3 up, 2 with errors, 0 timed out (archived)
  Cross-check defects: 0 missing, 0 unexpected
```

```
  CCM generation enabled:  Yes (Remote Defect detected: Yes)
  CCM defects detected:    R - Remote Defect received
                           P - Peer port down
                           C - Config (our ID received)
  AIS generation enabled:  Yes (level: 6, interval: 1s)
  Sending AIS:             Yes (to higher MEP, started 01:32:56 ago)
  Receiving AIS:           No
```

Example 4: Detail

This example shows how to display detailed statistics for MEPs in a domain service:

```
RP/0/RP0/CPU0:router# show ethernet cfm local meps detail

Domain foo (level 6), Service bar
Down MEP on TenGigE0/0/0/1, MEP-ID 100
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 0 up, 0 with errors, 0 timed out (archived)

  CCM generation enabled:  No
  AIS generation enabled:  Yes (level: 7, interval: 1s)
  Sending AIS:             Yes (started 01:32:56 ago)
  Receiving AIS:           Yes (from lower MEP, started 01:32:56 ago)

Domain fred (level 5), Service barney
Down MEP on TenGigE0/0/0/1, MEP-ID 2
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 3 up, 2 with errors, 0 timed out (archived)
  Cross-check defects: 0 missing, 0 unexpected

  CCM generation enabled:  Yes (Remote Defect detected: Yes)
  CCM defects detected:    R - Remote Defect received
                           P - Peer port down
                           C - Config (our ID received)
  AIS generation enabled:  Yes (level: 6, interval: 1s)
  Sending AIS:             Yes (to higher MEP, started 01:32:56 ago)
  Receiving AIS:           No
```

show ethernet cfm local meps detail Command: Example

Use the **show ethernet cfm local meps detail** command to display MEP-related EFD status information. This example shows that EFD is triggered for MEP-ID 100:

```
RP/0/RP0/CPU0:router# show ethernet cfm local meps detail

Domain foo (level 6), Service bar
Down MEP on TenGigE0/0/0/1, MEP-ID 100
================================================================================
  Interface state: Up      MAC address: 1122.3344.5566
  Peer MEPs: 0 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 2 missing, 0 unexpected

  CCM generation enabled:  No
  AIS generation enabled:  Yes (level: 7, interval: 1s)
  Sending AIS:             Yes (started 01:32:56 ago)
  Receiving AIS:           Yes (from lower MEP, started 01:32:56 ago)
  EFD triggered:           Yes

Domain fred (level 5), Service barney
```

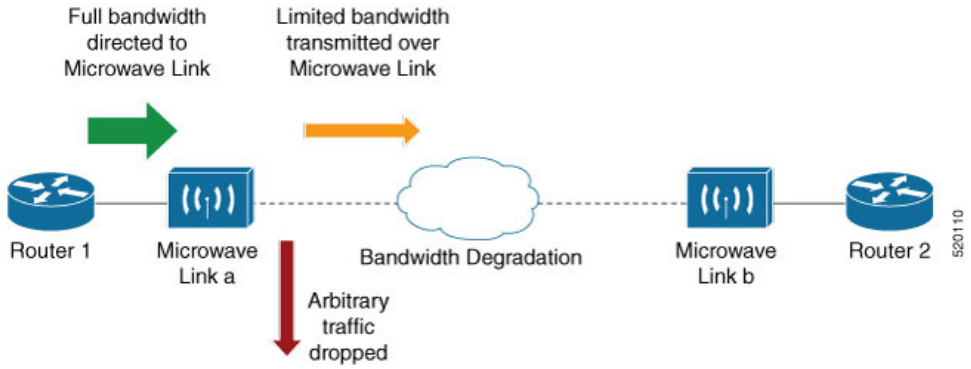
```
Down MEP on TenGigE0/0/0/1, MEP-ID 2
==============================================================================
  Interface state: Up       MAC address: 1122.3344.5566
  Peer MEPs: 3 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 0 missing, 0 unexpected

  CCM generation enabled:  Yes (Remote Defect detected: No)
  AIS generation enabled:  Yes (level: 6, interval: 1s)
  Sending AIS:             No
  Receiving AIS:           No
  EFD triggered:           No
```

Note You can also verify that EFD has been triggered on an interface using the **show interfaces** and **show interfaces brief** commands. When an EFD trigger has occurred, these commands will show the interface status as *up* and the line protocol state as *down*.

CFM Adaptive Bandwidth Notifications

Microwave links are used in carrier ethernet networks, because they are cheaper than laying fibre either in dense metro areas or rural locations. However, the disadvantage of microwave links is that the signal is affected by atmospheric conditions and can degrade.

Modern microwave devices support adaptive modulation schemes to prevent a complete loss of signal. This allows them to continue to operate during periods of degradation, but at a reduced bandwidth. However, to fully take advantage of this, it's necessary to convey the decrease in bandwidth to the head-end router so that appropriate actions can be taken. Otherwise, the link may become saturated and traffic dropped arbitrarily as shown in the following figure:



A generic solution to this is a Connectivity Fault Management (CFM) extension to send Bandwidth Notifications Messages (BNM) to Maintenance Endpoints (MEPs) on the corresponding interface on the head-end router. To be flexible in the actions taken, the choice of solution uses Embedded Event Manager (EEM) to invoke operator written TCL scripts. For information on EEM, see Embedded Event Manager, on page 146.

Bandwidth Notification Messages

The two types of messages used to notify the head-end router are:

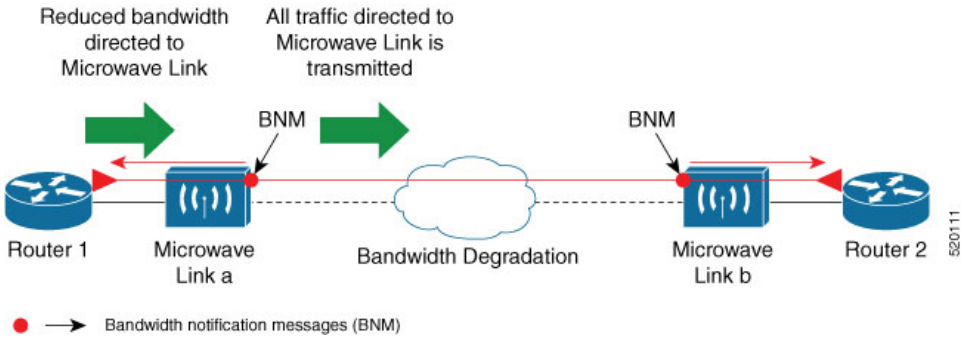
- G.8013 Bandwidth Notification Messages (G.8013 BNM)

- Cisco proprietary Bandwidth Vendor-Specific Messages (Cisco BW-VSM)

Both the message types contain the following information:

- Source MAC
- Port ID
- Maintenance Domain (MD) Level
- Transmission period
- Nominal Bandwidth
- Current Bandwidth

During signal degradation, periodic BNMs are sent to the head-end router containing the current bandwidth (sampled over a period of time) and nominal bandwidth (full bandwidth when there is no degradation). This allows the router to reduce the bandwidth directed to the link as shown in the figure below:



When degradation in bandwidth is detected, depending on the topology, the degradation may affect one or more paths in the network. Therefore, in more complex topologies, the head-end router may need information about links in each affected path. The BNM transmission period and a Link ID are used to differentiate between messages from the same source MAC address which refer to different links.

Restrictions for CFM Bandwidth Notifications

The list of restrictions for CFM Bandwidth Notifications is:

- Up to 200 unique BNM enabled links learnt from BNMs are supported per line card. Any BNMs for links over this limit will be discarded.

  To reset CFM BNM enabled links for the specified interfaces, use the `clear ethernet cfm interface [ <interface> ] bandwidth-notifications { all | state <state> } [ location { all | <node> } ]` command. An archive timer is used to clean up any BNM enabled links whose loss timer expired at least 24 hours ago.

- Over process restart:
  - Loss threshold, wait-to-restore, and hold-off timers are restarted. This may cause links to take longer to transition between states than they would have otherwise.
  - Archive timers are restarted. This may cause historical statistics for links to persist longer than they would have otherwise.

- Queued events for EEM scripts which have been rate-limited are not preserved. Scripts with at least one link in DEGRADED state, or BNMs have changed over process restart, and are invoked. Rate-limit timers are restarted. This may cause scripts to be invoked when they would otherwise have been filtered by the damping or conformance-testing algorithms. If the last link returns to its nominal bandwidth within the rate-limit period but before the process restart, then the script will not be invoked after the process restart. Thus, actions taken by the script may not reflect the (increased) latest bandwidths of any links which returned to their nominal bandwidths within the rate-limit period.

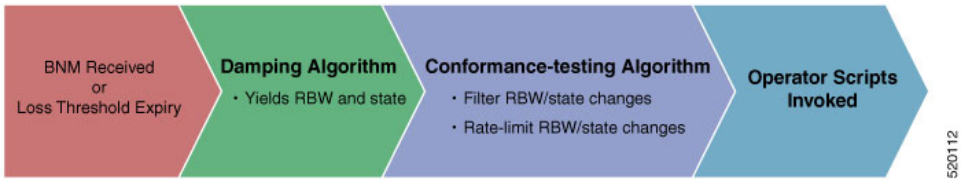
Bandwidth Reporting

Received BNMs are used to identify BNM enabled links within a Maintenance Entity Group (MEG), and should be uniquely identifiable within the MEG by Port-ID or MAC address. Each link has an associated nominal bandwidth, and a Reported Bandwidth (RBW), which are notified to the operator. The link is considered to be in OK state when the RBW is equal to the nominal bandwidth and DEGRADED if RBW is less than nominal.

Devices sending BNMs can detect changes in bandwidth many times a second. For example, changes caused by an object passing through a microwave link's line of sight. The protocol for sending BNMs is designed to mitigate fluctuating current bandwidth by sampling across a 'monitoring-interval' and applying basic damping to degradation events. To help mitigate this further, a damping algorithm is used. This algorithm is applied on the receiving device, and is distinct from any damping performed by the sender. For more information on this, see Damping Algorithm, on page 145.

An operator may be interested in more than one BNM enabled link, and needs the ability to register on a set of BNM enabled links which affect the path to a node in the network. To do this, the state and RBW for each link of interest are put into a conformance testing algorithm, which both filters and rate-limits changes to publish events notifying the operator only of significant changes. For more information on this, see Conformance Testing Algorithm, on page 146.

The following diagram shows how a received BNM flows through the damping and conformance testing algorithm to invoke operator scripts:



Note

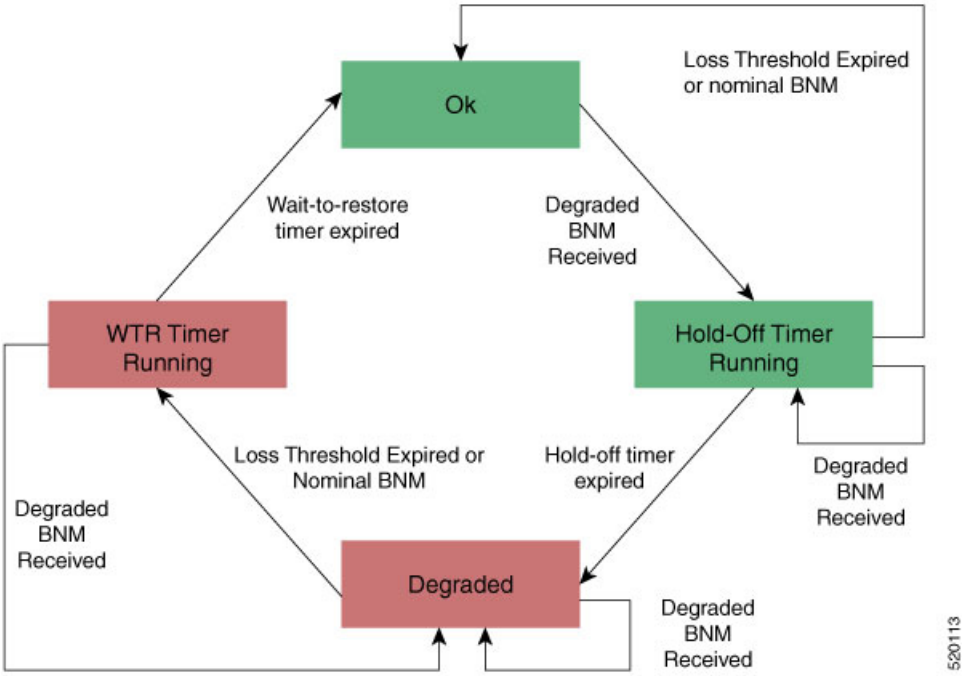
- Port ID takes precedence over MAC address. This means that BNMs with same port ID but different MAC addresses are counted as same BNMs.
- If BNM reported bandwidth is equal to the threshold, then EEM will not be invoked.
- If a degraded link having bandwidth higher than the threshold receives BNM with bandwidth less than the threshold, it doesn't wait for the hold-off timer and instantly changes the bandwidth by invoking EEM script.

Damping Algorithm

A damping algorithm is applied to each unique BNM enabled link for which BNMs are received. The table below describes the timers used for this purpose:

Timers	Description
loss threshold (in packet numbers)	This timer handles the case when BNMs stop being received. This timer is (re)started whenever any BNM is received for the link. The value is equal to the expected period between BNMs (as indicated by the last BNM) multiplied by the configured loss threshold. When the loss threshold timer expires, as the link may have changed or been removed entirely, bandwidth information is no longer available, therefore the link is considered to have been restored to its previously notified nominal bandwidth.
hold-off (in seconds)	This timer is used to damp transient transitions from OK to DEGRADED state. It is started when the first degraded BNM is received, and is stopped if the loss threshold timer expires or the current bandwidth returns to the nominal bandwidth. If the timer expires, then the BNM enabled link enters DEGRADED state. The value of this timer is configurable. If it is zero, then the link immediately enters degraded state and the timer is not started.
wait-to-restore (WTR, in seconds)	This timer is used to damp transient transitions from DEGRADED to OK state. It is started when a BNM Enabled Link is in DEGRADED state and either the loss threshold timer expires or a BNM is received that indicates the current bandwidth has returned to the nominal bandwidth. If a degraded BNM is received while the timer is running then it is stopped and the BNM Enabled Link remains in DEGRADED state. If this timer expires then the link returns to OK state.

The following internal state transition diagram shows how damping algorithm takes place:



Conformance Testing Algorithm

The conformance testing algorithm comprises of two parts:

1. Filtering bandwidth changes.

   Filtering is done so that events are published whenever either:

   - Any link which was in OK state or had a RBW more than or equal to the specified threshold, has transitioned to DEGRADED state and has a RBW less than the specified threshold.
   - Any link which was in DEGRADED state and had a RBW less than the specified threshold, is still in DEGRADED state and has a RBW less than the specified threshold, but the old and new RBWs are different.
   - Any link which was in DEGRADED state and had a RBW less than the specified threshold, has transitioned to OK state or has a RBW more than or equal to the specified threshold.

2. Rate-limiting bandwidth changes

   Rate-limiting is done by only publishing events at most once within any rate-limit period. If there is a change in bandwidth (which passes the filter) within this rate-limit period, a timer is started to expire at the end of the period. Upon timer expiry, an event is published which reflects the latest state and bandwidth of all links of interest which are in DEGRADED state.

Embedded Event Manager

The Embedded Event Manager (EEM) consists of an EEM server that monitors various real-time events in the system using programs called Event Detectors (EDs) and triggers registered policies (for example, TCLscripts) to run. The EEM supports at least 200 script registrations.

Typical actions taken in response to signal degradation events include:

- Signaling to G.8032 to switch some flows to alternative paths
- Modifying QoS configuration to adjust traffic shaping to the new bandwidth
- Adjusting IGP metrics to switch some traffic to an alternative path

The following variables can be queried within the TCL script:

EEM Variables	Comment
`interface, level, direction`	Identify the MEP in the registration
`min_reported_bandwidth`	Minimum reported bandwidth across all links in the registration that are currently in DEGRADED state, and below the specified threshold
`bnm_enabled_links [{ MAC address | Port ID }]`	Array of BNM enabled links, with each one containing the following elements: • `reported_bw`: Reported Bandwidth • `nominal_bw`: Nominal BW in last BNM
`event_type`	Either 'DEGRADED' or 'OK' DEGRADED indicates that at least one BNM enabled link in the registration is in DEGRADED state with a reported bandwidth less than the threshold. This means that the `event_type` could be 'OK' if all BNM enabled links in the registration which are in DEGRADED state have a reported bandwidth greater than or equal to the threshold.

The command for EEM TCL scripts registering for CFM Bandwidth Notification events is `interface <interface name> level <level> direction <direction> {mac-addresses { <addr1> [, …, <addr20>] } | port-ids { <id1> [, …, <id20>] } threshold <bandwidth> [ ratelimit <time> ].`

To configure EEM, use the following commands:

```
event manager directory user policy disk0:/
event manager directory user library disk0:/
event manager policy EEMscript7.tcl username root persist-time 3600
aaa authorization eventmanager default local
```

Individual scripts located in the specified directory can then be configured with:

```
event manager policy <script_name> username lab persist-time <time>
```

Event Publishing

CFM publishes events for a given EEM registration after applying the damping and conformance testing algorithms as described in Damping Algorithm, on page 145 and Conformance Testing Algorithm, on page 146 respectively. The set of BNM Enabled Links published in an event are those in DEGRADED state and whose RBW is less than the specified threshold.

Configure CFM Bandwidth Notifications

Use the following steps to configure CFM bandwidth notifications:

- Configure a CFM domain at the level BNMs are expected to be received at, and a CFM service in the direction (either up or down-MEPs) the BNMs are expected to be received.
- Configure a CFM MEP on the interface expected to receive BNMs in the domain and service above.

Configuration consists of two parts:

- Configuring global CFM. This is similar to Continuity Check Message (CCM) and other CFM configurations.

  Global CFM configuration:

  ```
  ethernet cfm
  domain DM1 level 2 id null
    service SR1 down-meps
    !
  !
  domain dom1 level 1
    service ser1 down-meps
    !
  !
  ```

- Configuration related to CFM-BNMs under interfaces. This is optional and used for changing default values.

Interface configuration:

```
Interface TenGigE0/0/1/1
ethernet cfm
  mep domain DM1 service SR1 mep-id 3001
  !
  bandwidth-notifications
   hold-off 0
   wait-to-restore 60
   loss-threshold 10
   log changes
  !
!
l2transport
!
!
interface TenGigE0/0/0/3
ethernet cfm
  mep domain dom1 service ser1 mep-id 11
  !
  bandwidth-notifications
  hold-off 10
   wait-to-restore 40
   log changes
  !
!
l2transport
!
!
```

Running Configuration

```
RP/0/RP0/CPU0:router#show running-configuration
!! IOS XR Configuration 7.1.1.104I
```

```
!! Last configuration change at Mon Jun 24 21:26:46 2019 by root
!
hostname R2_cXR
logging console debugging
logging buffered 125000000
event manager directory user policy harddisk:/tcl/
event manager directory user library harddisk:/tcl/
event manager policy EEMmac_lev1.tcl username root persist-time 3600
event manager policy EEMport_lev1.tcl username root persist-time 3600
aaa authorization exec default local group tacacs+
aaa authorization eventmanager default local
!
ethernet cfm
 domain DM0 level 1 id null
  service SR0 down-meps
   continuity-check interval 1m
   mep crosscheck
    mep-id 1003
   !
   ais transmission interval 1s cos 4
   log ais
   log continuity-check errors
   log crosscheck errors
   log continuity-check mep changes
  !
 !
 domain DM1 level 2 id null
  service SR1 down-meps id number 1
   continuity-check interval 1m
   mep crosscheck
    mep-id 431
   !
   ais transmission interval 1m
   log ais
   log continuity-check errors
   log crosscheck errors
   log continuity-check mep changes
  !
 domain dom1 level 3 id string domain3
  service ser1 xconnect group XG1 p2p XC1 id number 2300
   mip auto-create all
   continuity-check interval 1m
   mep crosscheck
    mep-id 2030
   !
interface Loopback0
 ipv4 address 30.30.30.30 255.255.255.255
!
interface MgmtEth0/RSP0/CPU0/0
 ipv4 address 5.18.9.102 255.255.0.0
!
interface MgmtEth0/RSP0/CPU0/1
 shutdown
!
interface TenGigE0/0/0/0
 shutdown
!
interface TenGigE0/0/0/3.1 l2transport
 encapsulation dot1q 6
 ethernet cfm
  mep domain DM1 service SR1 mep-id 231
  !
  bandwidth-notifications
   hold-off 50
```

```
   wait-to-restore 50
   loss-threshold 100
   log changes
  !
```

Verification

```
RP/0/RP0/CPU0:router#show ethernet cfm interfaces bandwidth-notifications detail
BNM Enabled Links at Level 3 (Down MEP) for GigabitEthernet/1
    MAC Address 000a.000a.000a
      State (OK):
        Nominal Bandwidth:                                  3000 Mbps
        Reported Bandwidth:                                 1000 Mbps
        Elapsed time in this state:                   00:00:13.000
        Transitions into degraded state:                      5000
        Hold-off:                                    111s remaining
      Last BNM received 00:00:10 ago
        Nominal Bandwidth:                                  1000 Mbps
        Current Bandwidth:                                  2000 Mbps
        Interval:                                             10s
        Packet-type:                                  Cisco BW-VSM
      Packets received:                                      20000

    Port ID 7 (MAC Address 000c.000c.000c)
      State (DEGRADED):
        Nominal Bandwidth:                                  6000 Mbps
        Reported Bandwidth:                                 2000 Mbps
        Elapsed time in this state:                   00:00:39.000
        Transitions into degraded state:                     10000
        Wait-to-restore:                             111s remaining
      Last BNM received 00:00:33 ago
        Nominal Bandwidth:                                  2000 Mbps
        Current Bandwidth:                                  4000 Mbps
        Interval:                                             1min
        Packet-type:                                  Cisco BW-VSM
      Packets received:                                      40000
```

CFM Over Bundles

CFM over bundle supports the following:

- CFM Maintenance Points—Up Maintenance-association End Points (MEP), Down MEP, and MIP, which includes L2 bundle main and sub-interfaces.
- CCM interval of 100 microsecond, 1second, 10 seconds, and 1 minute. CCM interval of 10 minutes is supported only in the versions earlier than IOS XR 7.3.2.
- RP OIR/VM reload, without impacting learned CFM peer MEPs.
- Process restart without impacting CFM sessions.
- CFM MEPs on bundle interfaces as software-offloaded-MEPs with all possible rewrite and encapsulation combinations supported by L2 sub-interfaces.
- CCM learning on MIP over bundle interfaces. CCM database learning supports investigation of one CCM out of 50 that goes over MIP.
- Static and dynamic Remote MEPs.

Restrictions for Configuration of CFM on Bundles

Following are the restrictions for configuring CFM:

- Only Layer 2 bundle Ethernet interfaces and sub-interfaces are supported except for those matching the VLAN tag `any`.
- CCM interval of 3.3 milliseconds and 10 milliseconds are not supported.
- CCM interval of 10 minutes is not supported from IOS XR 7.3.2.
- Supports 5000 pps rates of CCM traffic for bundle interfaces. For example, for CCM interval of 100 milliseconds, the number of MEPs can be 500.
- Ethernet CFM is not supported with MEP that are configured on default and untagged encapsulated sub-interfaces that are part of a single physical interface.
- CCM packets, being OAM data packets, cannot be prioritized over normal data traffic when using a policer; if traffic exceeds the configured rate, CCM packets might be dropped. To prevent interface flaps caused by CCM packet drops, configure a separate class map to prioritize CCM packets.

CFM with SAT and EDPL

CFM can run along with SAT (Service Activation Test) session on the same interface. Both works independent of each other.

However, other OAM sessions like SLM and DMM will go down during the SAT session. They get restored once the SAT session is completed. This is expected as per requirements.

Limitations and Restrictions

- SAT session works similar to MD-level 7 session. So, CFM sessions, on same interface, will have to be at levels lower than 7, i.e 0 to 6.

Example:

The below setup is an example:

```
Interface 1           ---------------------        Interface 2
         CFM (MDL 0 to 6)      ---------------------        CFM (MDL 0 to 6)
         DMM/SLM               ----------------             DMM/SLM
         SAT                   --------------               EDPL (with DestMac)
```

Note

- DMM/SLM goes down when SAT is active. They get restored once SAT session is completed.
- Ethernet Data Plane Loopback functionality (EDPL) does not support multicast destination MAC address packets for NCS 5700 line cards. So, it is recommended to use EDPL on peer node with filter - Destination_MAC (same as the destination of the SAT session).
- CCM have multicast destination MAC(0180.c200.003x).

CFM over Static L2VPN and LSP with Single-Pass GRE Tunnel

Table 15: Feature History Table

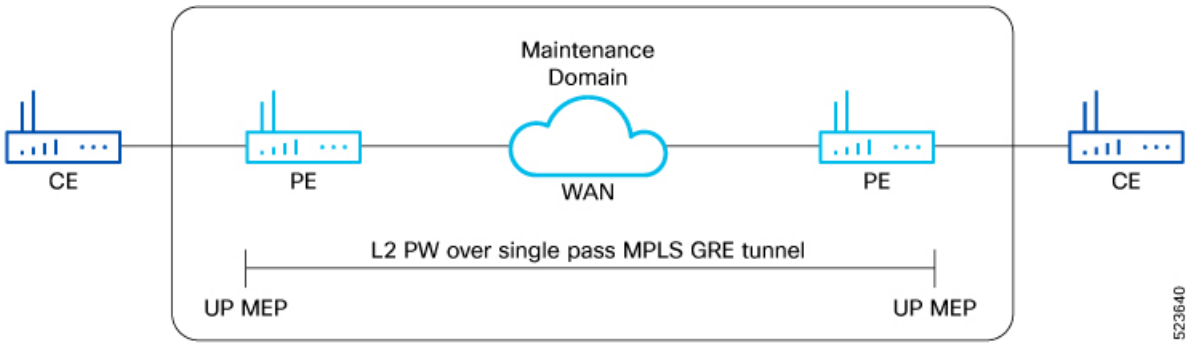
Feature Name	Release Information	Description
CFM over Static L2VPN and LSP with Single-Pass GRE Tunnel	Release 24.1.1	Introduced in this release on: NCS 5500 fixed port routers (select variants only*); NCS 5500 modular routers (select variants only*) By activating Connectivity Fault Management (CFM) when using GRE tunnel as the underlying transport mechanism, you can now monitor and isolate faults within a maintenance domain. CFM is now available over static L2VPN and LSP with single-pass GRE tunnels on your PE routers. It helps check if L2VPN services are working and possibly take corrective actions if they aren't. This capability enhances tunnel health monitoring and fault identification across the pseudowire (PW) tunnel between edge routers.

Using CFM over L2 pseudowire on single-pass MPLS GRE tunnels, you can now identify connectivity issues in a tunnel between PE routers. Previously, the support for CFM over MPLS GRE tunnels wasn't available. To know more about CFM functionality and its configuration, see Ethernet CFM, on page 96.

Topology

Let's understand how the CFM capability works over L2 PW tunnels using a sample topology.

Figure 12: Sample Topology



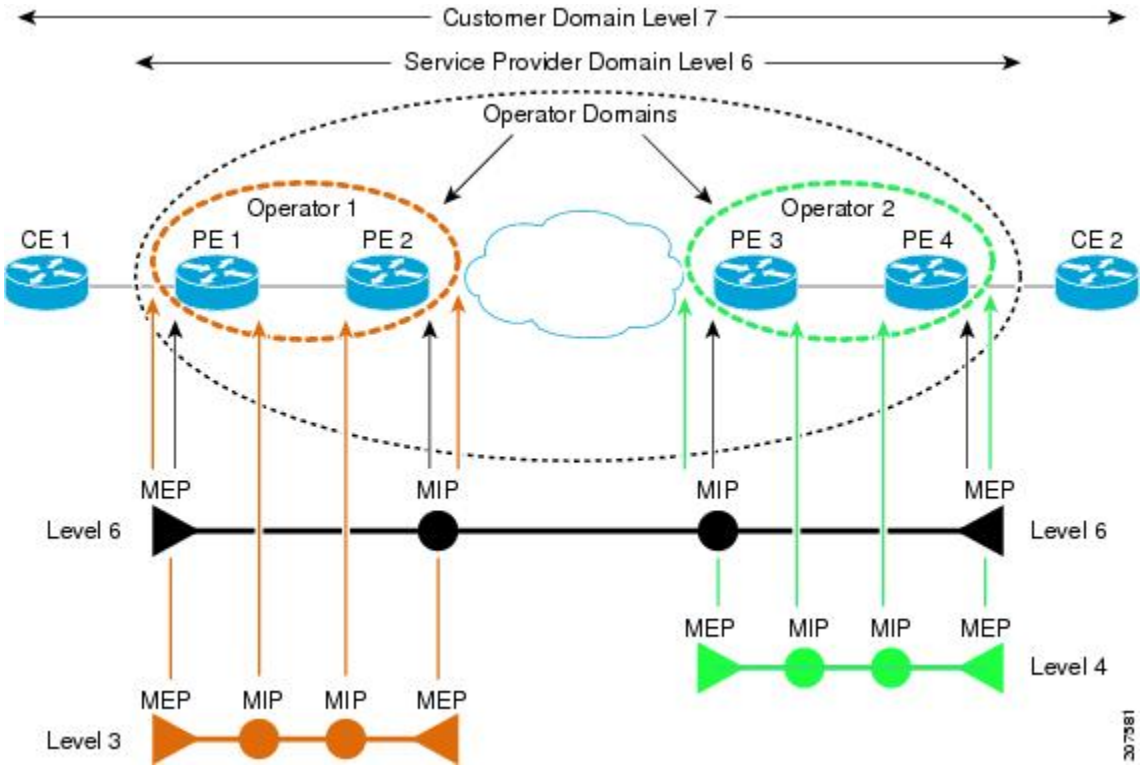
In this topology,

- The provider edge (PE) routers connect to customer on-premise equipment (CE).
- Two UP Maintenance End Points (MEPs) at the edge of the maintenance domain connect via an L2 PW on a single-pass MPLS GRE tunnel with a label-switched path (LSP).

  For more information on MEPs, see **Maintenance Points**.

The preceding topology is a subsection of the different CFM maintenance domains configured across a network, as shown in the following figure.

Figure 13: Different CFM Maintenance Domains Across a Network



CFM is configured with UP-UP connections at the PE routers through WAN. CFM PDUs are based on the Y.1731 standard. The PDUs travel through the L2 PW over an MPLSoGRE tunnel between the UP MEPs. For more information, see **MEP and CFM Processing Overview** and CFM Protocol Messages, on page 103.

The MEPs send Continuity Check Messages (CCMs) periodically to verify the connection between the PE routers. If the MEP detects a fault, it sends an Alarm Indication Signal (AIS) message. The AIS messages are sent via multicast similar to CCMs. However, unlike CCMs, AIS messages are sent in the direction away from the peer remote MEPs and towards the higher domain level than the sender MEP. As a result, the faults detected in one Maintenance Association (MA) are notified to the MA at the higher level. An example use case is to notify a customer network of the faults in the service provider network.

An interface without MEPs can also send AIS messages if it has a Maintenance Intermediate Point (MIP). In this case, the only fault that triggers the AIS message is the interface state going down. The MIPs forward the AIS messages to the bridge at their level without responding to the message. On receiving the AIS message at the bridge, the MEPs begin sending the AIS message to the next higher domain level. The process repeats until the message propagates to the highest-level domain. For more information on MIPs, see MIP Creation, on page 100.

Restrictions for CFM over Static L2VPN and LSP with Single-Pass GRE Tunnel

- Support for CFM over L2oMPLS with two-pass GRE tunnel isn't available.
- Y.1731 performance monitoring isn't available for this feature.
- Only select platform variants support this feature.

Supported Platform Variants for CFM over Static L2VPN and LSP with Single-Pass GRE Tunnel

The following table lists the platform variants that support this feature.

Table 16: Supported Platform Variants

NCS 5500 fixed port routers	NCS-55A1-24H NCS-55A1-36H-S NCS-55A1-36H-SE-S NCS-55A1-48Q6H NCS-55A1-24Q6H-S NCS-55A1-24Q6H-SS
NCS 5500 modular routers	NC55-36x100G-A-SE

Configure CFM over Static L2VPN and LSP with Single-Pass GRE Tunnel

This section describes how to configure CFM over MPLS GRE tunnel, while also considering the following aspects:

- GRE tunnel is configured in a single-pass encapsulation mode.
- Policy Based Routing (PBR) decapsulation is used for single-pass GRE decapsulation.
- L2VPN “Control word” is supported along with the single-pass GRE tunnel.
- Single-pass PBR decapsulation configuration is used for GRE decapsulation.

Configuration Example

PE1:

```
RP/0/RP0/CPU0:ios#configure
RP/0/RP0/CPU0:ios(config)#class-map type traffic match-all test_gre1
RP/0/RP0/CPU0:ios(config-cmap)#match protocol gre
RP/0/RP0/CPU0:ios(config-cmap)#match source-address ipv4 198.51.100.101 255.255.255.0
RP/0/RP0/CPU0:ios(config-cmap)# end-class-map
RP/0/RP0/CPU0:ios(config)#policy-map type pbr P1-test
RP/0/RP0/CPU0:ios(config-pmap)#class type traffic test_gre1
RP/0/RP0/CPU0:ios(config-pmap-c)#decapsulate gre
RP/0/RP0/CPU0:ios(config-pmap-c)#exit
RP/0/RP0/CPU0:ios(config-pmap)#class type traffic class-default
RP/0/RP0/CPU0:ios(config-pmap-c)#exit
RP/0/RP0/CPU0:ios(config-pmap)#end-policy-map
RP/0/RP0/CPU0:ios(config)#vrf-policy
```

```
RP/0/RP0/CPU0:ios(config-vrf-policy)#vrf default address-family ipv4 policy type pbr input
 P1-test
RP/0/RP0/CPU0:ios(config-vrf-policy)#exit
RP/0/RP0/CPU0:ios(config)#interface Loopback0
RP/0/RP0/CPU0:ios(config-if)#ipv4 address 198.51.100.100 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#interface Loopback11
RP/0/RP0/CPU0:ios(config-if)#ipv4 address 10.11.11.11 255.0.0.0
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#interface Bundle-ether100
RP/0/RP0/CPU0:ios(config-if)#interface Bundle-ether100.1 l2transport
RP/0/RP0/CPU0:ios(config-subif)#encapsulation dot1q 1
RP/0/RP0/CPU0:ios(config-subif)#ethernet cfm
RP/0/RP0/CPU0:ios(config-if-cfm)#mep domain UP6 service s61 mep-id 1
RP/0/RP0/CPU0:ios(config-if-cfm-mep)#exit
RP/0/RP0/CPU0:ios(config-if-cfm)#interface TenGigE0/0/0/16/0
RP/0/RP0/CPU0:ios(config-if)#bundle id 100
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#interface TenGigE0/0/0/17/1
RP/0/RP0/CPU0:ios(config-if)#ipv4 address 10.18.18.1 255.0.0.0
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#interface tunnel-ip100
RP/0/RP0/CPU0:ios(config-if)#ipv4 address 198.51.100.111 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)#tunnel mode gre ipv4 encap
RP/0/RP0/CPU0:ios(config-if)#tunnel source 198.51.100.100
RP/0/RP0/CPU0:ios(config-if)#tunnel destination 198.51.100.101
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#router static
RP/0/RP0/CPU0:ios(config-static)#address-family ipv4 unicast
RP/0/RP0/CPU0:ios(config-static-afi)#10.22.22.22/32 tunnel-ip100
RP/0/RP0/CPU0:ios(config-static-afi)#exit
RP/0/RP0/CPU0:ios(config-static)#exit
RP/0/RP0/CPU0:ios(config)#router bgp 100
RP/0/RP0/CPU0:ios(config-bgp)#nsr
RP/0/RP0/CPU0:ios(config-bgp)#bgp router-id 198.51.100.100
RP/0/RP0/CPU0:ios(config-bgp)#bgp graceful-restart
RP/0/RP0/CPU0:ios(config-bgp)#bgp log neighbor changes detail
RP/0/RP0/CPU0:ios(config-bgp)#address-family ipv4 unicast
RP/0/RP0/CPU0:ios(config-bgp-af)#maximum-paths ebgp 64
RP/0/RP0/CPU0:ios(config-bgp-af)#neighbor 198.51.100.101
RP/0/RP0/CPU0:ios(config-bgp-nbr)#remote-as 300
RP/0/RP0/CPU0:ios(config-bgp-nbr)#ebgp-multihop 10
RP/0/RP0/CPU0:ios(config-bgp-nbr)#update-source Loopback0
RP/0/RP0/CPU0:ios(config-bgp-nbr)#address-family ipv4 unicast
RP/0/RP0/CPU0:ios(config-bgp-nbr-af)#next-hop-self
RP/0/RP0/CPU0:ios(config-bgp-nbr-af)#route-policy pass-all in
RP/0/RP0/CPU0:ios(config-bgp-nbr-af)#route-policy pass-all out
RP/0/RP0/CPU0:ios(config-bgp-nbr-af)#exit
RP/0/RP0/CPU0:ios(config-bgp-nbr)#exit
RP/0/RP0/CPU0:ios(config-bgp)#l2vpn
RP/0/RP0/CPU0:ios(config-l2vpn)#pw-class controlword
RP/0/RP0/CPU0:ios(config-l2vpn-pwc)#encapsulation mpls
RP/0/RP0/CPU0:ios(config-l2vpn-pwc-mpls)#control-word
RP/0/RP0/CPU0:ios(config-l2vpn-pwc-mpls)#exit
RP/0/RP0/CPU0:ios(config-l2vpn-pwc)#exit
RP/0/RP0/CPU0:ios(config-l2vpn)#xconnect group 1
RP/0/RP0/CPU0:ios(config-l2vpn-xc)#p2p 1
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p)#interface Bundle-ether100.1
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p)#neighbor ipv4 10.22.22.22 pw-id 1
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p-pw)#mpls static label local 25011 remote 25022
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p-pw)#pw-class controlword
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p-pw)#exit
```

```
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p)#exit
RP/0/RP0/CPU0:ios(config-l2vpn-xc)#exit
RP/0/RP0/CPU0:ios(config-l2vpn)#exit
RP/0/RP0/CPU0:ios(config)#mpls static
RP/0/RP0/CPU0:ios(config-mpls-static)#interface TenGigE0/0/0/17/1
RP/0/RP0/CPU0:ios(config-mpls-static)#address-family ipv4 unicast
RP/0/RP0/CPU0:ios(config-mpls-static-af)#exit
RP/0/RP0/CPU0:ios(config-mpls-static)#lsp v4_gre_mpls_1
RP/0/RP0/CPU0:ios(config-mpls-static-lsp)#in-label 24022 allocate per-prefix 10.22.22.22/32
RP/0/RP0/CPU0:ios(config-mpls-static-lsp)#forward
RP/0/RP0/CPU0:ios(config-mpls-static-lsp-fwd)#path 1 nexthop tunnel-ip100 out-label pop
RP/0/RP0/CPU0:ios(config-mpls-static-lsp-fwd)#exit
RP/0/RP0/CPU0:ios(config-mpls-static-lsp)#exit
RP/0/RP0/CPU0:ios(config-mpls-static)#exit
RP/0/RP0/CPU0:ios(config)#ethernet cfm
RP/0/RP0/CPU0:ios(config-cfm)#domain UP6 level 6 id null
RP/0/RP0/CPU0:ios(config-cfm-dmn)#service s6 xconnect group 1 p2p 1 id number 6
RP/0/RP0/CPU0:ios(config-cfm-dmn-svc)#continuity-check interval 100ms
RP/0/RP0/CPU0:ios(config-cfm-dmn-svc)#mep crosscheck
RP/0/RP0/CPU0:ios(config-cfm-xcheck)#mep-id 4001
RP/0/RP0/CPU0:ios(config-cfm-xcheck)#exit
RP/0/RP0/CPU0:ios(config-cfm-dmn-svc)#end
Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:yes
```

PE2:

```
RP/0/RP0/CPU0:ios#configure
RP/0/RP0/CPU0:ios(config)#class-map type traffic match-all test_gre1
RP/0/RP0/CPU0:ios(config-cmap)#match protocol gre
RP/0/RP0/CPU0:ios(config-cmap)#match source-address ipv4 198.51.100.100 255.255.255.0
RP/0/RP0/CPU0:ios(config-cmap)# end-class-map
RP/0/RP0/CPU0:ios(config)#policy-map type pbr P1-test
RP/0/RP0/CPU0:ios(config-pmap)#class type traffic test_gre1
RP/0/RP0/CPU0:ios(config-pmap-c)#decapsulate gre
RP/0/RP0/CPU0:ios(config-pmap-c)#exit
RP/0/RP0/CPU0:ios(config-pmap)#class type traffic class-default
RP/0/RP0/CPU0:ios(config-pmap-c)#exit
RP/0/RP0/CPU0:ios(config-pmap)#end-policy-map
RP/0/RP0/CPU0:ios(config)#vrf-policy
RP/0/RP0/CPU0:ios(config-vrf-policy)#vrf default address-family ipv4 policy type pbr input
 P1-test
RP/0/RP0/CPU0:ios(config-vrf-policy)#exit
RP/0/RP0/CPU0:ios(config)#interface Loopback0
RP/0/RP0/CPU0:ios(config-if)#ipv4 address 198.51.100.101 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#interface Loopback22
RP/0/RP0/CPU0:ios(config-if)#ipv4 address 10.22.22.22 255.255.255.255
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#interface tunnel-ip100
RP/0/RP0/CPU0:ios(config-if)#ipv4 address 198.51.100.112 255.255.255.0
RP/0/RP0/CPU0:ios(config-if)#tunnel mode gre ipv4 encap
RP/0/RP0/CPU0:ios(config-if)#tunnel source 198.51.100.101
RP/0/RP0/CPU0:ios(config-if)#tunnel destination 198.51.100.100
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#interface TenGigE0/0/0/24
RP/0/RP0/CPU0:ios(config-if)#ipv4 address 10.18.18.2 255.0.0.0
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#interface Bundle-ether100
RP/0/RP0/CPU0:ios(config-if)#interface Bundle-ether100.1 l2transport
RP/0/RP0/CPU0:ios(config-subif)#encapsulation dot1q 1
RP/0/RP0/CPU0:ios(config-subif)#ethernet cfm
RP/0/RP0/CPU0:ios(config-if-cfm)#mep domain UP6 service s6 mep-id 4001
RP/0/RP0/CPU0:ios(config-if-cfm-mep)#exit
```

```
RP/0/RP0/CPU0:ios(config-if-cfm)#interface TenGigE0/0/0/26
RP/0/RP0/CPU0:ios(config-if)#bundle id 100
RP/0/RP0/CPU0:ios(config-if)#exit
RP/0/RP0/CPU0:ios(config)#router static
RP/0/RP0/CPU0:ios(config-static)#address-family ipv4 unicast
RP/0/RP0/CPU0:ios(config-static-afi)#10.10.10.11/32 tunnel-ip100
RP/0/RP0/CPU0:ios(config-static-afi)#exit
RP/0/RP0/CPU0:ios(config-static)#exit
RP/0/RP0/CPU0:ios(config)#router bgp 300
RP/0/RP0/CPU0:ios(config-bgp)#nsr
RP/0/RP0/CPU0:ios(config-bgp)#bgp router-id 198.51.100.101
RP/0/RP0/CPU0:ios(config-bgp)#bgp graceful-restart
RP/0/RP0/CPU0:ios(config-bgp)#bgp log neighbor changes detail
RP/0/RP0/CPU0:ios(config-bgp)#address-family ipv4 unicast
RP/0/RP0/CPU0:ios(config-bgp-af)#maximum-paths ebgp 64
RP/0/RP0/CPU0:ios(config-bgp-af)#neighbor 198.51.100.100
RP/0/RP0/CPU0:ios(config-bgp-nbr)#remote-as 100
RP/0/RP0/CPU0:ios(config-bgp-nbr)#ebgp-multihop 10
RP/0/RP0/CPU0:ios(config-bgp-nbr)#update-source Loopback0
RP/0/RP0/CPU0:ios(config-bgp-nbr)#address-family ipv4 unicast
RP/0/RP0/CPU0:ios(config-bgp-nbr-af)#next-hop-self
RP/0/RP0/CPU0:ios(config-bgp-nbr-af)#route-policy pass-all in
RP/0/RP0/CPU0:ios(config-bgp-nbr-af)#route-policy pass-all out
RP/0/RP0/CPU0:ios(config-bgp-nbr-af)#exit
RP/0/RP0/CPU0:ios(config-bgp-nbr)#exit
RP/0/RP0/CPU0:ios(config-bgp)#l2vpn
RP/0/RP0/CPU0:ios(config-l2vpn)#pw-class controlword
RP/0/RP0/CPU0:ios(config-l2vpn-pwc)#encapsulation mpls
RP/0/RP0/CPU0:ios(config-l2vpn-pwc-mpls)#control-word
RP/0/RP0/CPU0:ios(config-l2vpn-pwc-mpls)#exit
RP/0/RP0/CPU0:ios(config-l2vpn-pwc)#exit
RP/0/RP0/CPU0:ios(config-l2vpn)#xconnect group 1
RP/0/RP0/CPU0:ios(config-l2vpn-xc)#p2p 1
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p)#interface bundle-ether100.1
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p)#neighbor ipv4 10.10.10.11 pw-id 1
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p-pw)#mpls static label local 25022 remote 25011
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p-pw)#pw-class controlword
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p-pw)#exit
RP/0/RP0/CPU0:ios(config-l2vpn-xc-p2p)#exit
RP/0/RP0/CPU0:ios(config-l2vpn-xc)#exit
RP/0/RP0/CPU0:ios(config-l2vpn)#exit
RP/0/RP0/CPU0:ios(config)#ethernet cfm
RP/0/RP0/CPU0:ios(config-cfm)#domain UP6 level 6 id null
RP/0/RP0/CPU0:ios(config-cfm-dmn)#service s6 xconnect group 1 p2p 1 id number 6
RP/0/RP0/CPU0:ios(config-cfm-dmn-svc)#continuity-check interval 100ms
RP/0/RP0/CPU0:ios(config-cfm-dmn-svc)#mep crosscheck
RP/0/RP0/CPU0:ios(config-cfm-xcheck)#mep-id 1
RP/0/RP0/CPU0:ios(config-cfm-xcheck)#exit
RP/0/RP0/CPU0:ios(config-cfm)#exit
RP/0/RP0/CPU0:ios(config)#mpls static
RP/0/RP0/CPU0:ios(config-mpls-static)#interface TenGigE0/0/0/24
RP/0/RP0/CPU0:ios(config-mpls-static)#address-family ipv4 unicast
RP/0/RP0/CPU0:ios(config-mpls-static-af)#exit
RP/0/RP0/CPU0:ios(config-mpls-static)#lsp v4_gre_mpls_1
RP/0/RP0/CPU0:ios(config-mpls-static-lsp)#in-label 24011 allocate per-prefix 10.10.10.11/32
RP/0/RP0/CPU0:ios(config-mpls-static-lsp)#forward
RP/0/RP0/CPU0:ios(config-mpls-static-lsp-fwd)#path 1 nexthop tunnel-ip100 out-label pop
RP/0/RP0/CPU0:ios(config-mpls-static-lsp-fwd)#exit
RP/0/RP0/CPU0:ios(config-mpls-static-lsp)#exit
RP/0/RP0/CPU0:ios(config-mpls-static)#exit
RP/0/RP0/CPU0:ios(config-mpls)#end
Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:yes
```

Running Configuration

PE1:

```
class-map type traffic match-all test_gre1
 match protocol gre
 match source-address ipv4 198.51.100.101 255.255.255.0
 end-class-map
!
policy-map type pbr P1-test
 class type traffic test_gre1
  decapsulate gre
 !
 class type traffic class-default
 !
 end-policy-map
!
vrf-policy
 vrf default address-family ipv4 policy type pbr input P1-test
!
interface Loopback0
 ipv4 address 198.51.100.100 255.255.255.0
!
interface Loopback11
 ipv4 address 10.11.11.11 255.0.0.0
!
interface Bundle-ether100
interface Bundle-ether100.1 l2transport
 encapsulation dot1q 1
 ethernet cfm
  mep domain UP6 service s61 mep-id 1
!
interface TenGigE0/0/0/16/0
 bundle id 100
!
interface TenGigE0/0/0/17/1
 ipv4 address 10.18.18.1 255.0.0.0
!
interface tunnel-ip100
 ipv4 address 198.51.100.111 255.255.255.0
 tunnel mode gre ipv4 encap
 tunnel source 198.51.100.100
 tunnel destination 198.51.100.101
!
router static
 address-family ipv4 unicast
  10.22.22.22/32 tunnel-ip100
 !
!
router bgp 100
 nsr
 bgp router-id 198.51.100.100
 bgp graceful-restart
 bgp log neighbor changes detail
 address-family ipv4 unicast
   maximum-paths ebgp 64
 neighbor 198.51.100.101
   remote-as 300
   ebgp-multihop 10
   update-source Loopback0
   address-family ipv4 unicast
    next-hop-self
   route-policy pass-all in
   route-policy pass-all out
  !
```

```
!
l2vpn
  pw-class controlword
    encapsulation mpls
     control-word
    !
 !
 xconnect group 1
  p2p 1
   interface Bundle-ether100.1
   neighbor ipv4 10.22.22.22 pw-id 1
    mpls static label local 25011 remote 25022
    pw-class controlword
   !
  !
 !
!
mpls static
 interface TenGigE0/0/0/17/1
 address-family ipv4 unicast
 !
  lsp v4_gre_mpls_1
  in-label 24022 allocate per-prefix 10.22.22.22/32
  forward
   path 1 nexthop tunnel-ip100 out-label pop
  !
 !
!
ethernet cfm
domain UP6 level 6 id null
  service s6 xconnect group 1 p2p 1 id number 6
   continuity-check interval 100ms
   mep crosscheck
    mep-id 4001
!
```

PE2:

```
 class-map type traffic match-all test_gre1
 match protocol gre
 match source-address ipv4 198.51.100.100 255.255.255.0
 end-class-map
!
policy-map type pbr P1-test
 class type traffic test_gre1
  decapsulate gre
 !
 class type traffic class-default
 !
 end-policy-map
!
vrf-policy
 vrf default address-family ipv4 policy type pbr input P1-test
!
interface Loopback0
 ipv4 address 198.51.100.101 255.255.255.0
!
interface Loopback22
 ipv4 address 10.22.22.22 255.255.255.255
!
interface tunnel-ip100
 ipv4 address 198.51.100.112 255.255.255.0
 tunnel mode gre ipv4 encap
 tunnel source 198.51.100.101
 tunnel destination 198.51.100.100
```

```
!
interface TenGigE0/0/0/24
 ipv4 address 10.18.18.2 255.0.0.0
!
!
interface Bundle-ether100
!
interface Bundle-ether100.1 l2transport
 encapsulation dot1q 1
 ethernet cfm
  mep domain UP6 service s6 mep-id 4001
!
interface TenGigE0/0/0/26
bundle id 100
!
router static
 address-family ipv4 unicast
  10.10.10.11/32 tunnel-ip100
 !
!
router bgp 300
 nsr
 bgp router-id 198.51.100.101
 bgp graceful-restart
 bgp log neighbor changes detail
 address-family ipv4 unicast
  maximum-paths ebgp 64
 neighbor 198.51.100.100
  remote-as 100
  ebgp-multihop 10
  update-source Loopback0
  address-family ipv4 unicast
   next-hop-self
   route-policy pass-all in
   route-policy pass-all out
  !
!
l2vpn
  pw-class controlword
    encapsulation mpls
     control-word
    !
 !
 xconnect group 1
  p2p 1
   interface bundle-ether100.1
   neighbor ipv4 10.10.10.11 pw-id 1
    mpls static label local 25022 remote 25011
    pw-class controlword
!
ethernet cfm
domain UP6 level 6 id null
  service s6 xconnect group 1 p2p 1 id number 6
   continuity-check interval 100ms
   mep crosscheck
    mep-id 1
!
mpls static
 interface TenGigE0/0/0/24
  address-family ipv4 unicast
 !
 lsp v4_gre_mpls_1
  in-label 24011 allocate per-prefix 10.10.10.11/32
  forward
```

```
   path 1 nexthop tunnel-ip100 out-label pop
  !
!
```

Verification

This section provides some sample commands and corresponding outputs to verify the CFM configuration.

1. Check peer MEP status

```
RP/0/RP0/CPU0:ios#show ethernet cfm peer meps | utility more
Wed Jan 10 13:38:27.713 UTC
Flags:
> - Ok                          I - Wrong interval
R - Remote Defect received      V - Wrong level
L - Loop (our MAC received)     T - Timed out
C - Config (our ID received)    M - Missing (cross-check)
X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
* - Multiple errors received    S - Standby

Domain sp (level 3), Service s1
Up MEP on Bundle-Ether191.1 MEP-ID 1
================================================================================
St     ID MAC Address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ----------- --------- ------ ----- -----
>  5001 008a.968d.54db Up      02:56:38       106011      0     1     0
```

2. Check local MEP status

```
RP/0/RP0/CPU0:ios#show ethernet cfm local meps interface Bundle-Ether191.1 verbose
Wed Jan 10 13:39:17.994 UTC
Domain sp (level 3), Service s1
Up MEP on Bundle-Ether191.1 MEP-ID 1
================================================================================
  Interface state: Up      MAC address: fcbc.cec4.e48a
  Peer MEPs: 1 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 0 missing, 0 unexpected

  CCM generation enabled:  Yes, 100ms (Remote Defect detected: No)
                           CCM processing offloaded to software
  AIS generation enabled:  Yes (level: 5, interval: 1s)
  Sending AIS:             No
  Receiving AIS:           No
  Sending CSF:             No
  Receiving CSF:           No

  Packet        Sent      Received
  ------  ----------  ------------------------------------------------------------
  CCM         106571        106514  (out of seq: 0)
  AIS              7             0
```

3. Check complete CFM configuration

```
RP/0/RP0/CPU0:ios#show ethernet cfm summary
Wed Jan 10 13:40:43.106 UTC

CFM System Summary
==================

Domains                                 2
Services                             1600
Total CCM rate (pps)               305000
Local Meps                           1500
  Operational                        1500
    Down MEPs                           0
```

```
    Up MEPs                          1500
    Offloaded                        1500
      3.3ms                          1000
      10ms                              0
      100ms or greater                500
  Disabled (misconfiguration)           0
  Disabled (resource limit)             0
  Disabled (operational error)          0
Peer MEPs                           1500
  Operational                       1500
    Defect detected                    0
    No defect detected              1500
  Timed out                            0
MIPs                                 100
Interfaces                          1500
Bridge domains/Xconnects            1500
Traceroute cache entries               0
Traceroute cache replies               0
CCM Learning database entries       1500
BNM Enabled Links                      0

CFM Summary for 0/3/CPU0
========================

Domains                                2
Services                            1600
Total CCM rate (pps)                   0
Local Meps                             0
  Operational                          0
    Down MEPs                          0
    Up MEPs                            0
    Offloaded                          0
      3.3ms                            0
      10ms                             0
      100ms or greater                 0
  Disabled (misconfiguration)          0
  Disabled (resource limit)            0
  Disabled (operational error)         0
Peer MEPs                              0
  Operational                          0
    Defect detected                    0
    No defect detected                 0
  Timed out                            0
MIPs                                   0
Interfaces                             0
Bridge domains/Xconnects            1500
Traceroute cache entries               0
Traceroute cache replies               0
CCM Learning database entries          0
BNM Enabled Links                      0
ISSU Role                        Primary

CFM Summary for 0/7/CPU0
========================

Domains                                2
Services                            1600
Total CCM rate (pps)              300000
Local Meps                          1000
  Operational                       1000
    Down MEPs                          0
    Up MEPs                         1000
    Offloaded                       1000
      3.3ms                         1000
```

```
      10ms                                0
      100ms or greater                    0
  Disabled (misconfiguration)             0
  Disabled (resource limit)               0
  Disabled (operational error)            0
Peer MEPs                              1000
  Operational                          1000
    Defect detected                       0
    No defect detected                 1000
  Timed out                               0
MIPs                                      0
Interfaces                             1000
Bridge domains/Xconnects               1500
Traceroute cache entries                  0
Traceroute cache replies                  0
CCM Learning database entries          1000
BNM Enabled Links                         0
ISSU Role                           Primary

CFM Summary for 0/RP0/CPU0
==========================

Domains                                   2
Services                               1600
Total CCM rate (pps)                   5000
Local Meps                              500
  Operational                           500
    Down MEPs                             0
    Up MEPs                             500
    Offloaded                           500
      3.3ms                               0
      10ms                                0
      100ms or greater                  500
  Disabled (misconfiguration)             0
  Disabled (resource limit)               0
  Disabled (operational error)            0
Peer MEPs                               500
  Operational                           500
    Defect detected                       0
    No defect detected                  500
  Timed out                               0
MIPs                                    100
Interfaces                              500
Bridge domains/Xconnects                500
Traceroute cache entries                  0
Traceroute cache replies                  0
CCM Learning database entries           500
BNM Enabled Links                         0
ISSU Role                           Primary
```

4. Ping and Traceroute

```
RP/0/RP0/CPU0:ios#ping ethernet cfm domain sp service s1 mep-id 5001 source interface
Bundle-Ether191.1
Wed Jan 10 13:41:59.562 UTC
Type escape sequence to abort.
Sending 5 CFM Loopbacks, timeout is 2 seconds -
Domain sp (level 3), Service s1
Source: MEP ID 1, interface Bundle-Ether191.1
Target: 008a.968d.54db (MEP ID 5001):
  Running (5s) ...
Success rate is 100.0 percent (5/5), round-trip min/avg/max = 1/1/3 ms
Out-of-sequence: 0.0 percent (0/5)
Bad data: 0.0 percent (0/5)
Received packet rate: 1.3 pps
```

```
RP/0/RP0/CPU0:ios#traceroute ethernet cfm domain sp service s1 mep-id 5001 source interface
 Bundle-Ether191.1
Wed Jan 10 13:42:13.129 UTC
Type escape sequence to return to prompt.

Traceroutes in domain sp (level 3), service s1
Source: MEP-ID 1, interface Bundle-Ether191.1
================================================================================
Traceroute at 2024-01-10 13:42:13 to 008a.968d.54db,
TTL 64, Trans ID 677741245:

  Running (7s) ...

Hop Hostname/Last            Ingress MAC/name       Egress MAC/Name            Relay
--- ----------------------- ---------------------- ---------------------- ----------
  1 R1-5508                 fcbc.cec4.e48a [Ok]     FDB 0000-fcbc.cec4.e48a   BE191.1

  2 R3                      008a.968d.54db [Ok]     Hit R1-5508               BE391.1
          MEP
Replies dropped: 0
```

Y.1731 Performance Monitoring

Table 17: Feature History Table

Feature Name	Release	Description
Cisco NC57 Native Mode: Y.1731 Loss and Delay Measurement	Release 7.3.1	This feature is now supported on routers that have the Cisco NC57 line cards installed and operate in the native mode.

Y.1731 Performance Monitoring (PM) provides a standard Ethernet PM function that includes measurement of Ethernet frame delay, frame delay variation, frame loss, and frame throughput measurements. This is specified by the ITU-T Y-1731 standard and interpreted by the Metro Ethernet Forum (MEF) standards group.

The router supports the following:

- Delay Measurement (DM)
- Synthetic Loss Measurement (SLM)

Restrictions for Y.1731 Performance Monitoring

Y.1731 Performance Monitoring is not supported for the following:

- Segment Routing over IPv6 (SRv6) based transport
- GRE tunnel based transport

Two-Way Delay Measurement for Scalability

Use the Ethernet frame delay measurement to measure frame delay and frame delay variations. The system measures the Ethernet frame delay by using the Delay Measurement Message (DMM) method.

Restrictions for Configuring Two-Way Delay Measurement

Follow the guidelines and restrictions listed here when you configure two-way delay measurement:

- NCS5502 and NCS5508 routers support only software-based timestamping for Two-Way DMM. For accurate hardware-based timestamping, PTP (Precision Time Protocol) must be enabled.

Configuring Two-Way Delay Measurement

Perform the following steps to configure two-way delay measurement:

```
RP/0/RP0/CPU0:router(config)#ethernet sla

profile DMM type cfm-delay-measurement
  probe
   send burst every 5 seconds packet count 5 interval 1 seconds
  !
  schedule
   every 1 minutes for 40 seconds
  !
  statistics
   measure round-trip-delay
    buckets size 1 probes
    buckets archive 5
   !
   measure round-trip-jitter
    buckets size 1 probes
    buckets archive 1
   !
!
!
!
interface TenGigE0/0/0/10.1 l2transport
encapsulation dot1q 1
ethernet cfm
  mep domain DOWN0 service s10 mep-id 2001
   sla operation profile DMM target mep-id 6001
  !
```

On-Demand Ethernet SLA Operation for CFM Delay Measurement

To run an on-demand Ethernet SLA operation for CFM delay measurement, use this command in privileged EXEC mode:

```
RP/0/RP0/CPU0:router

ethernet sla on-demand operation type cfm-delay-measurement probe domain D1 source interface
 TenGigE 0/6/1/0 target mac-address 2.3.4
```

Running Configuration

```
RP/0/RP0/CPU0:router# show ethernet cfm peer meps
Mon Sep 11 12:09:44.534 UTC
Flags:
> - Ok                          I - Wrong interval
R - Remote Defect received      V - Wrong level
L - Loop (our MAC received)     T - Timed out
C - Config (our ID received)    M - Missing (cross-check)
X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
* - Multiple errors received    S - Standby

Domain UP6 (level 6), Service s6
```

```
Up MEP on FortyGigE0/0/1/2.1 MEP-ID 1
==============================================================================
St     ID MAC Address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ------------ --------- ------ ----- -----
 >  4001 70e4.227c.2865 Up      00:01:27            0      0     0     0

Domain DOWN0 (level 0), Service s10
Down MEP on TenGigE0/0/0/10.1 MEP-ID 2001
==============================================================================
St     ID MAC Address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ------------ --------- ------ ----- -----
 >  6001 70e4.227c.287a Up      00:02:11            0      0     0     0
RP/0/RP0/CPU0:router#
RP/0/RP0/CPU0:router# show running-config
Mon Sep 11 12:10:18.467 UTC
interface TenGigE0/0/0/10.1 l2transport
 encapsulation dot1q 1
 ethernet cfm
  mep domain UP6 service s6 mep-id 1
    sla operation profile DMM target mep-id 6001
    sla operation profile test-slm target mep-id 6001
  !
 !
!
l2vpn
 xconnect group g1
  p2p p1
   interface TenGigE0/0/0/10.1
   interface FortyGigE0/0/1/2.1
  !
 !
!
end
```

Verification

Note Although one-way delay is included in the output, it is not supported because PTP synchronization of the router clocks is required. The values for the one-way delay measurements should be disregarded as they are not accurate.

```
Round Trip Delay
~~~~~~~~~~~~~~~~
1 probes per bucket
Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
Result count: 10
Min: 0.009ms; Max: 0.010ms; Mean: 0.009ms; StdDev: 0.000ms


One-way Delay (Source->Dest)
~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 10
    Min: 1912765.961ms; Max: 1912765.961ms; Mean: 1912765.961ms; StdDev: -2147483.648ms
```

```
One-way Delay (Dest->Source)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 10
    Min: -1912765.952ms; Max: -1912765.951ms; Mean: -1912765.951ms; StdDev: -2147483.648ms


Round Trip Jitter
~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 9
    Min: 0.000ms; Max: 0.001ms; Mean: 0.000ms; StdDev: 0.000ms


One-way Jitter (Source->Dest)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 9
    Min: 0.000ms; Max: 0.000ms; Mean: 0.000ms; StdDev: 0.000ms


One-way Jitter (Dest->Source)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 9
    Min: 0.000ms; Max: 0.001ms; Mean: 0.000ms; StdDev: 0.000ms


RP/0/RP0/CPU0:ios#ethernet sla on-demand operation type cfm-syn probe domain DOWN0 source
interface tenGigE 0/0/0/10.1 target mep-id 6001
Mon Sep 11 12:12:39.259 UTC
Warning: Burst configuration is present and so this profile cannot be represented in the
MEF-SOAM-PM-MIB configuration tables. However, the statistics are still collected
On-demand operation 2 succesfully created
 / - Completed - statistics will be displayed shortly.

RP/0/RP0/CPU0:ios#show ethernet sla statistics on-demand id 2

Mon Sep 11 12:13:24.825 UTC
Source: Interface TenGigE0/0/0/10.1, Domain DOWN0
Destination: Target MEP-ID 6001
================================================================================
On-demand operation ID #2, packet type 'cfm-synthetic-loss-measurement'
Started at 12:12:41 UTC Mon 11 September 2017, runs once for 10s
Frame Loss Ratio calculated every 10s
```

```
One-way Frame Loss (Source->Dest)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:12:41 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 100; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                  Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 1
    Min: 0.000%; Max: 0.000%; Mean; 0.000%; StdDev: 0.000%; Overall: 0.000%


One-way Frame Loss (Dest->Source)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:12:41 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 100; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                  Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 1
    Min: 0.000%; Max: 0.000%; Mean; 0.000%; StdDev: 0.000%; Overall: 0.000%

RP/0/RP0/CPU0:ios#show ethernet cfm local meps verbose
Mon Sep 11 12:13:04.461 UTC
Domain UP6 (level 6), Service s6
Up MEP on FortyGigE0/0/1/2.1 MEP-ID 1
================================================================================
  Interface state: Up      MAC address: 008a.960f.c4a8
  Peer MEPs: 1 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 0 missing, 0 unexpected

  CCM generation enabled:  Yes, 1s (Remote Defect detected: No)
                           CCM processing offloaded to hardware
  AIS generation enabled:  No
  Sending AIS:             No
  Receiving AIS:           No

  No packets sent/received

Domain DOWN0 (level 0), Service s10
Down MEP on TenGigE0/0/0/10.1 MEP-ID 2001
================================================================================
  Interface state: Up      MAC address: 008a.960f.c428
  Peer MEPs: 1 up, 0 with errors, 0 timed out (archived)
  Cross-check errors: 0 missing, 0 unexpected

  CCM generation enabled:  Yes, 1s (Remote Defect detected: No)
                           CCM processing offloaded to hardware
  AIS generation enabled:  No
  Sending AIS:             No
  Receiving AIS:           No

  Packet        Sent      Received
  ------  ----------  ------------------------------------------------------------
  DMM             10             0
  DMR              0            10
  SLM            100             0
  SLR              0           100
```

Synthetic Loss Measurement

The loss measurement mechanism defined in Y.1731 can only be used in point-to-point networks, and only works when there is sufficient flow of data traffic. The difficulties with the Y.1731 loss measurement mechanism

were recognized across the industry and hence an alternative mechanism has been defined and standardized for measuring loss of traffic.

This alternative mechanism does not measure the loss of the actual data traffic, but instead injects synthetic CFM frames and measures the loss of these synthetic frames. You can perform a statistical analysis to give an approximation of the loss of data traffic. This technique is called Synthetic Loss Measurement (SLM). SLM has been included in the latest version of the Y.1731 standard. Use SLA to perform the following measurements:

- One-way loss (Source to Destination)
- One-way loss (Destination to Source)

SLM supports the following:

- All Layer 2 transport interfaces, such as physical, bundle interfaces, Layer2 sub-interfaces, pseudowire Head-end interfaces or attachment circuits.
- Up and Down MEPs.
- Transparent passing of the SLM packets through the MIP without punting it to the software.
- 1000 pps of SLM/SLR traffic.

Configuring Synthetic Loss Measurement

The following section describes how you can configure Synthetic Loss Measurement:

```
RP/0/RP0/CPU0:router (config)# ethernet sla

profile test-slm type cfm-synthetic-loss-measurement
  probe
   send packet every 1 seconds
   synthetic loss calculation packets 24
  !
  schedule
   every 3 minutes for 120 seconds
  !
  statistics
   measure one-way-loss-sd
    buckets size 1 probes
    buckets archive 5
   !
   measure one-way-loss-ds
    buckets size 1 probes
    buckets archive 5
!
!
!
!
interface TenGigE0/0/0/10.1 l2transport
encapsulation dot1q 1
ethernet cfm
  mep domain DOWN0 service s10 mep-id 2001
   sla operation profile test-slm target mep-id 6001
  !
```

Configuring an On-Demand Ethernet SLA Operation for CFM Synthetic Loss Measurement

To configure an on-demand Ethernet SLA operation for CFM synthetic loss measurement, use this command in privileged EXEC mode:

```
RP/0/RP0/CPU0:router ethernet sla on-demand operation type cfm-synthetic-loss-measurement
probe Domain DOWN0 source interface TenGigE0/0/0/10.1 target mac-address 2.3.4
```

Running Configuration

```
RP/0/RP0/CPU0:router# show ethernet sla statistics on-demand id 1
Mon Sep 11 12:12:00.699 UTC
Source: Interface TenGigE0/0/0/10.1, Domain DOWN0
Destination: Target MEP-ID 6001
================================================================================
On-demand operation ID #1, packet type 'cfm-delay-measurement'
RP/0/RP0/CPU0:router#
RP/0/RP0/CPU0:router# show running-config
Mon Sep 11 12:10:18.467 UTC
Building configuration...
!! IOS XR Configuration version = 6.4.1.14I
!! Last configuration change at Mon Sep 11 12:08:16 2017 by root
!
logging console disable
telnet vrf default ipv4 server max-servers 10
username root
group root-lr
group cisco-support
secret 5 $1$QJT3$94M5/wK5J0v/lpAu/wz31/
!
line console
exec-timeout 0 0
!
ethernet cfm
domain UP6 level 6 id null
  service s6 xconnect group g1 p2p p1 id number 6
   mip auto-create all ccm-learning
   continuity-check interval 1s
   mep crosscheck
    mep-id 4001
   !
  !
!
domain DOWN0 level 0 id null
 service s10 down-meps id number 10
   continuity-check interval 1s
   mep crosscheck
    mep-id 6001
   !
  !
!
!
interface TenGigE0/0/0/10.1 l2transport
encapsulation dot1q 1
ethernet cfm
  mep domain DOWN0 service s10 mep-id 2001
   sla operation profile DMM target mep-id 6001
   sla operation profile test-slm target mep-id 6001
  !
!
!

interface FortyGigE0/0/1/2.1 l2transport
```

```
 encapsulation dot1q 1
 ethernet cfm
  mep domain UP6 service s6 mep-id 1
    sla operation profile DMM target mep-id 6001
    sla operation profile test-slm target mep-id 6001
  !
 !
!
l2vpn
 xconnect group g1
  p2p p1
   interface TenGigE0/0/0/10.1
   interface FortyGigE0/0/1/2.1
  !
 !
!
end
```

Verification

```
Round Trip Delay
~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 10
    Min: 0.009ms; Max: 0.010ms; Mean: 0.009ms; StdDev: 0.000ms


One-way Delay (Source->Dest)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 10
    Min: 1912765.961ms; Max: 1912765.961ms; Mean: 1912765.961ms; StdDev: -2147483.648ms


One-way Delay (Dest->Source)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 10
    Min: -1912765.952ms; Max: -1912765.951ms; Mean: -1912765.951ms; StdDev: -2147483.648ms


Round Trip Jitter
~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                   Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 9
    Min: 0.000ms; Max: 0.001ms; Mean: 0.000ms; StdDev: 0.000ms
```

```
One-way Jitter (Source->Dest)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                  Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 9
    Min: 0.000ms; Max: 0.000ms; Mean: 0.000ms; StdDev: 0.000ms


One-way Jitter (Dest->Source)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket

Bucket started at 12:11:19 UTC Mon 11 September 2017 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                  Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 9
    Min: 0.000ms; Max: 0.001ms; Mean: 0.000ms; StdDev: 0.000ms
```

CFM and Y 1731 on VPLS over BGP Signaling

Table 18: Feature History Table

Feature Name	Release Information	Feature Description
CFM and Y 1731 on VPLS over BGP Signaling	Release 7.6.1	VPLS over BGP Signaling services supports CFM continuity check, ITU-T Y.1731 compliant Delay Measurement Message (DMM), and Synthetic Loss Measurement (SLM) functions. This feature allows you to effectively manage a network with L2VPN services running VPLS using BGP AD.

Connectivity fault management (CFM) is a service-level Operations and Maintenance (OAM) protocol that provides tools for monitoring and troubleshooting end-to-end Ethernet services. This feature provides high-speed Layer 2 and Layer 3 services with high resiliency and less operational complexity to different market segments.

The CFM on VPLS over BGP Signaling feature allows you to effectively manage a network with L2VPN services running VPLS. The CFM provides proactive network management, troubleshooting, connectivity monitoring, fault verification, and fault isolation.

CFM on VPLS services supports CFM continuity check, ITU-T Y.1731 compliant Delay Measurement Message (DMM), and Synthetic Loss Measurement (SLM) functions.

DMM is used to periodically measure frame delay and frame delay variation between a pair of point-to-point Maintenance End Point (MEPs). Measurements are made between two MEPs belonging to the same domain and Maintenance Association (MA).

SLM is used to periodically measure Frame Loss between a pair of point-to-point MEPs. Measurements are made between two MEPs that belong to the same domain and MA.

Supported Offload Types and Timer Values

The following are supported offload types:

- Hardware (HW) Offload type: The check message (CCM) timers for a CFM session are 3.3ms 10ms, 100ms, or 1s.

Note CFM sessions with CCM timers set to less than 10 seconds over L2 VPLS on a physical interface are unsupported.

- Non-Offload type: The CCM timers for a CFM session on a physical interface are equal to 10s or 1m.
- Software (SW) Offload type: The CFM session on a bundle interface. SW Offload type supports 1s, 10s, or 1m.

The following are the supported timer values:

- 3.3ms: Interval of 3.3 milliseconds
- 10ms: Interval of 10 milliseconds
- 100ms: Interval of 100 milliseconds
- 1s: Interval of 1 second
- 10s: Interval of 10 seconds
- 1m: Interval of 1 minute

Feature Highlights

- CFM and Y 1731 on VPLS over BGP Signaling is now supported only on routers that have Cisco NC57 line cards that are installed and operate in native mode only.
- Supports single homing with one AC per PW.
- Support 1 and 2 Way DMM and SLM for UP and Down MEPs

Restrictions

- Supports single homing with one AC per PW.
- Supports 1 Way DMM for the hardware with support for timing sync.
- The Cisco NC57 line cards operating in native mode support hardware timestamping only when the RP card is used as an RP-E card. With non-RP-E cards, the Cisco NC 57 line cards perform software timestamping and Delay Measurement Message (DMM) results have higher value for Mean, Maximum, and Minimum.

Configure CFM and Y 1731 on VPLS over BGP Signaling

Configuration Example

```
/* BGP AD based VPLS with single AC.
 */
l2vpn
```

```
 bridge group cfmvpls
  bridge-domain cfmvpls1
   interface Bundle-Ether203.6001
   !
   vfi cfmvpls1
    vpn-id 1001
    autodiscovery bgp
     rd auto
     route-target 1001:1001
     signaling-protocol bgp
      ve-id 1


/* Global CFM UP MEP configuration */
ethernet cfm
 domain cfmvpls level 3 id null
  service cfmvpls1 bridge group cfmvpls bridge-domain cfmvpls1 id number 50001
   continuity-check interval 1s loss-threshold 3
   mep crosscheck
    mep-id 4000


/* Global CFM DOWN MEP configuration */
ethernet cfm
 domain cfmvplsdown level 3 id null
  service cfmvplsdown1 down-meps id number 29001
   continuity-check interval 1s loss-threshold 3
   mep crosscheck
    mep-id 4000


/* Global Y1731 DMM Configuration */
ethernet sla
 profile dmm1 type cfm-delay-measurement
  probe
   send burst every 1 minutes packet count 30 interval 2 seconds
   priority 4
  schedule
   every 5 minutes for 300 seconds
  statistics
   measure round-trip-delay
   measure one-way-delay-sd
   !
   measure one-way-delay-ds
   measure round-trip-jitter
   measure one-way-jitter-sd
   measure one-way-jitter-ds


/* Global Y1731 SLM Configuration */
ethernet sla
 profile eth_sla_slm type cfm-synthetic-loss-measurement
  probe
   send burst every 1 minutes packet count 60 interval 1 seconds
   priority 7
  !
  schedule
   every 5 minutes for 300 seconds
  !
  statistics
   measure one-way-loss-sd
   !
   measure one-way-loss-ds
   !
```

```
/* CFM UP MEP or DOWN MEP and Ethernet SLA applied to interface  */
interface Bundle-Ether203.6001 l2transport
 encapsulation dot1q 4002 second-dot1q 1
 rewrite ingress tag pop 2 symmetric
 ethernet cfm
  mep domain cfmvpls service cfmvpls1 mep-id 1
    sla operation profile dmm1 target mep-id 4000
  !
  mep domain cfmvplsdown service cfmvplsdown1 mep-id 1
    sla operation profile eth_sla_slm target mep-id 4000
```

Verification Example

Example output with the CFM Up MEP is configured.

```
Router(PE1)# show ethernet cfm peer meps interface bundle-Ether 203.6001
Flags:
> - Ok                          I - Wrong interval
R - Remote Defect received      V - Wrong level
L - Loop (our MAC received)     T - Timed out
C - Config (our ID received)    M - Missing (cross-check)
X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
* - Multiple errors received    S - Standby
Domain cfmvpls (level 3), Service cfmvpls1
Up MEP on Bundle-Ether203.6001 MEP-ID 1
================================================================================
St     ID MAC Address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ------------ --------- ------ ----- -----
 >  4000 d46d.5059.1db0 Up      15:33:42         56055      0     0     0
```

Example output with the CFM Down MEP is configured.

```
Router(PE1)#show ethernet cfm peer meps interface bundle-Ether 203.6001
Flags:
> - Ok                          I - Wrong interval
R - Remote Defect received      V - Wrong level
L - Loop (our MAC received)     T - Timed out
C - Config (our ID received)    M - Missing (cross-check)
X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
* - Multiple errors received    S - Standby

Domain cfmvplsdown (level 3), Service cfmvplsdown1
Down MEP on Bundle-Ether203.6001 MEP-ID 1
================================================================================
St     ID MAC Address    Port    Up/Downtime   CcmRcvd SeqErr   RDI Error
-- ----- -------------- ------- ------------ --------- ------ ----- -----
 >  4000 0024.f71d.af3e Up      15:37:33       112487      0     0     0
```

Example output with the Ethernet SLA DMM statistics.

```
Router(PE1)#show ethernet sla statistics interface bundle-Ether 203.6001 domain cfmvpls
profile  dmm1
Source: Interface Bundle-Ether203.6001, Domain cfmvpls
Destination: Target MEP-ID 4000
================================================================================
Profile 'dmm1', packet type 'cfm-delay-measurement'
Scheduled to run every 5min first at 00:03:31 UTC for 5min
Round Trip Delay
~~~~~~~~~~~~~~~~
1 probes per bucket
No stateful thresholds.
Bucket started at 03:18:31 IST Mon 14 February 2022 lasting 5min
    Pkts sent: 150; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
```

```
                Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 150
    Min: 290857.011ms; Max: 291925.308ms; Mean: 291367.479ms; StdDev: 317.339ms
```

Example output with the Ethernet SLA SLM statistics.

```
Router(PE1)#show ethernet sla statistics interface bundle-Ether 203.6001 domain cfmvplsdown
 profile eth_sla_slm
Source: Interface Bundle-Ether203.6001, Domain cfmvplsdown
Destination: Target MEP-ID 4000
================================================================================
Profile 'eth_sla_slm', packet type 'cfm-synthetic-loss-measurement'
Scheduled to run every 5min first at 00:01:50 UTC for 5min
Frame Loss Ratio calculated every 5min
One-way Frame Loss (Source->Dest)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1 probes per bucket
No stateful thresholds.
Bucket started at 03:21:50 IST Mon 14 February 2022 lasting 5min
    Pkts sent: 300; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 1
    Min: 0.000%; Max: 0.000%; Mean; 0.000%; StdDev: 0.000%; Overall: 0.000%
```

Ethernet SLA Statistics Measurement in a Profile

Table 19: Feature History Table

Feature Name	Release Information	Feature Description
Enhancement to Ethernet SLA Statistics Measurement	Release 7.7.1	You can now configure the size of bins that are used to aggregate the results of Ethernet SLA statistics, in microseconds. The size of the bins is defined by the **width** value of delay and jitter measurement in Ethernet SLA statistics. You can configure the **width** value ranging from 1 to 10000000 microseconds. This enhancement provides granularity to store more accurate results of Ethernet SLA statistics in the aggregate bins. In earlier releases, you could only configure the **width** value for the delay and jitter measurement in milliseconds. This feature introduces the **usec** keyword in the **aggregate** command.

The Ethernet SLA feature supports measurement of one-way and two-way delay and jitter statistics, and one-way FLR statistics.

Ethernet SLA statistics measurement for network performance is performed by sending packets and storing data metrics such as:

- Round-trip delay time—The time for a packet to travel from source to destination and back to source again.
- Round-trip jitter—The variance in round-trip delay time (latency).
- One-way delay and jitter—The router also supports measurement of one-way delay or jitter from source to destination, or from destination to source.
- One-way frame loss—The router also supports measurement of one-way frame loss from source to destination, or from destination to source.

In addition to these metrics, these statistics are also kept for SLA probe packets:

- Packet loss count
- Packet corruption event
- Out-of-order event
- Frame Loss Ratio (FLR)

Counters for packet loss, corruption, and, out-of-order packets are kept for each bucket, and in each case, a percentage of the total number of samples for that bucket is reported (for example, 4% packet corruption). For delay, jitter, and loss statistics, the minimum, maximum, mean and standard deviation for the whole bucket are reported, as well as the individual samples or aggregated bins. Also, the overall FLR for the bucket, and individual FLR measurements or aggregated bins are reported for synthetic loss measurement statistics. The packet loss count is the overall number of measurement packets lost in either direction and the one-way FLR measures the loss in each direction separately.

When aggregation is enabled using the **aggregate** command, bins are created to store a count of the samples that fall within a certain value range, which is set by the **width** keyword. Only a counter of the number of results that fall within the range for each bin is stored. This uses less memory than storing individual results. When aggregation is not used, each sample is stored separately, which can provide a more accurate statistics analysis for the operation, but it is highly memory-intensive due to the independent storage of each sample.

A bucket represents a time period during which statistics are collected. All the results received during that time period are recorded in the corresponding bucket. If aggregation is enabled, each bucket has its own set of bins and counters, and only results relating to the measurements initiated during the time period represented by the bucket are included in those counters.

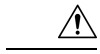
Frame Loss Ratio (FLR) is a primary attribute that can be calculated based on loss measurements. FLR is defined by the ratio of lost packets to sent packets and expressed as a percentage value. FLR is measured in each direction (source to destination and destination to source) separately. Availability is an attribute that is typically measured over a long period of time, such as weeks or months. The intent is to measure the proportion of time when there was prolonged high loss.

To configure one-way delay or jitter measurements, you must first configure the **profile (SLA)** command using the **type cfm-delay-measurement** form of the command.

For valid one-way delay results, you must have both local and remote devices time synchronized. In order to do this, you must select sources for frequency and time-of-day (ToD).

Frequency selection can be between any source of frequency available to the router, such as: BITS, GPS, SyncE, or PTP. The ToD selection is between the source selected for frequency and PTP or DTI. Note that NTP is not sufficient.

Configuration Guidelines



Caution Certain SLA configurations can use a large amount of memory which can affect the performance of other features on the router.

Before you configure Ethernet SLA, consider the following guidelines:

- Aggregation—Use of the **aggregate none** command significantly increases the amount of memory required because each individual measurement is recorded, rather than just counts for each aggregation bin. When you configure aggregation, consider that more bins will require more memory.
- Buckets archive—When you configure the **buckets archive** command, consider that the more history that is kept, the more memory will be used.
- Measuring two statistics (such as both delay and jitter) will use approximately twice as much memory as measuring one.
- Separate statistics are stored for one-way source-to-destination and destination-to-source measurements, which consumes twice as much memory as storing a single set of round-trip statistics.
- You must define the schedule before you configure SLA probe parameters to send probes for a particular profile. It is recommended to set up the profile—probe, statistics, and schedule before any commit.

Restrictions

One-way delay and jitter measurements are not supported by cfm-loopback profile types.

Configure Ethernet SLA Statistics Measurement in a Profile

To configure SLA statistics measurement in a profile, perform these steps:

1. Enter the Ethernet SLA configuration mode, using the **ethernet sla** command in Global Configuration mode.
2. Create an SLA operation profile with the **profile** *profile-name* **type cfm-delay-measurement** command.
3. Enable the collection of SLA statistics using the **statistics measure** {**one-way-delay-ds | one-way-delay-sd | one-way-jitter-ds | one-way-jitter-sd | round-trip-delay | round-trip-jitter | one-way-loss-ds | one-way-loss-sd**} command.
4. Configure the size and number of bins into which to aggregate the results of statistics collection. For delay measurements and data loss measurements, the default is that all values are aggregated into 1 bin. For synthetic loss measurements, by default the aggregation is disabled. Use the **aggregate** {**bins** *count* **width** [**usec**] *width* | **none**} command to configure the bins.
   - For delay and jitter measurements, you can configure a width value from 1 to 10000 milliseconds, if the number of bins is at least 2. To configure the width value in microseconds, use the **usec** option. You can configure the width value from 1 to 10000000 microseconds.
   - For data loss and synthetic loss measurements, you can configure a width value from 1 to 100 percentage points, if the number of bins is at least 2.
5. Configure the size of the buckets in which statistics are collected, using the **buckets size** *number* **probes** command.

6. Configure the number of buckets to store in memory using the **buckets archive** *number* command.
7. Save the configuration changes using the **end** or **commit** command.

Configuration Example

This example shows configuration of round-trip-delay statistics measurement in 5 bins each with a range of 123 microseconds:

```
Router(config)# ethernet sla
Router(config-sla)# profile test type cfm-delay-measurement
Router(config-sla-prof)# statistics measure round-trip-delay
Router(config-sla-prof-stat-cfg)# aggregate bins 5 width usec 123
Router(config-sla-prof-stat-cfg)# buckets size 1 probes
Router(config-sla-prof-stat-cfg)# buckets archive 50
Router(config-sla-prof-stat-cfg)# commit
```

This example shows configuration of round-trip-delay statistics measurement in 5 bins each with a range of 10 milliseconds:

```
Router(config)# ethernet sla
Router(config-sla)# profile test type cfm-delay-measurement
Router(config-sla-prof)# statistics measure round-trip-delay
Router(config-sla-prof-stat-cfg)# aggregate bins 5 width 10
Router(config-sla-prof-stat-cfg)# buckets size 1 probes
Router(config-sla-prof-stat-cfg)# buckets archive 50
Router(config-sla-prof-stat-cfg)# commit
```

Verification

This example displays aggregate bins configured with a range of 123 microseconds:

```
Router# show ethernet sla statistics detail
Tue Sep 28 07:59:22.340 PDT
Source: Interface GigabitEthernet0/0/0/2, Domain dom1
Destination: Target MAC Address 0012.0034.0056
================================================================================
Profile 'test', packet type 'cfm-delay-measurement'
Scheduled to run every 1min first at 00:00:31 UTC for 10s

Round Trip Delay
~~~~~~~~~~~~~~~~
1 probes per bucket

No stateful thresholds.

Bucket started at 07:56:31 PDT Tue 28 September 2021 lasting 10s
    Pkts sent: 10; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                  Misordered: 0 (0.0%); Duplicates: 0 (0.0%)
    Result count: 10
    Min: 0.000ms, occurred at 07:56:32 PDT Tue 28 September 2021
    Max: 1.000ms, occurred at 07:56:31 PDT Tue 28 September 2021
    Mean: 0.100ms; StdDev: 0.300ms

    Bins:
    Range                 Samples   Cum. Count     Mean
    ----------------  ----------  -----------  -------
        0 to 0.123 ms  9  (90.0%)   9  (90.0%)  0.000ms
    0.123 to 0.246 ms  0   (0.0%)   9  (90.0%)        -
    0.246 to 0.369 ms  0   (0.0%)   9  (90.0%)        -
```

```
    0.369 to 0.492 ms  0   (0.0%)   9  (90.0%)        -
    > 0.492        ms  1  (10.0%)  10 (100.0%)  1.000ms
```

This example displays aggregate bins configured with a range of 10 milliseconds:

```
Router# show ethernet sla statistics detail
Tue Sep 28 08:00:57.527 PDT
Source: Interface GigabitEthernet0/0/0/2, Domain dom1
Destination: Target MAC Address 0012.0034.0056
================================================================================
Profile 'test', packet type 'cfm-delay-measurement'
Scheduled to run every 1min first at 00:00:31 UTC for 10s

Round Trip Delay
~~~~~~~~~~~~~~~~
1 probes per bucket

No stateful thresholds.

Bucket started at 08:00:32 PDT Tue 28 September 2021 lasting 10s
    Pkts sent: 9; Lost: 0 (0.0%); Corrupt: 0 (0.0%);
                  Misordered: 1 (11.1%); Duplicates: 0 (0.0%)
    Result count: 9
    Min: 0.000ms, occurred at 08:00:32 PDT Tue 28 September 2021
    Max: 0.000ms, occurred at 08:00:32 PDT Tue 28 September 2021
    Mean: 0.000ms; StdDev: 0.000ms

    Results suspect due to a probe starting mid-way through a bucket

    Bins:
    Range           Samples  Cum. Count     Mean
    -----------  ----------  ----------  -------
     0 to 10 ms  9 (100.0%)  9 (100.0%)  0.000ms
    10 to 20 ms  0   (0.0%)  9 (100.0%)        -
    20 to 30 ms  0   (0.0%)  9 (100.0%)        -
    30 to 40 ms  0   (0.0%)  9 (100.0%)        -
    > 40     ms  0   (0.0%)  9 (100.0%)        -
```

Link Loss Forwarding

The Cisco NCS 5500 Series Routers support Link Loss Forwarding (LLF). LLF uses CFM to transmit notification of a signal loss or fault across the network. If a local AC goes down, LLF sends signals across to the neighboring device.

The following packet types indicate a fault in a network:

- Continuity Check Message (CCM).
- Alarm Indication Signal (AIS)
- Client Signal Frame (CSF)

When the system receives a CCM or AIS with fault indication, or a CSF error packet, the interface is disabled for transmission (TX-disabled).

Ether-MA handles owner channel communication and resyncs from CFMD, L2VPN, and other Ether- MA processes.

Restrictions for LLF

- LLF isn't permitted on sub-interfaces.
- LLF is only permitted on up MEPs.
- LLF is not supported on LACP bundle.
- The system runs a damping timer to govern transitions from an interface being TX-disabled to an interface being TX-enabled. The following restrictions apply on such a scenario:
  - The period of the damping timer is given by three times the configured CCM interval. However, you can't configure the damping timer.
  - The system doesn't provide damping for transitions from TX-enabled to TX-disabled.

Configure Link Loss Forwarding

This section describes how to configure LLF on a network by using the `propagate-remote-status config` command.

```
/* Enable LLF */
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface GigabitEthernet0/2/0/0
RP/0/RP0/CPU0:router(config-cfm)# ethernet cfm
RP/0/RP0/CPU0:router(config-cfm)# mep domain foo service bar mep-id 1
RP/0/RP0/CPU0:router(config-cfm)# propagate remote-status
RP/0/RP0/CPU0:router(config-cfm)# commit
```

Optional Configuration for Client Signal Fail (CSF)

Note CSF configuration is required for inter-operation with certain client-end setups that contain devices from other clients.

```
ethernet cfm
  domain <domain> level <level> service <service> <type>
    csf [<interval> {1s | 1m}] [cos <cos>]
      log csf
```

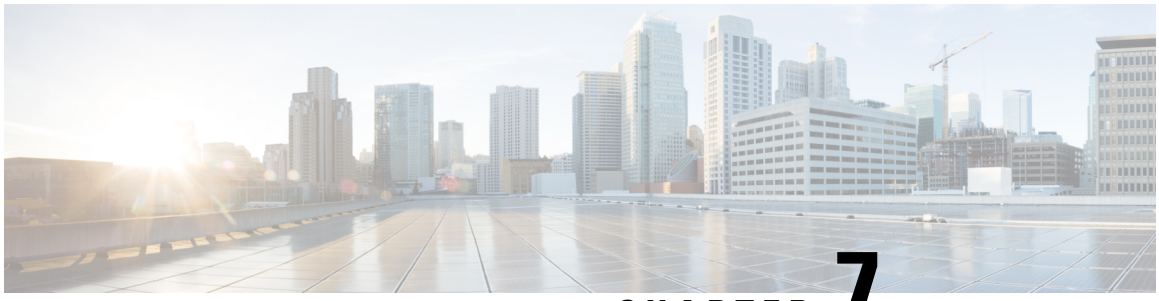
Running Configuration

```
ethernet cfm
 domain dom1 level 1
  service ser1 bridge group up-meps bridge-domain up-mep
   continuity-check interval 1m
   csf interval 1m cos 4
   csf-logging
  !
 !
!
interface GigabitEthernet0/2/0/0
 ethernet cfm
  mep domain dom1 service ser1 mep-id 1
   propagate-remote-status
  !
```

```
 !
!
```

Verification

```
show ethernet cfm interfaces [ <interface> ] llf [ location <node> ]
Defects (from at least one peer MEP):
 A - AIS received                I - Wrong interval
 R - Remote Defect received      V - Wrong Level
 L - Loop (our MAC received)     T - Timed out (archived)
 C - Config (our ID received)    M - Missing (cross-check)
 X - Cross-connect (wrong MAID)  U - Unexpected (cross-check)
 P - Peer port down              F - CSF received


GigabitEthernet0/1/0/0
  MEP Defects                           Restore Timer
----- ----------------------------------- --------------
  100 R                           Not running
  101 None       10s remaining
  102 RPF                               Not running

GigabitEthernet0/1/0/1
  MEP Defects                           Restore Timer
----- ----------------------------------- --------------
  110 None             3s remaining

GigabitEthernet0/1/0/2
  MEP Defects                           Restore Timer
----- ----------------------------------- --------------
  120 P                Not running
```



CHAPTER 7

Configuring Integrated Routing and Bridging

This module describes the configuration of Integrated Routing and Bridging (IRB). IRB provides the ability to exchange traffic between bridging services and a routed interface using a Bridge-Group Virtual Interface (BVI).

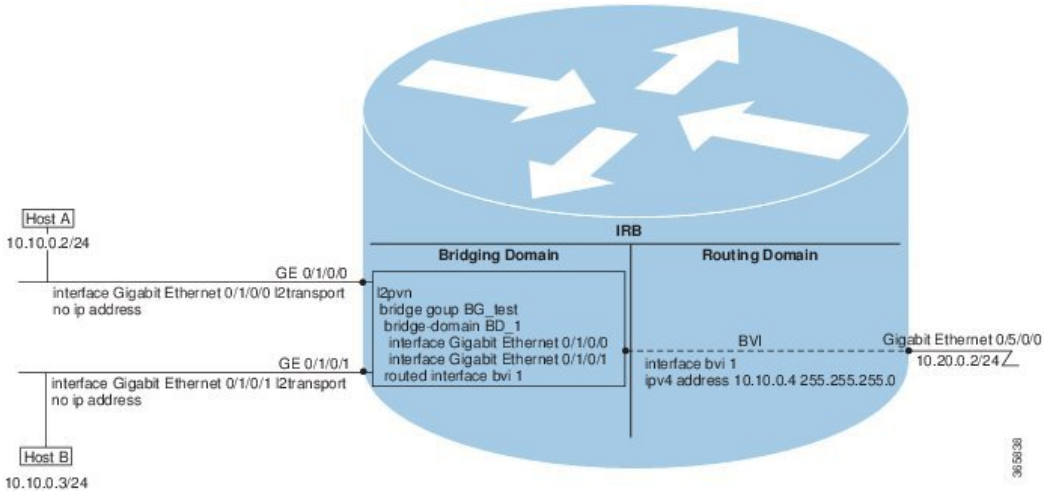
Feature History for IRB

Release	Modification
Release 6.1.1	This feature was introduced.

IRB Introduction

IRB provides the ability to route between a bridge group and a routed interface using a BVI. The BVI is a virtual interface within the router that acts like a normal routed interface. A BVI is associated with a single bridge domain and represents the link between the bridging and the routing domains on the router. To support receipt of packets from a bridged interface that are destined to a routed interface, the BVI must be configured with the appropriate IP addresses and relevant Layer 3 attributes.

Figure 14: IRB Functional View and Configuration Elements



Bridge-Group Virtual Interface

The BVI is a virtual interface within the router that acts like a normal routed interface. The BVI does not support bridging itself, but acts as a gateway for the corresponding bridge-domain to a routed interface within the router.

BVI supports only Layer 3 attributes, and has the following characteristics:

- Uses a MAC address taken from the local chassis MAC address pool, unless overridden at the BVI interface.
- Is configured as an interface type using the **interface bvi** command and uses an IPv4 address that is in the same subnet as the hosts on the segments of the bridged domain. The BVI also supports secondary addresses.
- The BVI identifier is independent of the bridge-domain identifier. These identifiers do not need to correlate like they do in Cisco IOS software.
- Is associated to a bridge group using the **routed interface bvi** command.
- BVI interfaces support a number range of 1 to 4294967295.

Supported Features on a BVI

- Two-pass packet forwarding model
- These interface commands are supported on a BVI:
  - **arp purge-delay**
  - arp timeout
  - **bandwidth** (The default is 10 Gbps and is used as the cost metric for routing protocols for the BVI)

- **ipv4**
- **ipv6**
- **mac-address**
- **shutdown**

- The BVI supports IP helper addressing and secondary IP addressing.
- BVI does not support MTU configuration using **mtu** command, which is for physical interfaces. However, **ip mtu** and **ipv6 mtu** commands, which are logical interface commands, are supported.

Two-Pass Forwarding over BVI

Table 20: Feature History Table

Feature Name	Release	Description
Two-pass Forwarding over BVI	Release 7.9.1	With this release, Integrated Routing and Bridging/Bridge-group Virtual Interface (IRB/BVI) supports Layer 2 ACL, QoS, and statistics on BVI-routed packets, using a two-pass forwarding model for packets over BVI. This feature introduces the following changes: • CLI: **hw-module irb** • YANG Data Model: New XPaths for modules Cisco-IOS-XR-fia-hw-profile-cfg.yang and Cisco-IOS-XR-um-hw-module-profile-cfg.yang

The IRB/BVI implementation was originally based on single-pass or collapsed forwarding model in which each packet is processed only once. This forwarding model has some restrictions in supporting Layer 2 accounting and QoS over BVI. With this release, you have the flexibility to choose either the default single-pass model or two-pass forwarding model for packets over BVI. In the two-pass forwarding model L2 and L3 forwarding is split across two paths and packet processing happens in two cycles. This model supports Layer 2 ACL, QoS, and statistics accounting on BVI-routed packets. The earlier implementation with single-pass forwarding did not support these. You can enable the two-pass forwarding using the CLI command **hw-module irb**.

The two-pass forwarding model supports the following features:

- Layer 2 Access Control List (ACL)
- Layer 2 QoS on the BVI-routed packets
- Ingress statistics support for BVI in L2 to L3 packet flow
- Egress statistics support for BVI in L3 to L2 packet flow

The following table shows the configuration commands for different forwarding flows in BVI interfaces.

Flow	Forwarding Model	CLI Command
IRB L2 to L3	Two-Pass	**hw-module irb l2-l3 2-pass**
IRB L3 to L2	Two-Pass	**hw-module irb l3-l2 2-pass**

By default, single-pass forwarding is enabled in both IRB L2 to L3 and IRB L3 to L2 flows.

L2 to L3 Packet Flow

When a packet arrives at the ingress port, the forwarding lookup on ingress line card (LC) points to the egress BVI interface. Based on this egress BVI interface, the packet is queued to the receiving LC. The egress interface is mapped to a physical port.

When the egress BVI bandwidth is available, the receiving LC ports that are ready to receive the packets (based on the packet marking and distribution model) send grants to the ingress ports via the connectors. The ingress ports respond to this permission by transmitting the packets to the receiving LC ports. Then, according to the policy maps (PMs) the packet is queued to the appropriate egress interface. If there is no PM configured, the packet is queued to the main egress interface.

The following support is available:

- Ingress policy map (PM) is supported on both L2 access control (AC) and BVI simultaneously.
- Ingress PM on L2 AC applies to traffic on L2 to L2 direction.
- Ingress PM on BVI interface applies to the traffic on L2 to L3 direction.
- Ingress policer applied on L2 AC can check both L2 to L2 and L2 to L3 flows.
- Ingress policer applied on the BVI interface polices only L2 to L3 flow.
- Setting QoS-group, traffic-class, and discard-class are supported at ingress policy-map.

L3 to L2 Packet Flow

When a Layer 3 packet arrives at the ingress port, the destination IP address is resolved to find the corresponding Layer 2 MAC address of the destination device. Once the MAC address is obtained, a new Layer 2 Ethernet header for the packet is created with the source as the MAC address of the BVI, and the destination as the MAC address of the destination device. The packet is then transmitted over the local network and delivered to the destination device.

The following support is available:

- Egress marking and egress queuing PM are supported on L2 AC.
- No egress policy map is supported on BVI interface.
- Match on QoS-group is supported at egress marking policy-map.
- Match on discard-class is supported only for value 0 at egress marking policy-map.
- Egress queuing policy-map traffic class-based match is supported only for class default.

The two-pass model is supported on routers that have the following Cisco NCS 5700 line cards in native mode:

- NC57-18DD-SE

- NC57-36H-SE

IRB Recycle Performance

The throughput of the BVI IRB recycle port is increased from 400 to 600 Gbps in native mode. The 600 Gbps throughput mode is activated using the **hw-module profile qos irb-recycle-bandwidth** *600*.

```
Router(config)#hw-module profile qos irb-recycle-bandwidth 600
  Router(config)#
```

Note

- You should enable the two-pass forwarding capability before you configure the IRB recycle bandwidth.
- Before disabling the two-pass forwarding capability, you should remove the IRB recycle bandwidth configuration using the **no hw-module profile qos irb-recycle-bandwidth** *600*.

Configuration

To enable the two-pass forwarding capability, use the following sample configuration.

The example shows how to enable the two-pass forwarding of packets from layer 2 to layer 3:

```
Router#configure terminal
Mon Mar 27 05:17:23.887 UTC
Router(config)#hw-module irb L2-L3 2-pass
Mon Mar 27 05:17:31.421 UTC
In order to activate this new IRB model, you must manually reload the chassis/all line cards
```

The example shows how to enable the two-pass forwarding of packets from layer 3 to layer 2:

```
Router#configure terminal
Mon Mar 27 05:17:43.887 UTC
Router(config)#hw-module irb L3-L2 2-pass
Mon Mar 27 05:17:41.751 UTC
In order to activate this new IRB model, you must manually reload the chassis/all line cards
Router(config)#
```

After enabling the two-pass model, apply the ingress PM on both L2 AC and BVI interface. Use the following sample command:

```
Router(config)#
/*Apply ingress PM on both L2 AC and BVI interface*/
Router(config)#int fourHundredGigE 0/5/0/23.601
Router(config-subif)#service-policy input L2AC
Router(config-subif)#commit
Router(config-subif)#exit

Router(config)#int bvi 97
Router(config-if)#service-policy input BVI
Router(config-if)#commit
Router(config-if)#end
```

Verification

Verify the ingress policy map on BVI interface using the **show qos interface bvi** command.

To display the BVI **show qos** output, location keyword is mandatory.

```
Router#show qos interface bvi 97 input location 0/5/CPU0
NOTE:- Configured values are displayed within parentheses
Interface BVI97 ifh 0x20008034  -- input policy
NPU Id:                        0
Total number of classes:       2
Interface Bandwidth:           104857600 kbps
Policy Name:                   BVI
SPI Id:                        0x0
Accounting Type:               Layer2 (Include Layer 2 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                                =   DSCPAF33
New qos group                               =   3
New traffic class                           =   2

Policer Bucket ID                           =   0x21
Policer Stats Handle                        =   0x0
Policer committed rate                      =   150390 kbps (150 mbits/sec)
Policer peak rate                           =   200195 kbps (200 mbits/sec)
Policer conform burst                       =   186624 bytes (default)
Policer exceed burst                        =   436096 bytes (default)

Level1 Class                                =   class-default

Default Policer Bucket ID                   =   0x20
Default Policer Stats Handle                =   0x0
Policer not configured for this class

Interface BVI97 ifh 0x20008034  -- input policy
NPU Id:                        1
Total number of classes:       2
Interface Bandwidth:           104857600 kbps
Policy Name:                   BVI
SPI Id:                        0x0
Accounting Type:               Layer2 (Include Layer 2 encapsulation and above)
------------------------------------------------------------------------------
Level1 Class                                =   DSCPAF33
New qos group                               =   3
New traffic class                           =   2

Policer Bucket ID                           =   0x21
Policer Stats Handle                        =   0x0
Policer committed rate                      =   150390 kbps (150 mbits/sec)
Policer peak rate                           =   200195 kbps (200 mbits/sec)
Policer conform burst                       =   186624 bytes (default)
Policer exceed burst                        =   436096 bytes (default)

Level1 Class                                =   class-default

Default Policer Bucket ID                   =   0x20
Default Policer Stats Handle                =   0x0
Policer not configured for this class
```

To verify the ingress policy map on L2 AC using the **show qos int** *interface name* **input** command.

```
Router#show qos int fourHundredGigE 0/5/0/23.601 input
NOTE:- Configured values are displayed within parentheses
Interface FourHundredGigE0/5/0/23.601 ifh 0xa00883a  -- input policy
NPU Id:                        1
Total number of classes:       2
Interface Bandwidth:           400000000 kbps
Policy Name:                   L2AC
SPI Id:                        0x0
Accounting Type:               Layer2 (Include Layer 2 encapsulation and above)
```

```
------------------------------------------------------------------------------
Level1 Class                          =   DSCPAF43
New qos group                         =   2
New traffic class                     =   1

Policer Bucket ID                     =   0x9
Policer Stats Handle                  =   0x0
Policer committed rate                =   99609 kbps (100 mbits/sec)
Policer conform burst                 =   124672 bytes (default)

Level1 Class                          =   class-default

Default Policer Bucket ID             =   0x8
Default Policer Stats Handle          =   0x0
Policer not configured for this class
Router#
```

BVI Interface and Line Protocol States

Like typical interface states on the router, a BVI has both an Interface and Line Protocol state.

- The BVI interface state is Up when the following occurs:
  - The BVI interface is created.
  - The bridge-domain configured with the **routed interface bvi** command has at least one active bridge port available, either an Attachment Circuit or a Pseudowire.

    Attachment Circuit (AC) is a physical or logical interface that connects a customer network to a service provider network. Pseudowire (PW) is a virtual connection that emulates a physical wire, enabling data transport across a packet-switched network.

Note A BVI will be moved to the Down state if all of the bridge ports (Ethernet flow points [EFPs]) associated with the bridge domain for that BVI are down. However, the BVI will remain up if at least one bridgeport is up, even if all EFPs are down.

- These characteristics determine when the the BVI line protocol state is up:
  - The bridge-domain is in Up state.
  - The BVI IP address is not in conflict with any other IP address on another active interface in the router.

Prerequisites for Configuring IRB

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Before configuring IRB, be sure that these tasks and conditions are met:

- Know the IP addressing and other Layer 3 information to be configured on the bridge virtual interface (BVI).
- Complete MAC address planning if you decide to override the common global MAC address for all BVIs.
- Be sure that the BVI network address is being advertised by running static or dynamic routing on the BVI interface.

Restrictions for Configuring IRB

Before configuring IRB, consider these restrictions:

- Only one BVI can be configured in any bridge domain.
- The same BVI can not be configured in multiple bridge domains.
- MTU configuration and fragmentation of packets is not supported on BVI interfaces.
- IGP ECMP path list with mix of BVI and non-BVI paths is not supported.
- The following areas are *not* supported on the BVI:
  - Access Control Lists (ACLs). However, Layer 2 ACLs can be configured on each Layer 2 port of the bridge domain.
  - IP fast reroute (FRR)
  - TI-LFA
  - SR
  - LDP
  - NetFlow
  - MoFRR
  - Quality of Service (QoS)
  - Traffic mirroring
  - Unnumbered interface for BVI
  - Video monitoring (Vidmon)
  - IRB with 802.1ah (BVI and Provider Backbone Bridge (PBB) should not be configured in the same bridge domain).
  - PIM snooping. (Need to use selective flood.)
  - VRF-aware DHCP relay
- The following areas are *not* supported on the Layer2 bridging (with BVI):
  - Static mac entry configuration in Bridge.
  - Mac ageing configuration at global config mode.

- MAC Learning Disable.
- Vlan rewrite.

- QOS configuration on BVI interface is not supported for egress.
- Label allocation mode per-CE with BVI is not supported in an access network along with PE-CE protocols enabled.

How to Configure IRB

This section includes the following configuration tasks:

Configuring the Bridge Group Virtual Interface

To configure a BVI, complete the following steps.

Configuration Guidelines

Consider the following guidelines when configuring the BVI:

- The BVI must be assigned an IPv4 or IPv6 address that is in the same subnet as the hosts in the bridged segments.
- If the bridged network has multiple IP networks, then the BVI must be assigned secondary IP addresses for each network.

SUMMARY STEPS

1. **configure**
2. **interface bvi** *identifier*
3. **ipv4 address** *ipv4-address mask* [**secondary**] **ipv6 address** *ipv6-prefix/prefix-length* [**eui-64**] [**route-tag** *route-tag value*]
4. **arp purge-delay** *seconds*
5. **arp timeout** *seconds*
6. **bandwidth** *rate*
7. **end** or **commit**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
Router# configure
```

Enters the global configuration mode.

Step 2 **interface bvi** *identifier*

Example:

```
Router(config)# interface bvi 1
```

Specifies or creates a BVI, where *identifier* is a number from 1 to 65535.

Step 3 **ipv4 address** *ipv4-address mask* [**secondary**] **ipv6 address** *ipv6-prefix/prefix-length* [**eui-64**] [**route-tag** *route-tag value*]

Example:

```
Router(config-if)# ipv4 address 10.10.0.4 255.255.255.0
```

Specifies a primary or secondary IPv4 address or an IPv6 address for an interface.

Step 4 **arp purge-delay** *seconds*

Example:

```
Router(config-if)#arp purge-delay 120
```

(Optional) Specifies the amount of time (in *seconds*) to delay purging of Address Resolution Protocol (ARP) table entries when the interface goes down.

The range is 1 to 65535. By default purge delay is not configured.

Step 5 **arp timeout** *seconds*

Example:

```
Router(config-if)# arp timeout 12200
```

(Optional) Specifies how long dynamic entries learned on the interface remain in the ARP cache.

The range is 30 to 2144448000 seconds. The default is 14,400 seconds (4 hours).

Step 6 **bandwidth** *rate*

Example:

```
Router(config-if)# bandwidth 1000000
```

(Optional) Specifies the amount of bandwidth (in kilobits per second) to be allocated on the interface. This number is used as the cost metric in routing protocols for the BVI.

The range is 0 to 4294967295. The default is 10000000 (10 Gbps).

Step 7 **end** or **commit**

Example:

```
Router(config-if)# end
```

or

```
Router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

  Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.

  Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

  Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring the Layer 2 AC Interfaces

To configure the Layer 2 Attachment Circuit (AC) interfaces for routing by a BVI, complete these steps.

SUMMARY STEPS

1. **configure**
2. **interface** [**HundredGigE | TenGigE**] **l2transport**
3. **end** or **commit**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** [**HundredGigE | TenGigE**] **l2transport**

Example:

```
RP/0/RP0/CPU0:router(config)# interface TenGigE 0/1/0/0.1 l2transport
```

Enables Layer 2 transport mode on a Gigabit Ethernet or 10-Gigabit Ethernet interface or subinterface and enters interface or subinterface configuration mode.

Step 3 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Configuring a Bridge Group and Assigning Interfaces to a Bridge Domain

To configure a bridge group and assign interfaces to a bridge domain, complete the following steps.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **interface** [**HundredGigE | TenGigE**
6. **end** or **commit**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RP0/CPU0:router(config-l2vpn)# bridge group 10
```

Creates a bridge group and enters L2VPN bridge group configuration mode.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RP0/CPU0:router(config-l2vpn-bg)# bridge-domain BD_1
```

Creates a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **interface** [**HundredGigE | TenGigE**

Example:

```
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd)# interface HundredGigE 0/1/0/0.1
```

Associates the 100-Gigabit Ethernet or 10-Gigabit Ethernet interface with the specified bridge domain and enters L2VPN bridge group bridge domain attachment circuit configuration mode.

Repeat this step for as many interfaces as you want to associate with the bridge domain.

Step 6 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd-ac)# end
```

or

```
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd-ac)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Associating the BVI as the Routed Interface on a Bridge Domain

To associate the BVI as the routed interface on a bridge domain, complete the following steps.

SUMMARY STEPS

1. **configure**
2. **l2vpn**
3. **bridge group** *bridge-group-name*
4. **bridge-domain** *bridge-domain-name*
5. **routed interface bvi** *identifier*
6. **end** or **commit**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **l2vpn**

Example:

```
RP/0/RP0/CPU0:router(config)# l2vpn
```

Enters L2VPN configuration mode.

Step 3 **bridge group** *bridge-group-name*

Example:

```
RP/0/RP0/CPU0:router(config-l2vpn)# bridge group BG_test
```

Creates a bridge group and enters L2VPN bridge group configuration mode.

Step 4 **bridge-domain** *bridge-domain-name*

Example:

```
RP/0/RP0/CPU0:router(config-l2vpn-bg)# bridge-domain 1
```

Creates a bridge domain and enters L2VPN bridge group bridge domain configuration mode.

Step 5 **routed interface bvi** *identifier*

Example:

```
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd)# routed interface bvi 1
```

Associates the specified BVI as the routed interface for the interfaces assigned to the bridge domain.

Step 6 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd)# end
```

or

```
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Displaying Information About a BVI

To display information about BVI status and packet counters, use the following commands:

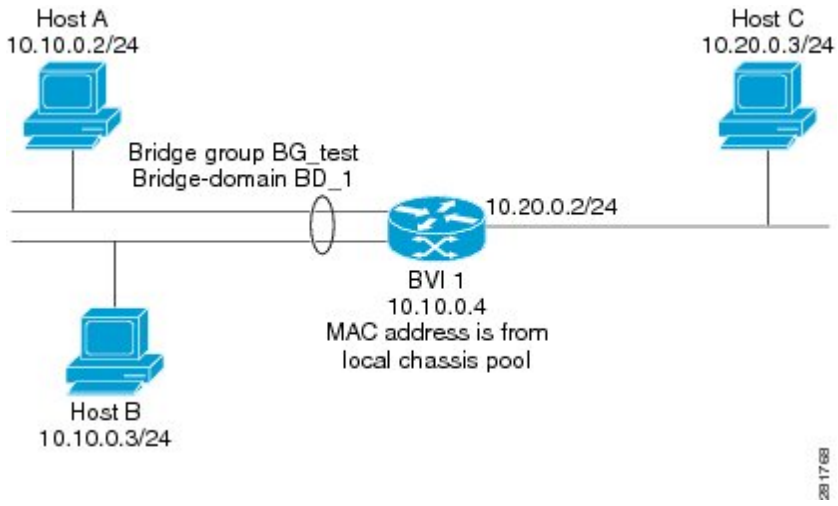
show interfaces bvi *identifier* [**accounting** | **brief** | **description** | **detail**]	Displays interface status, line protocol state, and packet counters for the specified BVI.
show adjacency bvi *identifier* [**detail** | **remote**]	Displays packet and byte transmit counters per adjacency to the specified BVI.
show l2vpn bridge-domain detail	Displays the reason that a BVI is down.

Additional Information on IRB

Packet Flows Using IRB

This figure shows a simplified functional diagram of an IRB implementation to describe different packet flows between Host A, B, and C. In this example, Host C is on a network with a connection to the same router. In reality, another router could be between Host C and the router shown.

Figure 15: IRB Packet Flows Between Hosts



When IRB is configured on a router, the following processing happens:

- ARP requests are resolved between the hosts and BVI that are part of the bridge domain.
- All packets from a host on a bridged interface go to the BVI if the destination MAC address matches the BVI MAC address. Otherwise, the packets are bridged.
- For packets destined for a host on a routed network, the BVI forwards the packets to the routing engine before sending them out a routed interface.
- All packets either from or destined to a host on a bridged interface go to the BVI first (unless the packet is destined for a host on the bridge domain).
- For packets that are destined for a host on a segment in the bridge domain that come in to the router on a routed interface, the BVI forwards the packet to the bridging engine, which forwards it through the appropriate bridged interface.

Packet Flows When Host A Sends to Host B on the Bridge Domain

When Host A sends data to Host B in the bridge domain on the 10.10.0.0 network, no routing occurs. The hosts are on the same subnet and the packets are bridged between their segment interfaces on the router.

Packet Flows When Host A Sends to Host C From the Bridge Domain to a Routed Interface

Using host information from this figure, the following occurs when Host A sends data to Host C from the IRB bridging domain to the routing domain:

- Host A sends the packet to the BVI (as long any ARP request the is resolved between the host and the BVI). The packet has the following information:
  - Source MAC address of host A.
  - Destination MAC address of the BVI.
- Since Host C is on another network and needs to be routed, the BVI forwards the packet to the routed interface with the following information:
  - IP source MAC address of Host A (10.10.0.2) is changed to the MAC address of the BVI (10.10.0.4).
  - IP destination address is the IP address of Host C (10.20.0.3).
- Interface 10.20.0.2 sees receipt of a packet from the routed BVI 10.10.0.4. The packet is then routed through interface 10.20.0.2 to Host C.

Packet Flows When Host C Sends to Host B From a Routed Interface to the Bridge Domain

Using host information from this figure, the following occurs when Host C sends data to Host B from the IRB routing domain to the bridging domain:

- The packet comes into the routing domain with the following information:
  - MAC source address—MAC of Host C.
  - MAC destination address—MAC of the 10.20.0.2 ingress interface.
  - IP source address—IP address of Host C (10.20.0.3).
  - IP destination address—IP address of Host B (10.10.0.3).
- When interface 10.20.0.2 receives the packet, it looks in the routing table and determines that the packet needs to be forwarded to the BVI at 10.10.0.4.
- The routing engine captures the packet that is destined for the BVI and forwards it to the BVI's corresponding bridge domain. The packet is then bridged through the appropriate interface if the destination MAC address for Host B appears in the bridging table, or is flooded on all interfaces in the bridge group if the address is not in the bridging table.

Configuration Examples for IRB

This section provides the following configuration examples:

Basic IRB Configuration: Example

The following example shows how to perform the most basic IRB configuration:

```
! Configure the BVI and its IPv4 address
!
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)#interface bvi 1
RP/0/RP0/CPU0:router(config-if)#ipv4 address 10.10.0.4 255.255.255.0
RP/0/RP0/CPU0:router(config-if))# exit
!
! Configure the Layer 2 AC interface
!
RP/0/RP0/CPU0:router(config)#interface HundredGigE 0/1/0/0 l2transport
RP/0/RP0/CPU0:router(config-if))# exit
!
! Configure the L2VPN bridge group and bridge domain and assign interfaces
!
RP/0/RP0/CPU0:router(config)#l2vpn
RP/0/RP0/CPU0:router(config-l2vpn)#bridge group 10
RP/0/RP0/CPU0:router(config-l2vpn-bg)#bridge-domain 1
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd)#interface HundredGigE 0/1/0/0
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd-if)# exit
!
! Associate a BVI to the bridge domain
!
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd)# routed interface bvi 1
RP/0/RP0/CPU0:router(config-l2vpn-bg-bd)# commit
```

IPv4 Addressing on a BVI Supporting Multiple IP Networks: Example

The following example shows how to configure secondary IPv4 addresses on a BVI that supports bridge domains for the 10.10.10.0/24, 10.20.20.0/24, and 10.30.30.0/24 networks. In this example, the BVI must have an address on each of the bridge domain networks:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)#interface bvi 1
RP/0/RP0/CPU0:router(config-if)#ipv4 address 10.10.10.4 255.255.255.0
RP/0/RP0/CPU0:router(config-if)#ipv4 address 10.20.20.4 255.255.255.0 secondary
RP/0/RP0/CPU0:router(config-if)#ipv4 address 10.30.30.4 255.255.255.0 secondary
RP/0/RP0/CPU0:router(config-if))# commit
```

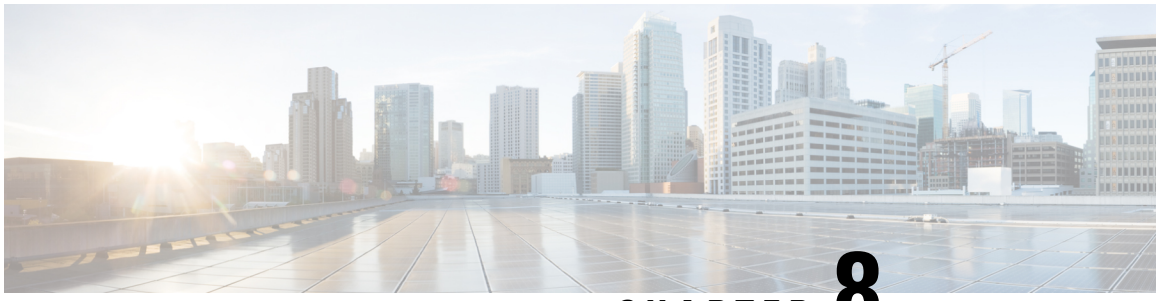
IRB With BVI and VRRP Configuration: Example

This example shows a partial router configuration for the relevant configuration areas for IRB support of a BVI and VRRP:

Note VRRPv6 is also supported.

```
l2vpn
 bridge group IRB
  bridge-domain IRB-EDGE
   interface TenGigE0/0/0/8
```

```
!
   routed interface BVI 100
!
interface TenGigE0/0/0/8
  l2transport
!
interface BVI 100
 ipv4 address 10.21.1.1 255.255.255.0
!
router vrrp
 interface BVI 100
 address-family ipv4
 vrrp 1
 address 10.21.1.100
 priority 100
 !
```



CHAPTER 8

Configuring Link Bundling

The Link Bundling feature allows you to group multiple point-to-point links together into one logical link and provide higher bidirectional bandwidth, redundancy, and load balancing between two routers. A virtual interface is assigned to the bundled link. The component links can be dynamically added and deleted from the virtual interface.

The virtual interface is treated as a single interface on which one can configure an IP address and other software features used by the link bundle. Packets sent to the link bundle are forwarded to one of the links in the bundle.

A link bundle is simply a group of ports that are bundled together and act as a single link. The advantages of link bundles are as follows:

- Multiple links can span several line cards to form a single interface. Thus, the failure of a single link does not cause a loss of connectivity.
- Bundled interfaces increase bandwidth availability, because traffic is forwarded over all available members of the bundle. Therefore, traffic can flow on the available links if one of the links within a bundle fails. Bandwidth can be added without interrupting packet flow.

Cisco IOS XR software supports the following method of forming bundles of Ethernet interfaces:

- IEEE 802.3ad—Standard technology that employs a Link Aggregation Control Protocol (LACP) to ensure that all the member links in a bundle are compatible. Links that are incompatible or have failed are automatically removed from a bundle.

Limitations and Compatible Characteristics of Ethernet Link Bundles

This list describes the properties and limitations of ethernet link bundles:

- The router supports mixed speed bundles. Mixed speed bundles allow member links of different bandwidth to be configured as active members in a single bundle. The ratio of the bandwidth for bundle members must not exceed 10. Also, the total weight of the bundle must not exceed 64. For example, 100Gbps link and 10Gbps links can be active members in a bundle and load-balancing on member links is based on bandwidth weightage.
- The weight of each bundle member is the ratio of its bandwidth to the lowest bandwidth member. Total weight of the bundle is the sum of weights or relative bandwidth of each bundle member. Since the weight for a bundle member is greater than or equal to 1 and less than or equal to 10, the total member of links in a bundle is less than 64 in mixed bundle case.
- Any type of Ethernet interfaces can be bundled, with or without the use of LACP (Link Aggregation Control Protocol).
- A single router can support a maximum of 256 bundle interfaces. Link bundles of only physical interfaces are supported.
- When enabling HQoS profile, the maximum available trunks by default (bundle main + sub-interfaces) are 256. If you need more trunks, configure the **hw-module profile bundle-scale <256/512/1024>** command. With HQoS enabled on bundle interfaces, the maximum priority level supported is 4.
- The following limitations apply to the number of supported bundle members with HQoS profile on Layer2 and Layer3 intefaces:
  - Maximum of 1024 trunks (128 physical interfaces + 896 sub-interfaces) and 16 bundle members.
  - Maximum of 256 trunks (128 physical interfaces + 128 sub-interfaces) and 64 bundle members.
  - Maximum of 512 trunks (128 physical interfaces + 384 sub-interfaces) and 32 bundle members.
- The following limitations apply to bundle sub-interfaces and the number of members per bundle :
  - Maximum of 1024 bundle sub-interfaces, each containing up to 16 member-links.
  - Maximum of 256 bundle sub-interfaces, each containing up to 64 member-links
  - Maximum of 512 bundle sub-interfaces, each containing up to 32 member-links
- Physical layer and link layer configuration are performed on individual member links of a bundle.
- Configuration of network layer protocols and higher layer applications is performed on the bundle itself.
- IPv4 and IPv6 addressing is supported on ethernet link bundles.
- A bundle can be administratively enabled or disabled.
- Each individual link within a bundle can be administratively enabled or disabled.
- Ethernet link bundles are created in the same way as Ethernet channels, where the user enters the same configuration on both end systems.

- QoS is supported and is applied proportionally on each bundle member.
- In case static MAC address is configured on a bundle-ether interface, the following limitations are applied:
  - Locally generated packets, such as ICMP, BGP, and so on, going out from the interface have the source MAC address as the statically configured MAC address.
  - Transit (forwarded) packets going out of the interface do not have the configured static MAC as source MAC address. In such a scenario, the upper 36-bits come from the system MAC address (or the original/dynamic MAC address) and the lower 12-bits come from the MAC address configured on the bundle. To check the dynamic pool of MAC addresses included, use the `show ethernet mac-allocation detail` command.

    For example, if the dynamic MAC address was 008A.9624.48D8 and the configured static MAC address is 0011.2222.ABCD. Then, the source MAC for transit (forwarded) traffic will be 008A.9624.4BCD.

Note This limitation can cause traffic blackholing for the transit traffic, in case there is L2 ACL applied for security purpose. In such case, it is necessary to add permit statement for both MAC addresses in the L2 ACL.

- Load balancing (the distribution of data between member links) is done by flow instead of by packet. Data is distributed to a link in proportion to the bandwidth of the link in relation to its bundle.
- All links within a single bundle must terminate on the same two systems.
- Bundled interfaces are point-to-point.
- A link must be in the up state before it can be in distributing state in a bundle.
- Only physical links can be bundle members.
- Multicast traffic is load balanced over the members of a bundle. For a given flow, the internal processes selects the member link, and the traffic for the flow is sent over that member.

Configuring Ethernet Link Bundles

This section describes how to configure an Ethernet link bundle.

Note In order for an Ethernet bundle to be active, you must perform the same configuration on both connection endpoints of the bundle.

Tip You can programmatically perform the configuration using `openconfig-if-aggregate.yang` OpenConfig data model. To get started with using data models, see the *Programmability Configuration Guide for Cisco NCS 5500 Series Routers*.

SUMMARY STEPS

1. **configure**
2. **interface Bundle-Ether** *bundle-id*
3. **ipv4 address** *ipv4-address mask*
4. **bundle minimum-active bandwidth** *kbps*
5. **bundle minimum-active links** *links*
6. **bundle maximum-active links** *links* [**hot-standby**]
7. **exit**
8. **interface HundredGigE** interface-path-id
9. **bundle id** *bundle-id* [**mode** {**active** | **on** | **passive**}]
10. **bundle port-priority** *priority*
11. **no shutdown**
12. **exit**
13. **bundle id** *bundle-id* [**mode** {**active** | **passive** | **on**}] **no shutdown exit**
14. **end** or **commit**
15. **exit**
16. **exit**
17. Perform Step 1 through Step 15 on the remote end of the connection.
18. **show bundle Bundle-Ether** *bundle-id*
19. **show lacp Bundle-Ether** *bundle-id*

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface Bundle-Ether** *bundle-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface Bundle-Ether 3
```

Creates a new Ethernet link bundle with the specified bundle-id. The range is 1 to 65535.

This **interface Bundle-Ether** command enters you into the interface configuration submode, where you can enter interface specific configuration commands are entered. Use the **exit** command to exit from the interface configuration submode back to the normal global configuration mode.

Step 3 **ipv4 address** *ipv4-address mask*

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv4 address 10.1.2.3 255.0.0.0
```

Assigns an IP address and subnet mask to the virtual interface using the **ipv4 address** configuration subcommand.

Note
- Only a Layer 3 bundle interface requires an IP address.

Step 4 **bundle minimum-active bandwidth** *kbps*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle minimum-active bandwidth 580000
```

(Optional) Sets the minimum amount of bandwidth required before a user can bring up a bundle.

Step 5 **bundle minimum-active links** *links*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle minimum-active links 2
```

(Optional) Sets the number of active links required before you can bring up a specific bundle.

Step 6 **bundle maximum-active links** *links* [**hot-standby**]

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle maximum-active links 1 hot-standby
```

(Optional) Implements 1:1 link protection for the bundle, which causes the highest-priority link in the bundle to become active and the second-highest-priority link to become the standby. Also, specifies that a switchover between active and standby LACP-enabled links is implemented per a proprietary optimization.

Note
- The priority of the active and standby links is based on the value of the **bundle port-priority** command.

Step 7 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# exit
```

Exits interface configuration submode for the Ethernet link bundle.

Step 8 **interface HundredGigE** interface-path-id

Example:

```
RP/0/RP0/CPU0:router(config)# interface HundredGigE 0/1/0/1
```

Enters interface configuration mode for the specified interface.

Enter the **HundredGigE** keyword to specify the interface type. Replace the *interface-path-id* argument with the node-id in the *rack*/*slot*/*module* format.

Step 9 **bundle id** *bundle-id* [**mode** {**active** | **on** | **passive**}]

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle id 3 mode on
```

Adds the link to the specified bundle.

To enable active or passive LACP on the bundle, include the optional **mode active** or **mode passive** keywords in the command string.

To add the link to the bundle without LACP support, include the optional **mode on** keywords with the command string.

Note
- If you do not specify the **mode** keyword, the default mode is **on (**LACP is not run over the port).

Step 10 **bundle port-priority** *priority*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle port-priority 1
```

(Optional) If you set the **bundle maximum-active links** command to 1, you must also set the priority of the active link to the highest priority (lowest value) and the standby link to the second-highest priority (next lowest value). For example, you can set the priority of the active link to 1 and the standby link to 2.

Step 11 **no shutdown**

Example:

```
RP/0/RP0/CPU0:router(config-if)# no shutdown
```

(Optional) If a link is in the down state, bring it up. The **no shutdown** command returns the link to an up or down state depending on the configuration and state of the link.

Step 12 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# exit
```

Exits interface configuration submode for the Ethernet interface.

Step 13 **bundle id** *bundle-id* [**mode** {**active** | **passive** | **on**}] **no shutdown exit**

Example:

```
RP/0/RP0/CPU0:router(config)# interface TenGigE 0/1/0/1

RP/0/RP0/CPU0:router(config-if)# bundle id 3

RP/0/RP0/CPU0:router(config-if)# bundle port-priority 2

RP/0/RP0/CPU0:router(config-if)# no shutdown

RP/0/RP0/CPU0:router(config-if)# exit

RP/0/RP0/CPU0:router(config)# interface TenGigE 0/1/0/1

RP/0/RP0/CPU0:router(config-if)# bundle id 3

RP/0/RP0/CPU0:router(config-if)# no shutdown

RP/0/RP0/CPU0:router(config-if)# exit
```

(Optional) Repeat Step 8 through Step 11 to add more links to the bundle.

Step 14 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 15 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# exit
```

Exits interface configuration mode.

Step 16 **exit**

Example:

```
RP/0/RP0/CPU0:router(config)# exit
```

Exits global configuration mode.

Step 17 Perform Step 1 through Step 15 on the remote end of the connection.

Brings up the other end of the link bundle.

Step 18 **show bundle Bundle-Ether** *bundle-id*

Example:

```
RP/0/RP0/CPU0:router# show bundle Bundle-Ether 3
```

(Optional) Shows information about the specified Ethernet link bundle.

Step 19 **show lacp Bundle-Ether** *bundle-id*

Example:

```
RP/0/RP0/CPU0:router# show lacp Bundle-Ether 3
```

(Optional) Shows detailed information about LACP ports and their peers.

Configuring LACP Fallback

This section describes how to configure the LACP Fallback feature.

SUMMARY STEPS

1. **configure**
2. **interface Bundle-Ether** *bundle-id*
3. **bundle lacp-fallback timeout** *timeout value*
4. **end** or **commit**
5. **show bundle infrastructure database ma bdl-info Bundle-e1010 | inc** *text*
6. **show bundle infrastructure database ma bdl-info Bundle-e1015 | inc** *text*

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface Bundle-Ether** *bundle-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface Bundle-Ether 3
```

Creates and names a new Ethernet link bundle.

The **interface Bundle-Ether** command enters into the interface configuration submode, where you can enter interface-specific configuration commands. Use the **exit** command to exit from the interface configuration submode back to the normal return to global configuration mode.

Step 3 **bundle lacp-fallback timeout** *timeout value*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle lacp-fallback timeout 4
```

Enables the LACP Fallback feature.

Step 4 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# commit
```

Saves configuration changes.

Step 5 **show bundle infrastructure database ma bdl-info Bundle-e1010 | inc** *text*

Example:

```
RP/0/RP0/CPU0:router# show bundle infrastructure database ma bdl-info Bundle-e1010 | inc "fallback"
```

(Optional) Shows the MA information of the bundle manager.

Step 6 **show bundle infrastructure database ma bdl-info Bundle-e1015 | inc** *text*

Example:

```
RP/0/RP0/CPU0:router# show bundle infrastructure database ma bdl-info Bundle-e1015 | inc "fallback"
```

(Optional) Shows the MA information of the bundle manager.

VLANs on an Ethernet Link Bundle

802.1Q VLAN subinterfaces can be configured on 802.3ad Ethernet link bundles. Keep the following information in mind when adding VLANs on an Ethernet link bundle:

- There is no separate limit defined for Layer 3 sub-interfaces on a bundle. However, an overall system limit of 4000 is applicable for NCS5001 and NCS5002, while a limit of 2000 is applicable for NCS5011.

Note The memory requirement for bundle VLANs is slightly higher than standard physical interfaces.

To create a VLAN subinterface on a bundle, include the VLAN subinterface instance with the **interface Bundle-Ether** command, as follows:

interface Bundle-Ether *interface-bundle-id.subinterface*

After you create a VLAN on an Ethernet link bundle, all VLAN subinterface configuration is supported on that link bundle.

VLAN subinterfaces can support multiple Layer 2 frame types and services, such as Ethernet Flow Points - EFPs) and Layer 3 services.

Layer 2 EFPs are configured as follows:

```
interface bundle-ether instance.subinterface l2transport. encapsulation dot1q xxxxx
```

Layer 3 VLAN subinterfaces are configured as follows:

```
interface bundle-ether instance.subinterface, encapsulation dot1q xxxxx
```

Note The difference between the Layer 2 and Layer 3 interfaces is the **l2transport** keyword. Both types of interfaces use **dot1q encapsulation**.

Configuring VLAN over Bundles

This section describes how to configure a VLAN bundle. The creation of a VLAN bundle involves three main tasks:

SUMMARY STEPS

1. Create an Ethernet bundle.
2. Create VLAN subinterfaces and assign them to the Ethernet bundle.
3. Assign Ethernet links to the Ethernet bundle.

DETAILED STEPS

Procedure

Step 1 Create an Ethernet bundle.

Step 2 Create VLAN subinterfaces and assign them to the Ethernet bundle.

Step 3 Assign Ethernet links to the Ethernet bundle.

These tasks are describe in detail in the procedure that follows.

Note In order for a VLAN bundle to be active, you must perform the same configuration on both ends of the bundle connection.

SUMMARY STEPS

1. **configure**
2. **interface Bundle-Ether** *bundle-id*
3. **ipv4 address** *ipv4-address mask*
4. **bundle minimum-active bandwidth** *kbps*
5. **bundle minimum-active links** *links*
6. **bundle maximum-active links** *links* [**hot-standby**]
7. **exit**
8. **interface Bundle-Ether** *bundle-id.vlan-id*
9. **encapsulation dot1q***vlan-id*
10. **ipv4 address** *ipv4-address mask*
11. **no shutdown**

12. **exit**
13. Repeat Step 9 through Step 12 to add more VLANS to the bundle you created in Step 2.
14. **end** or **commit**
15. **exit**
16. **exit**
17. **configure**
18. **interface** {**TenGigE** | **FortyGigE** | **HundredGigE**}*interface-path-id*

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface Bundle-Ether** *bundle-id*

Example:

```
RP/0/RP0/CPU0:router#(config)# interface Bundle-Ether 3
```

Creates and names a new Ethernet link bundle.

This **interface Bundle-Ether** command enters you into the interface configuration submode, where you can enter interface-specific configuration commands. Use the **exit** command to exit from the interface configuration submode back to the normal global configuration mode.

Step 3 **ipv4 address** *ipv4-address mask*

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv4 address 10.1.2.3 255.0.0.0
```

Assigns an IP address and subnet mask to the virtual interface using the **ipv4 address** configuration subcommand.

Step 4 **bundle minimum-active bandwidth** *kbps*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle minimum-active bandwidth 580000
```

(Optional) Sets the minimum amount of bandwidth required before a user can bring up a bundle.

Step 5 **bundle minimum-active links** *links*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle minimum-active links 2
```

(Optional) Sets the number of active links required before you can bring up a specific bundle.

Step 6 **bundle maximum-active links** *links* [**hot-standby**]

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle maximum-active links 1 hot-standby
```

(Optional) Implements 1:1 link protection for the bundle, which causes the highest-priority link in the bundle to become active and the second-highest-priority link to become the standby. Also, specifies that a switchover between active and standby LACP-enabled links is implemented per a proprietary optimization.

Note
The priority of the active and standby links is based on the value of the **bundle port-priority** command.

Step 7 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# exit
```

Exits the interface configuration submode.

Step 8 **interface Bundle-Ether** *bundle-id.vlan-id*

Example:

```
RP/0/RP0/CPU0:router#(config)# interface Bundle-Ether 3.1
```

Creates a new VLAN, and assigns the VLAN to the Ethernet bundle you created in Step 2.

Replace the *bundle-id* argument with the *bundle-id* you created in Step 2.

Replace the *vlan-id* with a subinterface identifier.

Range is from 1 to 4093 inclusive (0, 4094, and 4095 are reserved).

Note
When you include the **.***vlan-id* argument with the **interface Bundle-Ether** *bundle-id* command, you enter subinterface configuration mode.

Step 9 **encapsulation dot1q***vlan-id*

Example:

```
RP/0/RP0/CPU0:router(config-subif)# encapsulation dot1q 100
```

Sets the Layer 2 encapsulation of an interface.

Step 10 **ipv4 address** *ipv4-address mask*

Example:

```
RP/0/RP0/CPU0:router#(config-subif)# ipv4 address 10.1.2.3/24
```

Assigns an IP address and subnet mask to the subinterface.

Step 11 **no shutdown**

Example:

```
RP/0/RP0/CPU0:router#(config-subif)# no shutdown
```

(Optional) If a link is in the down state, bring it up. The **no shutdown** command returns the link to an up or down state depending on the configuration and state of the link.

Step 12 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# exit
```

Exits subinterface configuration mode for the VLAN subinterface.

Step 13 Repeat Step 9 through Step 12 to add more VLANS to the bundle you created in Step 2.

(Optional) Adds more subinterfaces to the bundle.

Step 14 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# end
```

or

```
RP/0/RP0/CPU0:router(config-subif)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before
exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.

- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 15 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# end
```

Exits interface configuration mode.

Step 16 **exit**

Example:

```
RP/0/RP0/CPU0:router(config)# exit
```

Exits global configuration mode.

Step 17 **configure**

Example:

```
RP/0/RP0/CPU0:router # configure
```

Enters global configuration mode.

Step 18 **interface** {**TenGigE** | **FortyGigE** | **HundredGigE**} *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface TenGigE 1/0/0/0
```

Enters interface configuration mode for the Ethernet interface you want to add to the Bundle.

Enter the **GigabitEthernet** or **TenGigE** keyword to specify the interface type. Replace the *interface-path-id* argument with the node-id in the rack/slot/module format.

Note
A VLAN bundle is not active until you add an Ethernet interface on both ends of the link bundle.

LACP Short Period Time Intervals

As packets are exchanged across member links of a bundled interface, some member links may slow down or time-out and fail. LACP packets are exchanged periodically across these links to verify the stability and reliability of the links over which they pass. The configuration of short period time intervals, in which LACP packets are sent, enables faster detection and recovery from link failures.

Short period time intervals are configured as follows:

- In milliseconds
- In increments of 100 milliseconds
- In the range 100 to 1000 milliseconds
- The default is 1000 milliseconds (1 second)
- Up to 64 member links
- Up to 1280 packets per second (pps)

After 6missed packets, the link is detached from the bundle.

When the short period time interval is *not* configured, LACP packets are transmitted over a member link every 30 seconds by default.

When the short period time interval is configured, LACP packets are transmitted over a member link once every 1000 milliseconds (1 second) by default. Optionally, both the transmit and receive intervals can be configured to less than 1000 milliseconds, independently or together, in increments of 100 milliseconds (100, 200, 300, and so on).

When you configure a custom LACP short period *transmit* interval at one end of a link, you must configure the same time period for the *receive* interval at the other end of the link.

Note You must always configure the *transmit* interval at both ends of the connection before you configure the *receive* interval at either end of the connection. Failure to configure the *transmit* interval at both ends first results in route flapping (a route going up and down continuously). When you remove a custom LACP short period, you must do it in reverse order. You must remove the *receive* intervals first and then the *transmit* intervals.

Configuring the Default LACP Short Period Time Interval

This section describes how to configure the default short period time interval for sending and receiving LACP packets on a Gigabit Ethernet interface. This procedure also enables the LACP short period.

SUMMARY STEPS

1. **configure**
2. **interface HundredGigE***interface-path*
3. **bundle id** *number* **mode active**
4. **lacp period short**
5. **end** or **commit**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface HundredGigE***interface-path*

Example:

```
RP/0/RP0/CPU0:router(config)# interface HundredGigE 0/1/0/1
```

Creates a Gigabit Ethernet interface and enters interface configuration mode.

Step 3 **bundle id** *number* **mode active**

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle id 1 mode active
```

Specifies the bundle interface and puts the member interface in active mode.

Step 4 **lacp period short**

Example:

```
RP/0/RP0/CPU0:router(config-if)# lacp period short
```

Configures a short period time interval for the sending and receiving of LACP packets, using the default time period of 1000 milliseconds or 1 second.

Step 5 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before
exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.

- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Example

This example shows how to configure the LACP short period time interval to the default time of 1000 milliseconds (1 second):

```
config
interface HundredGigE 0/1/0/1
   bundle id 1 mode active
   lacp period short
   commit
```

The following example shows how to configure custom LACP short period transmit and receive intervals to *less than* the default of 1000 milliseconds (1 second):

```
config
interface HundredGigE 0/1/0/1
   bundle id 1 mode active
```

```
   lacp period short
   commit

config
interface HundredGigE 0/1/0/1
    lacp period short transmit 100
   commit

config
interface HundredGigE 0/1/0/1
   lacp period short receive 100
   commit
```

Configuring Custom LACP Short Period Time Intervals

This section describes how to configure custom short period time intervals (less than 1000 milliseconds) for sending and receiving LACP packets on a Gigabit Ethernet interface.

Note You must always configure the *transmit* interval at both ends of the connection before you configure the *receive* interval at either end of the connection. Failure to configure the *transmit* interval at both ends first results in route flapping (a route going up and down continuously). When you remove a custom LACP short period, you must do it in reverse order. You must remove the *receive* intervals first and then the *transmit* intervals.

SUMMARY STEPS

1. **configure**
2. **interface Bundle-Ether** *bundle-id*
3. **ipv4 address** *ipv4-address mask*
4. **bundle minimum-active bandwidth** *kbps*
5. **bundle minimum-active links** *links*
6. **bundle maximum-active links** *links*
7. **exit**
8. **interface Bundle-Ether** *bundle-id.vlan-id*
9. **dot1q vlan** *vlan-id*
10. **ipv4 address** *ipv4-address mask*
11. **no shutdown**
12. **exit**
13. Repeat Step 7 through Step 12 to add more VLANs to the bundle you created in Step 2.
14. **end** or **commit**
15. **exit**
16. **exit**
17. **show ethernet trunk bundle-ether** *instance*
18. **configure**
19. **interface** {**HundredGigE** } *interface-path-id*
20. **bundle id** *bundle-id* [**mode** {**active** | **on** | **passive**}]

21. **no shutdown**
22. Repeat Step 19 through Step 21 to add more Ethernet interfaces to the VLAN bundle.
23. **end** or **commit**
24. Perform Step 1 through Step 23 on the remote end of the VLAN bundle connection.
25. **show bundle Bundle-Ether** *bundle-id* [**reasons**]
26. **show ethernet trunk bundle-ether** *instance*

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface Bundle-Ether** *bundle-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface Bundle-Ether 3
```

Creates and names a new Ethernet link bundle.

This **interface Bundle-Ether** command enters you into the interface configuration submode, where you can enter interface-specific configuration commands. Use the **exit** command to exit from the interface configuration submode back to the normal global configuration mode.

Step 3 **ipv4 address** *ipv4-address mask*

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv4 address 10.1.2.3 255.0.0.0
```

Assigns an IP address and subnet mask to the virtual interface using the **ipv4 address** configuration subcommand.

Step 4 **bundle minimum-active bandwidth** *kbps*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle minimum-active bandwidth 580000
```

(Optional) Sets the minimum amount of bandwidth required before a user can bring up a bundle.

Step 5 **bundle minimum-active links** *links*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle minimum-active links 2
```

(Optional) Sets the number of active links required before you can bring up a specific bundle.

Step 6 **bundle maximum-active links** *links*

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle maximum-active links 1
```

(Optional) Designates one active link and one link in standby mode that can take over immediately for a bundle if the active link fails (1:1 protection).

Note
- The default number of active links allowed in a single bundle is 8.
- If the **bundle maximum-active** command is issued, then only the highest-priority link within the bundle is active. The priority is based on the value from the **bundle port-priority** command, where a lower value is a higher priority. Therefore, we recommend that you configure a higher priority on the link that you want to be the active link.

Step 7 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# exit
```

Exits the interface configuration submode.

Step 8 **interface Bundle-Ether** *bundle-id.vlan-id*

Example:

```
RP/0/RP0/CPU0:router#(config)# interface Bundle-Ether 3.1
```

Creates a new VLAN, and assigns the VLAN to the Ethernet bundle you created in Step 2.

Replace the *bundle-id* argument with the *bundle-id* you created in Step 2.

Replace the *vlan-id* with a subinterface identifier. Range is from 1 to 4093 inclusive (0, 4094, and 4095 are reserved).

Note
- When you include the *vlan-id* argument with the **interface Bundle-Ether** *bundle-id* command, you enter subinterface configuration mode.

Step 9 **dot1q vlan** *vlan-id*

Example:

```
RP/0/RP0/CPU0:router(config-subif)# dot1q vlan 10
```

Assigns a VLAN to the subinterface.

Replace the *vlan-id* argument with a subinterface identifier. Range is from 1 to 4093 inclusive (0, 4094, and 4095 are reserved).

Step 10 **ipv4 address** *ipv4-address mask*

Example:

```
RP/0/RP0/CPU0:router(config-subif)# ipv4 address 10.1.2.3/24
```

Assigns an IP address and subnet mask to the subinterface.

Step 11 **no shutdown**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# no shutdown
```

(Optional) If a link is in the down state, bring it up. The **no shutdown** command returns the link to an up or down state depending on the configuration and state of the link.

Step 12 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# exit
```

Exits subinterface configuration mode for the VLAN subinterface.

Step 13 Repeat Step 7 through Step 12 to add more VLANs to the bundle you created in Step 2.

(Optional) Adds more subinterfaces to the bundle.

Step 14 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# end
```

or

```
RP/0/RP0/CPU0:router(config-subif)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting (yes/no/cancel)?`
- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 15 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# exit
```

Exits interface configuration mode.

Step 16 **exit**

Example:

```
RP/0/RP0/CPU0:router(config)# exit
```

Exits global configuration mode.

Step 17 **show ethernet trunk bundle-ether** *instance*

Example:

```
RP/0/RP0/CPU0:router# show ethernet trunk bundle-ether 5
```

(Optional) Displays the interface configuration.

The Ethernet bundle instance range is from 1 through 65535.

Step 18 **configure**

Example:

```
RP/0/RP0/CPU0:router # configure
```

Enters global configuration mode.

Step 19 **interface** {**HundredGigE** } *interface-path-id*

Example:

```
RP/0/RP0/CPU0:router(config)# interface HundredGigE 0/1/0/1
```

Enters the interface configuration mode for the Ethernet interface you want to add to the Bundle.

Enter the **HundredGigE** keyword to specify the interface type. Replace the *interface-path-id* argument with the node-id in the rack/slot/module format.

Note
- A VLAN bundle is not active until you add an Ethernet interface on both ends of the link bundle.

Step 20 **bundle id** *bundle-id* [**mode** {**active** | **on** | **passive**}]

Example:

```
RP/0/RP0/CPU0:router(config-if)# bundle-id 3
```

Adds an Ethernet interface to the bundle you configured in Step 2 through Step 13.

To enable active or passive LACP on the bundle, include the optional **mode active** or **mode passive** keywords in the command string.

To add the interface to the bundle without LACP support, include the optional **mode on** keywords with the command string.

Note
- If you do not specify the **mode** keyword, the default mode is **on (**LACP is not run over the port).

Step 21 **no shutdown**

Example:

```
RP/0/RP0/CPU0:router(config-if)# no shutdown
```

(Optional) If a link is in the down state, bring it up. The **no shutdown** command returns the link to an up or down state depending on the configuration and state of the link.

Step 22 Repeat Step 19 through Step 21 to add more Ethernet interfaces to the VLAN bundle.

—

Step 23 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-subif)# end
```

or

```
RP/0/RP0/CPU0:router(config-subif)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes: `Uncommitted changes found, commit them before exiting (yes/no/cancel)?`
- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 24 Perform Step 1 through Step 23 on the remote end of the VLAN bundle connection.

Brings up the other end of the link bundle.

Step 25 **show bundle Bundle-Ether** *bundle-id* [**reasons**]

Example:

```
RP/0/RP0/CPU0:router# show bundle Bundle-Ether 3 reasons
```

(Optional) Shows information about the specified Ethernet link bundle.

The **show bundle Bundle-Ether** command displays information about the specified bundle. If your bundle has been configured properly and is carrying traffic, the State field in the **show bundle Bundle-Ether** command output will show the number “4,” which means the specified VLAN bundle port is “distributing.”

Step 26 **show ethernet trunk bundle-ether** *instance*

Example:

```
RP/0/RP0/CPU0:router# show ethernet trunk bundle-ether 5
```

(Optional) Displays the interface configuration.

The Ethernet bundle instance range is from 1 through 65535.

Bundle Consistency Checker

Table 21: Feature History Table

Feature Name	Release Information	Feature Description
Bundle Consistency Checker (BCC)	Release 7.3.1	From the running configuration, Bundle Consistency Checker (BCC) fetches information about the ingress/egress traffic from the bundle, sub-bundle, and active member nodes and saves it in the database. BCC also collects data from all the running nodes and then compares it with the information saved in the database. Any inconsistencies, programming errors, stale entries are reported.

In a scaled setup, a bundle programming check is difficult to perform and time consuming. Moreover, an issue is reported only when the user detects it, and not automatically. During multiple test executions, it isn't possible to detect the initial failure, which causes other subsequent failures. Bundle Consistency Checker (BCC) implements bundle programming and consistency check by using the following steps:

1. BCC uses the running configuration to detect discrepancies.
2. BCC forms a Bundle Consistency Checker Data Base (BCCDB) with the bundle, sub-bundle, or member information fetched from the running configuration.
3. BCC dumps the required data from all available nodes. It then uses BCCDB as a source to verify bundle programming and consistency in all other layer dumps.
4. BCC reports inconsistencies, programming errors, stale entries, and deletes any pending objects.

Supporting Interfaces

The following interfaces support BCC:

- Bundle
- Bundle sub-interface

The following table lists BCC behaviour during inconsistencies in bundle configuration or programming errors.

Case	BCC Behaviour
When no bundle is configured	Router# **show bundle consistency** Building configuration... Dumping Data..... Done Parsing Data..... Not Done BCC Stopped: Found 3 info/exceptions/errors Logs Preview: 2020-07-13 10:34:22,774: INFO: Bundlemgr PD dont have any bundle data 2020-07-13 10:34:22,832: INFO: BMPI dont have any bundle data 2020-07-13 10:34:23,728: INFO: No Bundle is configured/No member is added to Bundle Logs: /var/log/bcc_exception.log /var/log/bcc_debug.log
When a bundle is configured but no member is added	Router# **show bundle consistency** Building configuration... Dumping Data..... Done Parsing Data..... Not Done BCC Stopped: Found 4 info/exceptions/errors Logs Preview: 2020-07-13 10:36:32,513: INFO: Bundlemgr PD dont have any bundle data 2020-07-13 10:36:32,566: INFO: No member is added to bundle BE1(0x3c00400c) 2020-07-13 10:36:32,566: INFO: BMPI dont have any bundle data 2020-07-13 10:36:33,453: INFO: No Bundle is configured/No member is added to Bundle Logs: /var/log/bcc_exception.log /var/log/bcc_debug.log

Case	BCC Behaviour
When a bundle is configured and members are added	Router# **show bundle consistency** Building configuration... Dumping Data..... Done Parsing Data..... Done Bundle Consistency Check..... Done Bundle Programming Check..... Done Stale Entry Check..... Done Bundle Health Check..... Done Overall Results: Inconsistencies : 0 Stale Entries : 0 BCM Programming Error : 0 Delete Pending DPA Objects : 0 Info/Error/Python Exception : 0 Overall Bundle Health Status : WARNING Execute 'show bundle status' to see detailed reason for 'WARNING' in bundle health check

Case	BCC Behaviour
When there is no encapsulation configuration for L2 or L3 sub-bundle or no member for L2 bundle	Router# **show bundle consistency** Building configuration... Dumping Data..... Done Parsing Data..... Done Bundle Consistency Check..... Done Bundle Programming Check..... Done Stale Entry Check..... Done Bundle Health Check..... Done Overall Results: Inconsistencies : 0 Stale Entries : 0 BCM Programming Error : 0 Delete Pending DPA Objects : 0 Info/Error/Python Exception : 3 Overall Bundle Health Status : WARNING Execute 'show bundle status' to see detailed reason for 'WARNING' in bundle health check Logs Preview: 2020-07-12 17:38:26,568: INFO: No member is added to bundle BE2(0x80042bc) ==> l2 bundle main 2020-07-12 17:38:32,573: interface Bundle-Ether1.1: Dont have any encapsulation config. ==> l3 sub 2020-07-12 17:38:32,574: interface Bundle-Ether1.130: Dont have any encapsulation config. ==> l2sub Logs: /var/log/bcc_inconsistencies.log /var/log/bcc_programming_error.log /var/log/bcc_stale_entries.log /var/log/bcc_delay_delete.log /var/log/bcc_bundle_health.log /var/log/bcc_exception.log /var/log/bcc_debug.log

Case	BCC Behaviour

During programming errors	`Router# show bundle consistency`
	
	`Building configuration...`
	`Dumping Data..... Done`
	`Parsing Data..... Done`
	`Bundle Consistency Check..... Done`
	`Bundle Programming Check..... Done`
	`Stale Entry Check..... Done`
	`Bundle Health Check..... Done`
	
	`Overall Results:`
	
	`Inconsistencies : 0 Stale Entries : 0`
	`BCM Programming Error : 1 Delete Pending DPA Objects : 0`
	`Info/Error/Python Exception : 0 Overall Bundle Health Status : WARNING`
	
	`Execute 'show bundle status' to see detailed reason for 'WARNING' in bundle health check`
	
	`Logs Preview:`
	
	`2020-07-12 18:48:22,658: Programming Error 1: BE1(0x80041ec) NPU 0,0/RP0/CPU0 Vlan Domain 0x33 != GigabitEthernet0_0_0_2 Vlan Domain 0xa`
	
	`Logs:`
	
	`/var/log/bcc_inconsistencies.log`
	`/var/log/bcc_programming_error.log`
	`/var/log/bcc_stale_entries.log`
	`/var/log/bcc_delay_delete.log`
	`/var/log/bcc_bundle_health.log`
	`/var/log/bcc_exception.log`
	`/var/log/bcc_debug.log`

Information About Configuring Link Bundling

To configure link bundling, you must understand the following concepts:

IEEE 802.3ad Standard

The IEEE 802.3ad standard typically defines a method of forming Ethernet link bundles.

For each link configured as bundle member, the following information is exchanged between the systems that host each end of the link bundle:

- A globally unique local system identifier
- An identifier (operational key) for the bundle of which the link is a member
- An identifier (port ID) for the link
- The current aggregation status of the link

This information is used to form the link aggregation group identifier (LAG ID). Links that share a common LAG ID can be aggregated. Individual links have unique LAG IDs.

The system identifier distinguishes one router from another, and its uniqueness is guaranteed through the use of a MAC address from the system. The bundle and link identifiers have significance only to the router assigning them, which must guarantee that no two links have the same identifier, and that no two bundles have the same identifier.

The information from the peer system is combined with the information from the local system to determine the compatibility of the links configured to be members of a bundle.

The MAC address of the first link attached to a bundle becomes the MAC address of the bundle itself. The bundle uses this MAC address until that link (the first link attached to the bundle) is detached from the bundle, or until the user configures a different MAC address. The bundle MAC address is used by all member links when passing bundle traffic. Any unicast or multicast addresses set on the bundle are also set on all the member links.

Note We recommend that you avoid modifying the MAC address, because changes in the MAC address can affect packet forwarding.

Link Bundle Configuration Overview

The following steps provide a general overview of the link bundle configuration. Keep in mind that a link must be cleared of all previous network layer configuration before it can be added to a bundle:

1. In global configuration mode, create a link bundle. To create an Ethernet link bundle, enter the **interface Bundle-Ether** command.
2. Assign an IP address and subnet mask to the virtual interface using the **ipv4 address** command.
3. Add interfaces to the bundle you created in Step 1 with the **bundle id** command in the interface configuration submode.

   You can add up to 32 links to a single bundle.
4. You can optionally implement 1:1 link protection for the bundle by setting the **bundle maximum-active links** command to 1. Performing this configuration causes the highest-priority link in the bundle to become active and the second-highest-priority link to become the standby. (The link priority is based on the value of the **bundle port-priority** command.) If the active link fails, the standby link immediately becomes the active link.

Note A link is configured as a member of a bundle from the interface configuration submode for that link.

Link Switchover

By default, a maximum of 64 links in a bundle can actively carry traffic. If one member link in a bundle fails, traffic is redirected to the remaining operational member links.

You can optionally implement 1:1 link protection for a bundle by setting the **bundle maximum-active links** command to 1. By doing so, you designate one active link and one or more dedicated standby links. If the active link fails, a switchover occurs and a standby link immediately becomes active, thereby ensuring uninterrupted traffic.

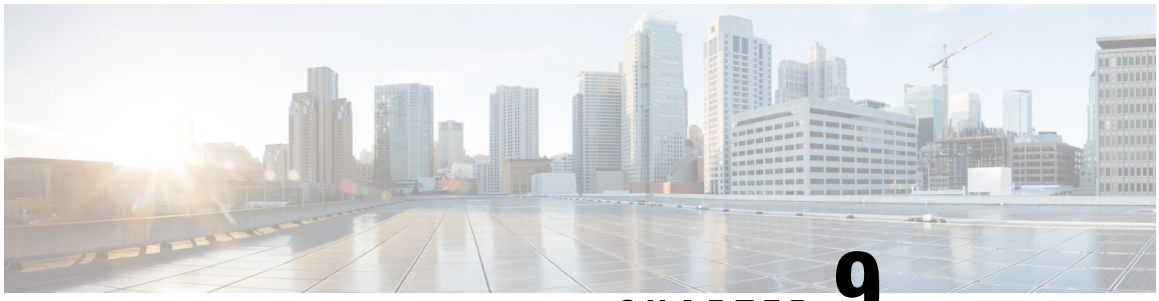
If the active and standby links are running LACP, you can choose between an IEEE standard-based switchover (the default) or a faster proprietary optimized switchover. If the active and standby links are not running LACP, the proprietary optimized switchover option is used.

Regardless of the type of switchover you are using, you can disable the wait-while timer, which expedites the state negotiations of the standby link and causes a faster switchover from a failed active link to the standby link.

To do so, you can use the **lacp fast-switchover** command.

LACP Fallback

The LACP Fallback feature allows an active LACP interface to establish a Link Aggregation Group (LAG) port-channel before the port-channel receives the Link Aggregation and Control Protocol (LACP) protocol data units (PDU) from its peer. With the LACP Fallback feature configured, the router allows the server to bring up the LAG, before receiving any LACP PDUs from the server, and keeps one port active. This allows the server to establish a connection to PXE server over one Ethernet port, download its boot image and then continue the booting process. When the server boot process is complete, the server fully forms an LACP port-channel.



CHAPTER 9

Configuring Traffic Mirroring

This module describes the configuration of the traffic mirroring feature. Traffic mirroring is sometimes called port mirroring, or switched port analyzer (SPAN). You can then pass this traffic to a destination port on the same router.

Feature Release History

Release	Modification
Release 6.1.3	ERSPAN Traffic to a Destination Tunnel in a Default VRF was introduced.
Release 7.0.2	SPAN over Pseudo-Wire was introduced.
Release 7.1.2	SPAN to File was introduced.
Release 7.2.1	File Mirroring was introduced. Traffic Mirroring was introduced on Cisco NC57 line cards in native mode only.
Release 7.3.1	PCAPng file format was introduced.
Release 7.4.1	Port Mirroring Enhancements for Cisco NC57 line cards were introduced.
Release 7.4.2	• Incoming (Rx) and outgoing (Tx) traffic to separate destinations on Cisco NC57 line cards was introduced. • Remote SPAN on Cisco NC57 line cards was introduced.
Release 7.5.2	Mirror first option in global configuration mode was introduced.
Release 7.5.3	ERSPAN Traffic to a Destination Tunnel in a Non-Default VRF was introduced.

Release	Modification
Release 7.5.4	• *Multiple SPAN ACL Sessions in a Single Interface was introduced . • *Monitor Multiple SPAN ACL and Security ACL Sessions was introduced. • *SPAN Using 7-Tuples ACL was introduced. • DSCP Marking on Egress GRE Tunnel in ERSPAN was introduced. • DSCP Bitmask to filter Ingress SPAN was introduced. • Mirroring Forward-Drop Packets was introduced. * - *Supported only on Cisco IOS XR Release 7.5.4, 7.10.1, and later releases*.
Release 7.6.1	VLAN Sub-interface as Ingress or Egress Source for Traffic Mirroringon NCS 5500 platforms and NC57 line cards was introduced.
Release 7.7.1	SPAN filtering of incoming traffic on Layer 2 interfaces for Cisco NC57 line cards was introduced.
Release 7.8.1	• SPAN filtering of outgoing traffic on Layer 2 interfaces for Cisco NC57 line cards was introduced. • Capture option support on Cisco NC57 line cards was introduced.
Release 7.10.1	Egress Hybrid ACL-based Traffic Mirroring on Cisco NCS 5700 Series Line Cards and Routers was introduced.
Release 7.11.1	Traffic Mirroring of Incoming and Outgoing Traffic Separately over Pseudowire was introduced.
Release 24.4.1	Multiple SPAN ACL Sessions for MPLS was introduced.

• Introduction to Traffic Mirroring, on page 234
• SPAN Types, Supported Features, and Configurations, on page 242
• Troubleshoot Traffic Mirroring, on page 293

Introduction to Traffic Mirroring

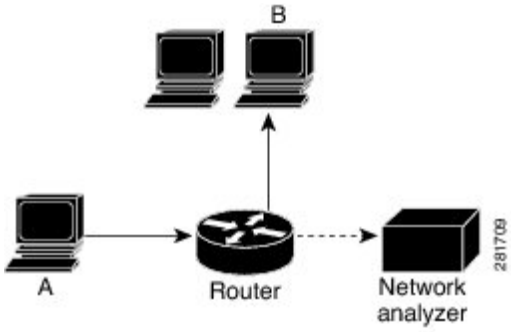
Traffic mirroring, also referred to as Port mirroring or Switched Port Analyzer (SPAN), is a Cisco proprietary feature that enables you to monitor network traffic passing in or out of a set of ports on a router. You can then mirror this traffic to a remote destination or a destination port on the same router.

Traffic mirroring copies traffic from one or more source ports and sends the copied traffic to one or more destinations for analysis by a network analyzer or other monitoring devices. Traffic mirroring does not affect

the flow of traffic on the source interfaces or sub-interfaces. It allows the mirrored traffic to be sent to a destination interface or sub-interface.

For example, you can attach a traffic or network analyzer to the router and capture the ethernet traffic that is sent by host A to host B.

Figure 16: Traffic Mirroring Operation



Traffic Mirroring Terminology

- Ingress Traffic — Traffic that comes into the router.
- Egress Traffic — Traffic that goes out of the router.
- Source port—A port that is monitored with the use of traffic mirroring. It is also called a monitored port.
- Destination port—A port that monitors source ports, usually where a network analyzer is connected. It is also called a monitoring port.
- Monitor session—A designation for a collection of SPAN configurations consisting of a single destination and, potentially, one or many source ports.

Traffic Mirroring Types

These are the supported traffic mirroring types.

- Local SPAN
- Remote SPAN
- SPAN on Layer 2 Interfaces
- ACL-based SPAN
- ERSPAN
- SPAN over Pseudo-Wire
- SPAN-to-File, on page 286
- Forward-Drop Packets Mirroring
- File Mirroring

Characteristics of Source Port

A source port, also called a monitored port, is a routed port that you monitor for network traffic analysis. In a single traffic mirroring session, you can monitor source port traffic. The Cisco NCS 5500 Series routers support a maximum of up to 800 source ports.

A source port has these characteristics:

- It can be any data port type, such as Bundle Interface, 100 Gigabit Ethernet physical port, or 10 Gigabit Ethernet physical port.
- Each source port can be monitored in only one traffic mirroring session.
- When a port is used as a source port, the same port cannot be used as a destination port.
- Each source port can be configured with a direction (ingress, egress, or both) to monitor local traffic mirroring. Remote traffic mirroring is supported both in the ingress and egress directions. For bundles, the monitored direction applies to all physical ports in the group.

Characteristics of Destination Port

Each session must have a destination port or file that receives a copy of the traffic from the source ports.

A destination port has these characteristics:

- A destination port cannot be a source port.
- For local traffic mirroring, a destination port must reside on the same router as the source port.
- For remote mirroring, the destination is always a GRE tunnel.

  From Release 7.4.1, the destination can be an L2 sub-interface on Cisco NCS 5700 Series line cards and routers.
- A destination port for local mirroring can be any Ethernet physical port, EFP, GRE tunnel interface, or bundle interface. It can be a Layer 2 or Layer 3 transport interface.
- At any time, a destination port can participate in only one traffic mirroring session. A destination port in one traffic mirroring session cannot be a destination port for a second traffic mirroring session. In other words, no two monitor sessions can have the same destination port.

Characteristics of Monitor Session

A monitor session is a collection of traffic mirroring configurations consisting of a single destination and, potentially, many source interfaces. For any given monitor session, the traffic from the source interfaces (called *source ports*) is sent to the monitoring port or destination port. If there are more than one source port in a monitoring session, the traffic from the several mirrored traffic streams is combined at the destination port. The result is that the traffic that comes out of the destination port is a combination of the traffic from one or more source ports.

Monitor sessions have these characteristics:

- A single monitor session can have only one destination port.
- A single destination port can belong to only one monitor session.

- A monitor session can have a maximum of 800 source ports. This maximum limit is applicable only when the maximum number of source ports from all monitoring sessions does not exceed 800.

Supported Scale

- For NCS 5500 line cards in NCS 5500 modular routers, a sub-interface with only one VLAN is supported as source for traffic mirroring. A maximum of four source sub-interfaces at system level are supported on NCS 5500.
- Prior to Cisco IOS XR Release 7.8.1, a single router could support up to four monitor sessions. However, configuring SPAN and CFM on the router reduced the maximum number of monitor sessions to two, as both shared the mirror profiles.
- Starting Cisco IOS XR Software Release 7.8.1, SPAN supports a maximum of up to three monitor sessions on the NCS 5500 routers. But, if you configure SPAN and CFM on the router, the maximum number of monitor sessions decreases to one, as both functions use the same mirror profiles. The decrease in the number of monitor sessions does not affect the NCS 5700 platforms.
- From Cisco IOS XR Software Release 7.2.1 to 7.3.1, Cisco NC57 line cards support only four Rx and three Tx monitor sessions in native mode. From 7.4.1 release, 24 sessions in total are supported in native mode. Sessions can be configured as Rx-only, Tx-only, or Rx/Tx.
- Cisco NC57 line cards support a maximum of 23 SPAN to file sessions in native mode.
- You can configure 23 SPAN-to-File sessions. The combined scale is listed in the table:

Combination Example	Scale
10 ERSPAN + 14 SPAN-to-File	24 sessions
13 RX ERSPAN + 11 SPAN-to-File	24 sessions
23 SPAN-to-File + 1 ERSPAN	24 sessions

Restrictions

Generic Restrictions

The following are the generic restrictions related to traffic mirroring:

- Partial mirroring and sampled mirroring are not supported.
- From Release 7.6.1, sub-interface configured as source interface is supported on SPAN.
- The destination bundle interfaces flap when:
  - both the mirror source and destination are bundle interfaces in the Link Aggregation Control Protocol (LACP) mode.
  - mirror packets next-hop is a router or a switch instead of a traffic analyzer.

This behavior is observed due to a mismatch of LACP packets on the next-hop bundle interface due to the mirroring of LACP packets on the source bundle interface.

- Bridge group virtual interfaces (BVIs) are not supported as source ports or destination ports.
- Bundle members cannot be used as source ports in NC57 line cards.
- Bundle members cannot be used as destination ports.
- Fragmentation of mirror copies is not handled by SPAN when SPAN destination MTU is less than the packet size. Existing behaviour if the MTU of destination interface is less than the packet size is as below:

Platforms	Rx SPAN	Tx SPAN
NCS 5500	Mirror copies are not fragmented. Receives whole packets as mirror copies.	Mirror copies are fragmented.
NCS 5700	Mirror copies are not fragmented. Do not receive mirror copies.	Mirror copies are fragmented.

You can configure the SPAN destination with an MTU which is greater than the packet size.

- Until Cisco IOS XR Software Release 7.6.1, SPAN only supports port-level source interfaces.
- Packets arriving at the subinterface will not be mirrored if Rx SPAN is enabled on the main bundle interface.

Restrictions on VLAN Sub-interface as Source

The following restrictions apply to VLAN sub-interface as source for traffic mirroring on NCS 5500 routers and NC57 line cards from Cisco IOS XR Release 7.6.1:

- Supports a maximum of 24 reception and transmission sessions together for mirroring. This restriction is applicable for sub-intefaces and ports as source.
- When the port is in Egress Traffic Management (ETM) mode, the outgoing or egress (Tx) traffic mirroring is possible only on the sub-interface for which the egress (Tx) traffic mirroring is configured.
- Tx mirroring is applicable on ETM mode only. Rx mirroring is applicable on both the ETM and non-ETM modes.

Restrictions on SPAN Filtering on VLAN Interfaces

These restrictions apply to SPAN filtering on Layer 2 and Layer 3 interfaces:

- For routers that have NC57 line cards operating in the native mode, you cannot choose to mirror only packets ingressing at a specific interface that is part of a bundle.

  Enable mirroring at the bundle level to mirror packets that ingress at a specific bundle interface. Packets that ingress other bundle members are also mirrored.
- On a main interface, if **span-acl** isn't configured and only **span** is configured, then the router performs only L2-L2 SPAN port filtering if **hw-module profile span-filter l2-rx-enable** command is enabled.
- Other Layer 2 point-to-point services such as Xconnect, VPWS, EVPN, and VPLS (PW) aren't supported.

Restrictions on ACL-based SPAN

The following restrictions apply to SPAN-ACL:

Table 22: SPAN-ACL Support

Platforms	Rx Direction	Tx Direction
NCS 5500	Supported at the port level, that is, in the ingress direction for IPv4 or IPv6 ACLs.	Not supported.
NCS 5700	Supported on both the main interfaces and sub-interfaces from Cisco IOS XR Release 7.4.1.	Supported in ETM mode on both the main interfaces and sub-interfaces from Cisco IOS XR Release 7.10.1.

- Multi-SPAN ACL is supported in the Rx direction in Cisco IOS XR Release 7.5.4 , Cisco IOS XR Release 7.10.1 and later releases.
- Multi-SPAN ACL sessions can be used only with 7-Tuples SPAN ACL.
- MPLS traffic cannot be captured with SPAN-ACL.
  - ACL for any MPLS traffic is not supported.
- Traffic mirroring counters are not supported.
- ACL-based traffic mirroring is not supported with Layer 2 (ethernet-services) ACLs.
- Main interface as span source interface and ACL with the **capture** keyword on same main interface's sub-interface are not supported.
- If a SPAN session with the **acl** keyword is applied on an interface with no ACL rule attached to that interface, SPAN happens without any filtering.
- Configure one or more ACLs on the source interface or any interface on the same network processing unit as the source interface, to avoid default mirroring of traffic. If a Bundle interface is a source interface, configure the ACL on any interface on the same network processing unit as all active bundle-members. Bundle members can be on multiple NPUs. Also, ensure that the ACLs configured are of the same protocol type and direction as the SPAN configuration. For example, if you configure SPAN with ACL for IPv4 or IPv6, configure an ingress IPv4 or IPv6 ACL on that network processing unit respectively.
- Starting from Cisco IOS XR Release 7.11.2, SPAN for MPLS traffic is supported using IPv4 and IPv6 ACLs on the following routers and line cards:
  - NCS-57B1-6D24-SYS
  - NCS-57B1-5DSE-SYS
  - NCS-57C3-MOD-S
  - NCS-57C3-MOD-SE-S
  - NC57-24DD
  - NC57-18DD-SE

- NC57-36H-SE
- NC57-36H6D
- NC57-MOD-S

Restrictions on ACL-based SPAN for Outgoing Traffic (Tx)

The following restrictions apply to traffic mirroring using ACLs for outgoing (Tx) traffic on Cisco NCS 5700 Series line cards and routers:

- SPAN configuration with **port mode** on the main interface and Tx SPAN ACL configuration on the sub-interface of the same port isn't supported.
- BVI interface as a SPAN source interface is not supported.
- Hybrid ACLs with only compress level 3 are supported.
- 24 SPAN sessions are supported for both Rx and Tx destinations.
- ACL-based traffic mirroring for the outgoing (Tx) traffic is supported on the following routers and line cards for L3 interfaces:
  - NCS-57B1-5DSE
  - NCS-57C3-MODS-SYS
  - NC57-18DD-SE
  - NC57-36H-SE

Restrictions on ERSPAN

This section provides the restrictions that apply to ERSPAN and multiple ERSPAN sessions.

The following restrictions apply to ERSPAN:

- ERSPAN next-hop must have ARP resolved.
- ERSPAN packets with outgoing interface having MPLS encapsulation are not supported. The next-hop router or any router in the path can encapsulate in MPLS.
  - Additional routers may encapsulate in MPLS.
- ERSPAN sessions can be created only on physical interfaces. The sessions cannot be created on sub-interfaces.
- ERSPAN supports a maximum of three sessions.
- ERSPAN decapsulation is not supported.
- ERSPAN does not work if the GRE next hop is reachable over sub-interface. For ERSPAN to work, the next hop must be reachable over the main interface.
- When you use the same ACEs defined in both the IPv4 and IPv6 ACLs, the router doesn’t perform ERSPAN mirroring for the ACLs that have the priority set as 2 ms.
- ERSPAN decapsulation is not supported. Tunnel destination should be network analyzer.

- ERSPAN is not supported when the **hw-module profile segment-routing srv6 mode micro-segment format f3216** configuration is enabled.

Restricitons on Multiple ERSPAN ACL on a Single Interface

- All sessions under the source port should have SPAN access control list (ACL) enabled.
- A few sessions with SPAN ACL and a few without SPAN ACLs in the same source interface are not supported.
- No two sessions should have the same ACL in the same source interface. Each session should have a different ACL.
- Multiple sessions without ACL in the same interface are not supported.
- Multi-SPAN ACL does not support the **Deny** action.
- One SPAN session with the keyword ACL (use security acl as the keyword) and other SPAN sessions with the keyword SPAN ACL are not supported.
- At a time, you can make only one mirror copy of a packet.
- Capturing keywords is not required.
- Multiple sessions under the same interface cannot have a combination of directions. Only RX is supported.

Restrictions on SPAN over Pseudowire

SPAN over Psedowire (PW-SPAN) has the following restrictions:

- PW-SPAN does not support the listed functionalities:
  - Monitor session statistics
  - Partial packet SPAN
  - Sampled SPAN
- ETM mode must be enabled for outgoing (Tx) traffic on sub-interface.

Restrictions on SPAN-to-File

SPAN to File has the following restrictions:

- A maximum of 1000 source ports are supported across the system. Individual platforms may support lower numbers. The SPAN session may be any of these currently supported classes: Ethernet, IPv4, IPv6, MPLS-IPv4, and MPLS-IPv6.
- Provides a buffer range of 1000-1000000 KB. The default buffer size is set to 1000 KB.
- Provides support for SPAN source.
  - Each source port can be monitored in only one traffic mirroring session.
  - Each source port can be configured with a direction (ingress, egress, or both) to monitor local traffic mirroring.
- Only supported on the Cisco NCS550x and Cisco NCS55Ax line cards.

- Only port-level is supported.
- VLAN interface as source port is not supported.
- Bundle members as source interfaces are not supported.
- Filtering based on Egress ACL is not supported.
- Source port statistics is not supported.
- Span to file mirror packets are punted from NPU to CPU at a maximum shaper rate of 40 mbps.
- From Cisco IOS XR Software Release 24.3.1, Cisco NC57 line cards support Span-to-File feature.
- You cannot use egress SPAN-to-File on a sub-interface of NC57 line cards when the interface is not in ETM mode.
- When you configure egress SPAN-to-File on a sub-interface or an egress ACL-based SPAN-to-File in ETM mode on NC57 line cards, the interface name is not available in pcapng.

Restrictions on File Mirroring

The following restrictions apply to file mirroring:

- Supported only on Dual RP systems.
- Supports syncing only from active to standby RP. If files are copied into standby `/harddisk:/mirror` location, it won't be synced to active RP.
- A slight delay is observed in `show mirror` command output when mirror checksum configuration is enabled.
- Not supported on multichassis systems.

Restrictions on Forward-Drop Packets Mirroring

These are some restrictions for Forward-Drop packets mirroring:

- Only one global forward-drop session can be configured on a router.
- When traffic-class is configured under monitor-session for forward-drop, the type of service (ToS) byte of the outgoing ERSPAN packet is overwritten with the configured traffic-class value.
- In-band traffic destined to router management interface cannot be captured using this functionality.
- Forward-drop packets mirroring does not support access control lists (ACL) drops.

SPAN Types, Supported Features, and Configurations

Local SPAN

This is the most basic form of traffic mirroring. The network analyzer or sniffer is attached directly to the destination interface. In other words, all monitored ports are located on the same router as the destination port.

Remote SPAN

Table 23: Feature History Table

Feature Name	Release Information	Feature Description
Remote SPAN on NC57 Line Cards	Release 7.4.1	You can configure a subinterface as a destination on Cisco NC57 line cards in native mode.

From Release 7.4.1, the destination can be an L2 subinterface on NC57 line cards.

From Release 7.4.1, a restricted form of remote traffic mirroring or remote SPAN is implemented on NC57 line cards. In this form, the router sends traffic to a single destination port that pushes a VLAN tag. Destination interface is a subinterface with VLAN encapsulation.

Configure Remote Traffic Mirroring

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **monitor-session** *session-name*

Example:

```
RP/0/RP0/CPU0:router(config)# monitor-session mon1 ethernet
RP/0/RP0/CPU0:router(config-mon)#
```

Defines a monitor session and enters monitor session configuration mode.

Step 3 **destination interface** *subinterface*

Example:

```
RP/0/RP0/CPU0:router(config-mon)# destination interface TenGigE 0/2/0/4.1
```

Specifies the destination subinterface to which traffic is replicated.

Step 4 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-mon)# exit
RP/0/RP0/CPU0:router(config)#
```

Exits monitor session configuration mode and returns to global configuration mode.

Step 5 **interface** *type number*

Example:

```
RP/0/RP0/CPU0:router(config)# interface HundredGigE 0/1/0/1
```

Enters interface configuration mode for the specified source interface. The interface number is entered in *rack*/*slot*/*module*/*port* notation. For more information about the syntax for the router, use the question mark (?) online help function.

Step 6 **monitor-session** *session-name* **ethernet direction rx-onlyport-only**

Example:

```
RP/0/RP0/CPU0:router(config-if)# monitor-session mon1 ethernet
direction rx-only port-only
```

Specifies the monitor session to be used on this interface. Use the **direction** keyword to specify that only ingress or egress traffic is mirrored.

Step 7 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting (yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.

- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 8 **show monitor-session [session-name] status** [**detail**] [**error**]

Example:

```
RP/0/RP0/CPU0:router# show monitor-session
```

Displays information about the traffic mirroring session.

Example

This example shows the basic configuration for traffic mirroring with physical interfaces.

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# monitor-session ms1
RP/0/RP0/CPU0:router(config-mon)# destination interface HundredGigE0/2/0/15
RP/0/RP0/CPU0:router(config-mon)# commit

RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface TenGigE0/2/0/19
RP/0/RP0/CPU0:router(config-if)# monitor-session ms1 port-level
RP/0/RP0/CPU0:router(config-if)# commit

RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface TenGigE0/2/0/19
RP/0/RP0/CPU0:router(config-if)# monitor-session ms1 direction rx-only port-level
RP/0/RP0/CPU0:router(config-if)# commit

RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface TenGigE0/2/0/19
RP/0/RP0/CPU0:router(config-if)# monitor-session ms1 direction tx-only port-level
RP/0/RP0/CPU0:router(config-if)# commit
```

This example shows sample output of the show monitor-session command with the status keyword:

```
RP/0/RSP0/CPU0:router# show monitor-session status
Monitor-session cisco-rtp1
Destination interface HundredGigE 0/5/0/38
================================================================================
Source Interface Dir Status
---------------------- ---- -----------------------------------------------------
TenGigE0/5/0/4 Both Operational
TenGigE0/5/0/17 Both Operational
RP/0/RSP0/CPU0:router# show monitor-session status detail
Monitor-session sess1
Destination interface is not configured
Source Interfaces
-----------------
TenGigE0/2/0/19
Direction: Both
ACL match: Disabled
Portion: Full packet
Status: Not operational (destination interface not known).
TenGigE0/1/0/1
Direction: Both
ACL match: Disabled
Portion: First 100 bytes

RP/0/RSP0/CPU0:router# show monitor-session status error
Monitor-session ms1
Destination interface TenGigE0/2/0/15 is not configured
================================================================================
Source Interface Dir Status
---------------------- ---- -----------------------------------------------------
Monitor-session ms2
Destination interface is not configured
================================================================================
Source Interface Dir Status
---------------------- ---- -----------------------------------------------------
RP/0/RP0/CPU0:router# show monitor-session test status
Monitor-session test (ipv4)
Destination Nexthop 255.254.254.4
================================================================================================
```

```
Source Interface Dir Status
-----------------------------------------------------------------------------------------
Gi0/0/0/2.2 Rx Not operational (source same as destination)
Gi0/0/0/2.3 Rx Not operational (Destination not active)
Gi0/0/0/2.4 Rx Operational
Gi0/0/0/4 Rx Error: see detailed output for explanation
RP/0/RP0/CPU0:router# show monitor-session test status error
Monitor-session test
Destination Nexthop ipv4 address 255.254.254.4
=============================================================
Source Interface Status
-------------------------------------------------------------
Gi0/0/0/4 < Error: FULL Error Details >
```

SPAN on Subinterfaces

Layer 2 source ports can be mirrored on Cisco NCS 5500 routers and Cisco NC57 line cards.

On NCS 5500 series line cards, SPAN can be configured on up to six subinterfaces (either physical subinterfaces or bundle subinterfaces) associated with a single physical interface.

VLAN Subinterface as Ingress or Egress Source for Traffic Mirroring

Table 24: Feature History Table

Feature Name	Release Information	Feature Description
VLAN Subinterface as Ingress or Egress Source for Traffic Mirroring on NCS 5500 Platforms and NC57 Line Cards	Release 7.6.1	You can now configure the VLAN subinterface as an egress or ingress source for traffic mirroring on both the NCS 5500 platforms and the NC57 line cards. This feature enables the monitoring of traffic mirrored on either egress or ingress or both directions. You could configure mirror functionality only at the main interface level in earlier releases.

VLAN subinterface provides the flexibility to monitor ingress or egress, or both ingress/egress traffic from all the active subinterfaces of the source VLAN. The active subinterfaces in the source VLAN are considered as source subinterfaces. When subinterfaces are added or removed from the source VLAN, the corresponding traffic is added or removed from the monitoring sources.

From Cisco IOS XR Release 7.6.1, the NCS 5500 Platforms and NC57 line cards support VLAN as source for ingress and egress traffic mirroring.

VLAN Subinterface as Ingress Source for Traffic Mirroring

Configuration Example

```
Router# configure
Router(config)# monitor-session mon1 ethernet
Router(config-mon)# destination interface tunnel-ip 3
Router(config-mon)# exit
Router(config)# interface HundredGigE 0/1/0/1.10
Router(config-subif)# monitor-session mon1 ethernet direction rx-only
Router(config-if-mon)# commit
```

Running Configuration

```
Router# show run monitor-session mon1
monitor-session mon1 ethernet
 destination interface tunnel-ip3
!


Router# show run interface HundredGigE 0/1/0/1.10
 interface HundredGigE0/1/0/1.10
  encapsulation dot1q 10
   ipv4 address 101.1.2.1 255.255.255.252
    monitor-session mon1 ethernet direction rx-only port-level
    !
   !
  !
```

Verification

Verify that the status for VLAN subinterface is in the operational state for the incoming (Rx) traffic by using the **show monitor-session status command**:

```
Router# show monitor-session status
Monitor-session mon1
Destination interface tunnel-ip3
================================================================================
Source Interface Dir Status
---------------------- ---- -----------------------------------------------------
HundredGigE 0/1/0/1.10 (port) Rx Both Operational
```

VLAN Interface as Egress Source for Traffic Mirroring

Configuration Example

```
Router# configure
Router(config)# controller optics 0/0/0/1
Router(config-Optics)# mode etm
Router(config-Optics)# exit
Router(config)# interface HundredGigE 0/1/0/1.10
Router(config-subif)# monitor-session mon1 ethernet direction tx-only
Router(config-if-mon)# commit
```

Running Configuration

```
Router# show run monitor-session mon1
monitor-session mon1 ethernet
 destination interface tunnel-ip3
!


Router# show run interface HundredGigE 0/1/0/1.10
interface HundredGigE0/1/0/1.10
 encapsulation dot1q 20
  ipv4 address 102.1.2.1 255.255.255.252
   monitor-session mon1 ethernet direction tx-only port-level
   !
  !
 !
```

Verification

Verify that the status for VLAN subinterface is in the operational state for the outgoing (Tx) traffic by using the **show monitor-session status command**:

```
Router# show monitor-session status
Monitor-session mon1
Destination interface tunnel-ip3
================================================================================
Source Interface Dir Status
---------------------- ---- -------------------------------------------------
HundredGigE 0/1/0/1.10 (port)  Tx Both Operational
```

Monitoring Traffic Mirroring on a Layer 2 Interface

This section describes the configuration for monitoring traffic on a Layer 2 interface.

Configuration

To monitor traffic mirroring on a Layer 2 interface, configure the monitor under `l2transport` sub-config of the interface:

```
RP/0/RP0/CPU0:router(config)# interface TenGigE0/0/0/42
RP/0/RP0/CPU0:router(config-if)# l2transport
RP/0/RP0/CPU0:router(config-if-l2)# monitor-session EASTON ethernet port-level
```

Verification

Verify that the status for traffic mirroring on a Layer 2 interface is in the operational state by using the **show monitor-session status command**:

```
RP/0/RP0/CPU0:router# show monitor-session status
Thu Aug 29 21:42:22.829 UTC
Monitor-session EASTON
Destination interface TenGigE0/0/0/20
================================================
Source Interface      Dir   Status
--------------------- ----  -----------------
Te0/0/0/42 (port)     Both  Operational
```

SPAN Filtering on Layer 2 Interface

Table 25: Feature History Table

Feature Name	Release Information	Description
SPAN Filtering of Incoming Traffic on Layer 2 Interfaces for Cisco NC57 Line Cards	Release 7.7.1	SPAN filtering allows you to filter and mirror the incoming (Rx) DNS, HTTP, HTTPS, and TLS Layer 2 interface traffic. Thus, providing the user more flexibility to monitor and troubleshoot the DNS, HTTP, HTTPS, and TLS traffic. This feature introduces the following command: • hw-module profile span-filter l2-rx-enable This feature is supported on routers that have the Cisco NC57 line cards installed that operate in the native mode.

SPAN filtering on Layer 2 interfaces enables you to filter and mirror the incoming (Rx) traffic flowing through bridge domain Layer 2 switching, also known as intra bridge.

The router supports SPAN filtering of the following IPv4 and IPv6 traffic types on a Layer 2 interface:

- DNS - TCP and UDP
- HTTP
- HTTPS
- TLS

Layer 2 interface can be any of the following interface types:

- Layer 2 Physical main interface
- Layer 2 Physical subinterface
- Layer 2 Bundle main interface
- Layer 2 Bundle subinterface

Prerequisites

- SPAN filtering is supported only on the routers that have the Cisco NC57 line cards installed that operate in the native mode. To enable the native mode, use the **hw-module profile npu native-mode-enable** command and then reload the router.
- To enable SPAN filtering for incoming (Rx) traffic on the Cisco NC57 line cards, enable the **hw-module profile span-filter l2-rx-enable** command and then reload the router.

-

Configure SPAN Filtering for Incoming (Rx) Traffic

To enable SPAN filtering on a Layer 2 interface for incoming (Rx) traffic, perform the following configuration steps:

```
/* For Cisco NC57 line cards, enable the native mode and then reload the router */
RP/0/RP0/CPU0:router configure
RP/0/RP0/CPU0:router(config)# hw-module profile npu native-mode-enable

/* Enable the hw-module profile span-filter l2-rx-enable command under global
configuration mode */
RP/0/RP0/CPU0:router(config)# hw-module profile span-filter l2-rx-enable

/* Reload the router. Specify the destination interface in the monitor session: */
RP/0/RP0/CPU0:router(config)# monitor-session mon1
RP/0/RP0/CPU0:router(config-mon)# destination interface Bundle-Ether99
RP/0/RP0/CPU0:router(config-mon)# commit

/* Apply the monitor session on the Layer 2 interface */
RP/0/RP0/CPU0:router(config)# interface Bundle-Ether1 l2transport
RP/0/RP0/CPU0:router(config-if-l2)# monitor-session mon1 ethernet direction rx-only port-level
RP/0/RP0/CPU0:router(config-if-l2)# commit
RP/0/RP0/CPU0:router(config-if-l2)# exit
```

Running Configuration

The following example shows the running configuration of SPAN filtering of incoming (Rx) traffic for a Layer 2 interface:

```
RP/0/RP0/CPU0:Router#show running-config monitor-session mon1
Wed Dec 14 06:15:27.314 UTC
monitor-session mon1 ethernet
 destination interface Bundle-Ether99
!
RP/0/RP0/CPU0:Router#show running-config interface bundle-ether1
Wed Dec 14 06:16:12.668 UTC
interface Bundle-Ether1
 l2transport
  monitor-session mon1 ethernet direction rx-only port-level
  !
 !
!
```

Verification

Verify that SPAN filtering is enabled for the incoming (Rx) traffic by using the **show monitor-session** *<sess-id>* **status detail** command:

```
Router:ios#show monitor-session mon1 status detail
Wed Dec 14 06:16:12.668 UTC
Monitor-session mon1
  Destination interface Bundle-Ether99
  Source Interfaces
  -----------------
  bundle-Ether 1
    Direction:  Rx-only
    Port level: True
    ACL match:  Enabled
    Portion:    Full packet
    Interval:   Mirror all packets
```

```
    Status:     Operational
RP/0/RP0/CPU0:ios#
```

ACL-based SPAN

Traffic is mirrored based on the configuration of the interface ACL.

You can mirror traffic based on the definition of an interface access control list. When you mirror Layer 3 traffic, the ACL is configured using the **ipv4 access-list** or the **ipv6 access-list** command with the **capture** option. The **permit** and **deny** commands determine if the packets in the traffic are permitted or denied. The **capture** option designates the packet is to be mirrored to the destination port, and it is supported only on permit type of Access Control Entries (ACEs).

Note

- Prior to Release 6.5.1, ACL-based traffic mirroring required the use of UDK (User-Defined TCAM Key) with the **enable-capture** option so that the **capture** option can be configured in the ACL.
- ACL must be defined before attaching the ACL name to SPAN source interface.

Configuring Security ACLs for Traffic Mirroring

This section describes the configuration for creating security ACLs for traffic mirroring.

In ACL-based traffic mirroring, traffic is mirrored based on the configuration of the interface ACL. You can mirror traffic based on the definition of an interface access control list. When you're mirroring Layer 3 or Layer 2 traffic, the ACL is configured using the **ipv4 access-list** or the **ipv6 access-list** command with the **capture** option. The **permit** and **deny** commands determine the behavior of the regular traffic.

Configure an IPv4 ACL for Traffic Mirroring

Use the following steps to configure ACLs for traffic mirroring.

```
/* Create an IPv4 ACL (TM-ACL) for traffic mirroring */
Router(config)# ipv4 access-list TM-ACL
Router(config-ipv4-acl)# 10 permit udp 10.1.1.0 0.0.0.255 eq 10 any capture
Router(config-ipv4-acl)# 20 permit udp 10.1.1.0 0.0.0.255 eq 20 any
Router(config-ipv4-acl)# exit
Router(config)# commit

/* Validate the configuration */
Router(config)# show run
Thu May 17 11:17:49.968 IST
Building configuration...
!! IOS XR Configuration 0.0.0
!! Last configuration change at Thu May 17 11:17:47 2018 by user
…
ipv4 access-list TM-ACL
 10 permit udp 10.1.1.0 0.0.0.255 eq 10 any capture
 20 permit udp 10.1.1.0 0.0.0.255 eq 20 any
!
…
```

You have successfully configured an IPv4 ACL for traffic mirroring.

Configuring UDF-Based Security ACL for Traffic Mirroring

Before you begin

This section describes the configuration steps for UDF-based security ACLs for traffic mirroring.

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **udf** *udf-name* **header** {**inner | outer**} {**l2 | l3 | l4**} **offset** *offset-in-bytes* **length** *length-in-bytes*

Example:

```
RP/0/RP0/CPU0:router(config)# udf udf3 header outer l4 offset 0 length 1
(config-mon)#
```

Example:

```
RP/0/RP0/CPU0:router(config)# udf udf3 header inner l4 offset 10 length 2
(config-mon)#
```

Example:

```
RP/0/RP0/CPU0:router(config)# udf udf3 header outer l4 offset 50 length 1
(config-mon)#
```

Configures individual UDF definitions. You can specify the name of the UDF, the networking header from which offset, and the length of data to be extracted.

The **inner** or **outer** keywords indicate the start of the offset from the unencapsulated Layer 3 or Layer 4 headers, or if there is an encapsulated packet, they indicate the start of offset from the inner L3/L4.

Note
The maximum offset allowed, from the start of any header, is 63 bytes

The **length** keyword specifies, in bytes, the length from the offset. The range is from 1 to 4.

Step 3 **ipv4 access-list** *acl-name*

Example:

```
RP/0/RP0/CPU0:router(config))# ipv4 access-list acl1
```

Creates ACL and enters IP ACL configuration mode. The length of the *acl-name* argument can be up to 64 characters.

Step 4 **permit** *regular-ace-match-criteria* **udf** *udf-name1 value1 ... udf-name8 value8*

Example:

```
RP/0/RP0/CPU0:router(config-ipv4-acl)# 10 permit ipv4 any any udf udf1 0x1234 0xffff udf3 0x56 0xff
```

```
 capture
RP/0/RP0/CPU0:router(config-ipv4-acl)# 30 permit ipv4 any any dscp af11 udf udf5 0x22 0x22 capture
```

Configures ACL with UDF match.

Step 5 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-ipv4-acl)# exit
```

Exits IP ACL configuration mode and returns to global configuration mode.

Step 6 **interface***type number*

Example:

```
RP/0/RP0/CPU0:router(config)# interface HundredGigE 0/2/0/2
```

Configures interface and enters interface configuration mode.

Step 7 **ipv4 access-group** *acl-name* **ingress**

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv4 access-group acl1 ingress
```

Applies access list to an interface.

Step 8 **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Applies access list to an interface.

Verifying UDF-based Security ACL

Use the **show monitor-session status detail** command to verify the configuration of UDF on security ACL.

```
RP/0/RP0/CPU0:leaf1# show monitor-session 1 status detail

Fri May 12 19:40:39.429 UTC
Monitor-session 1
  Destination interface tunnel-ip3
  Source Interfaces
  -----------------
  TenGigE0/0/0/15
    Direction:  Rx-only
    Port level: True
    ACL match:  Enabled
    Portion:    Full packet
    Interval:   Mirror all packets
    Status:     Not operational (destination not active)
```

DSCP Bitmask to Filter Ingress SPAN Traffic

Table 26: Feature History Table

Feature Name	Release Information	Feature Description
DSCP Bitmask to Filter Ingress SPAN Traffic	Release 7.5.4	You can now mirror multiple traffic flows for matched Differentiated Service Code Point (DSCP) value of IP header on the SPAN. The matched DSCP value is based on the DSCP value and the bitmask configured in Access Control List (ACL) rule. Earlier, you could monitor single traffic flow by setting the RFC 4594 defined DSCP values in the IP header. This feature introduces the following changes: • **CLI:** permit (IPv4), and permit (IPv6) are modified to include new keyword **bitmask**. • **YANG DATA Model:** New XPaths for Cisco-IOS-XR-um-ipv4-access-list-cfg and Cisco-IOS-XR-um-ipv6-access-list-cfg (see Github, YANG Data Models Navigator).

Starting Release 7.5.4, You can configure an ACL rule with DSCP bitmask on the SPAN to mirror specific traffic flows.

Without ACL rule, SPAN mirrors all the traffic on the incoming port. When ACL is configured with DSCP and DSCP mask on the SPAN, SPAN mirrors the traffic whose DSCP value lies within the combination of DSCP value and the specified mask.

A DSCP value is mapped to a single traffic class as per the defined value in RFC2474. Masking the DSCP value in ACL rule allows to mirror multiple traffic flows. DSCP value and mask operate similar to IPv4 address and mask.

Note ACL must be defined before attaching the ACL name to SPAN source interface.

Configure DSCP Bitmask to Filter Ingress SPAN Traffic

To configure DSCP bitmask, use the bitmask option along with the dscp option while configuring the ACL.

Configuration Example for IPv4

This example shows how you can configure DSCP bitmask on ingress SPAN for IPv4 traffic.

```
/*configure the ACL*/
Router# config
Router(config)# ipv4 access-list acl1
Router(config-ipv4-acl)# 10 permit ipv4 host 192.0.2.1 any dscp af22 bitmask 0x3f
Router(config-ipv4-acl)# commit
Router(config-ipv4-acl)# exit

/* Perform the following configurations to attach the created ACL to an interface*/
```

```
Router(config)# interface HundredGigE0/0/0/6
Router(config-if)# ipv4 address 192.0.2.51 255.255.255.0

/* Monitor the ingress ACL applied and DSCP masked IPv4 traffic on SPAN*/
Router(config-if)# monitor-session TEST ethernet direction rx-only port-level acl ipv4 acl1
Router(config-if)# commit
```

Running Configuration

```
Router(config)# show running-config ipv4 access-list
ipv4 access-list acl1
 10 permit ipv4 host 192.0.2.1 any dscp af22 bitmask 0x3f
!

interface HundredGigE0/0/0/6
 ipv4 address 192.0.2.51 255.255.255.0
 monitor-session TEST ethernet direction rx-only port-level  acl ipv4 acl1
!
!
```

Configuration Example for IPv6

This example shows how you can configure DSCP bitmask on ingress SPAN for IPv6 traffic.

```
/*configure the ACL*/
Router# config
Router(config)# ipv6 access-list acl1
Router(config-ipv6-acl)# 10 permit ipv6 host 2001:DB8::2/32 any dscp 33 bitmask 0x3f
Router(config-ipv6-acl)# commit
Router(config-ipv6-acl)# exit

/* Perform the following configurations to attach the created ACL to an interface*/
Router(config)# interface HundredGigE 0/0/10/3
Router(config-if)# ipv6 address 2001:DB8::1/32

/* Monitor the ingress ACL applied and DSCP masked IPv4 traffic on ERPSAN*/
Router(config-if)# monitor-session TEST ethernet direction rx-only port-level acl ipv6 acl1
Router(config-if)# commit
```

Running Configuration

```
Router(config)# show running-config ipv6 access-list
ipv6 access-list acl1
 10 permit ipv6 acl1 host 2001:DB8::2/32 any dscp 33 bitmask 0x3f
!
interface HundredGigE0/0/10/3
 ipv6 address 2001:db8::1/32
 monitor-session TEST ethernet direction rx-only port-level acl ipv6 acl1
!
!
```

SPAN Using 7-Tuples ACL

Table 27: Feature History Table

Feature Name	Release Information	Description
SPAN Using 7-Tuples ACL	Release 7.5.4	With this release, you can perform packet capturing with 7-tuple access control lists (ACL). This capability allows you to define seven specific attributes in the ACL and apply it to an interface using the **monitor-session** command. The 7-tuple parameters include source and destination IP addresses, source and destination port numbers, and so on. When the 7-tuples are configured in the ACL, only the matching packets are captured and mirrored. The administrators can examine the captured packets and identify issues such as network congestion and security threats. This analysis helps in diagnosing and resolving network problems, enhancing network performance, and ensuring robust security measures.

Packet capturing functionality enables the network administrators to capture and analyze packets that pass through a router. By defining the seven parameters in the ACL, known as the 7-tuples, data packets can be matched and captured. Only packets that satisfy any or all of the seven parameters are mirrored. The captured packets can be analyzed locally or can be saved and exported for offline analysis.

The following parameters can be included in a 7-tuple ACL:

- Source IP Address (`source ip prefix`)
- Destination IP Address (`dest ip prefx`)
- Protocol (`protocol`, for example, TCP, UDP)
- Differentiated services code point `DSCP`
- Source Port (`source port`)
- Destination Port (dest port)
- Multiple TCP flags

By leveraging this level of granularity, you can fine-tune the packet capturing process to focus on the data relevant to your monitoring objectives.

Configuration Example

You can define the ACL with the seven tuples and apply it to the interface. Use the following sample configuration:

```
RP/0/RP0/CPU0:ios#config
Tue Jul 23 08:35:18.506 UTC
RP/0/RP0/CPU0:ios(config)#ipv4 access-list v4-monitor-acl2
RP/0/RP0/CPU0:ios(config-ipv4-acl)#80 permit tcp 80.1.1.0 0.0.0.255 eq www 30.30.30.0
0.0.0.255 eq www fin dscp af11
RP/0/RP0/CPU0:ios(config-ipv4-acl)#commit
```

```
Tue Jul 23 08:37:05.265 UTC
RP/0/RP0/CPU0:ios(config-ipv4-acl)#exit
RP/0/RP0/CPU0:ios(config)#ipv6 access-list v6-monitor-acl2
RP/0/RP0/CPU0:ios(config-ipv6-acl)#80 permit tcp 8010::/64 eq www 3010::/64 eq www fin dscp
 af11
RP/0/RP0/CPU0:ios(config-ipv6-acl)#commit
Tue Jul 23 08:37:39.689 UTC
RP/0/RP0/CPU0:ios(config-ipv6-acl)#exit
RP/0/RP0/CPU0:ios(config)#exit
RP/0/RP0/CPU0:ios#
```

The following example shows ERSPAN with QoS Configuration:

```
Router#configure
/* GRE Tunnel Interface */
Router(config)#interface Loopback49
Router(config-if)#ipv4 address 172.16.0.1 255.240.0.0
Router(config-if)#exit
Router(config)#interface tunnel-ip100
Router(config-if)#ipv4 address 192.168.0.1 255.255.0.0
Router(config-if)#tunnel mode gre ipv4
Router(config-if)#tunnel source 49.49.49.49
Router(config-if)#tunnel destination 10.0.0.2
Router(config-if)#exit
/* ERSPAN Monitor Session with GRE tunnel as the Destination Interface, and with QoS
configuration */
Router(config)#monitor-session FOO ethernet
Router(config-mon)#destination interface tunnel-ip100
Router(config-mon)#traffic-class 5
Router(config-mon)#discard-class 1
Router(config-mon)#exit
/* ERSPAN Source Interface */
Router(config)#interface TenGigE0/6/0/4/0
Router(config-if)#description connected to TGEN 9/5
Router(config-if)#ipv4 address 10.0.0.1 255.0.0.0
Router(config-if)#monitor-session FOO ethernet port-level
Router(config-if-mon)#acl ipv4 v4-monitor-acl2
Router(config-if-mon)#acl ipv6 v6-monitor-acl2
Router(config-if-mon)#exit
Router(config-if)#exit
/* ERSPAN Destination ip-tunnel00's underlying interface, with egress policy-map shape-foo
 attached */
Router(config)#interface TenGigE0/6/0/9/0
Router(config-if)#service-policy output shape-foo
Router(config-if)#ipv4 address 10.0.0.3 255.0.0.0
Router(config-if)#commit
```

Verification

Use **show monitor-session status** command to get the details of the monitor session.

```
Router# show monitor-session status
```

Displays information about the monitor session.

Multiple SPAN ACL Sessions

Multiple SPAN ACL Sessions in Single Interface

Table 28: Feature History Table

Feature Name	Release Information	Description
Multiple SPAN ACL Sessions in a Single Interface	Release 7.5.4	With this release, you can configure multiple SPAN ACL sessions under a single interface. A maximum of three sessions can be configured simultaneously. This feature, which is supported on layer 3 interfaces, helps you in monitoring traffic from different parts of your network simultaneously to see the network's overall performance. In addition, using this feature, you can get a better network visibility, more efficient use of network resources, and flexibility. You should specify the monitor sessions to be used on the interface. Use the **monitor-session** *session name* **ethernet direction rx-only port-level** command to specify that only the ingress traffic is mirrored. This feature is not supported on subinterfaces.

This feature allows you to configure multiple SPAN ACL sessions in the same source interface. The maximum number of sessions that are supported under an interface is three. The ACL is applicable only in the ingress direction (direction Rx). This configuration is supported only on Layer 3 interfaces.

To differentiate multiple SPAN sessions under the same source interface, span session ID is used. When a packet matches multiple entries at the router, priority attribute is used to choose the correct destination for the packet. When a single packet tries to match multiple SPAN sessions, you should configure correct priority fields to identify the correct destination. The ACL with the lowest priority is chosen.

For Cisco NCS 5500 routers, the merge group value is always 1, and the priority value can be of any value within the supported range of 1 to1000.

Multiple SPAN ACL sessions in a single interface help the administrators in the following ways:

- Monitor traffic from different parts of your network simultaneously to see the overall network performance.
- Isolate traffic from specific networks for troubleshooting network issues.
- Segment traffic for different purposes, such as security, compliance, or performance analysis.

Configure Multiple SPAN ACL Sessions

Define ACLs

The following example defines multiple IPv4 ACLs for outgoing (Tx) traffic or packets captured.

```
/* Create multiple SPAN IPv4 ACLs (acl1, acl2, acl3, acl4) for traffic mirroring */
Router(config)# ipv4 access-list acl1
Router(config-ipv4-acl)# 10 permit icmp net-group sip net-group dip capture
Router(config-ipv4-acl)# 20 permit udp net-group sip net-group dip port-group dport
Router(config-ipv4-acl)# 30 permit ipv4 net-group sip_traffic net-group dip_traffic capture
Router(config-ipv4-acl)# exit
```

```
Router(config)# ipv4 access-list acl2
Router(config-ipv4-acl)# 10 permit icmp net-group sip net-group dip capture
Router(config-ipv4-acl)# 20 permit udp net-group sip net-group dip port-group dport
Router(config-ipv4-acl)# 30 permit ipv4 net-group sip_traffic net-group dip_traffic capture
Router(config-ipv4-acl)# exit
Router(config)# ipv4 access-list acl3
Router(config-ipv4-acl)# 10 permit icmp net-group sip net-group dip capture
Router(config-ipv4-acl)# 20 permit udp net-group sip net-group dip port-group dport
Router(config-ipv4-acl)# 30 permit ipv4 net-group sip_traffic net-group dip_traffic capture
Router(config-ipv4-acl)# exit
Router(config)# ipv4 access-list acl4
Router(config-ipv4-acl)# 10 permit icmp net-group sip net-group dip capture
Router(config-ipv4-acl)# 20 permit udp net-group sip net-group dip port-group dport
Router(config-ipv4-acl)# 30 permit ipv4 net-group sip_traffic net-group dip_traffic capture
Router(config-ipv4-acl)# exit
Router(config)# commit
```

Configure Multiple SPAN ACL Sessions

Specify the monitor sessions to be used on the interface. Use the direction keyword to specify that only ingress traffic is mirrored. See the following example:

```
Router(config)#interface TenGigE0/0/0/26
Router(config-if)#monitor-session ses1 ethernet direction rx-only port-level
Router(config-if)#acl ipv4 acl1
!
Router(config-if)#monitor-session ses2 ethernet direction rx-only port-level
Router(config-if)#acl ipv4 acl2
!
Router(config-if)#monitor-session ses3 ethernet direction rx-only port-level
Router(config-if)#acl ipv4 acl3
!
Router(config-if)#monitor-session ses4 ethernet direction rx-only port-level
Router(config-if)#acl ipv4 acl4
!
!
```

Verify the Sessions

The following example shows the details of the monitor sessions.

```
Router##sh monitor-session status
Tue Mar 21 16:14:15.879 UTC
Monitor-session ses1
Destination interface TenGigE0/0/0/9
================================================================================
Source Interface      Dir   Status
--------------------- ----  ------------------------------------------------
Te0/0/0/0 (port)      Rx    Operational

Monitor-session ses2
Destination interface TenGigE0/0/0/1
================================================================================
Source Interface      Dir   Status
--------------------- ----  ------------------------------------------------
Te0/0/0/0 (port)      Rx    Operational

Monitor-session ses3
Destination interface TenGigE0/0/0/2
================================================================================
Source Interface      Dir   Status
--------------------- ----  ------------------------------------------------
Te0/0/0/0 (port)      Rx    Operational
```

```
RP/0/RP0/CPU0:ios#
```

Configuring the Correct Priority

When one packet tries to match more than one SPAN session, the priority field helps in identifying the correct destination.

Note Merge group and priority fields are not mandatory. But if used, configure both fields.

```
Router(config)#interface tenGigE 0/0/0/24
Router(config-if)#monitor-session ses1 ethernet port-level
Router(config-if)#acl ipv4 acl1 merge-group 1 priority 30
```

To verify the traffic, use the following sample **show monitor-session** command:

```
Router#show monitor-session status detail
Tue Mar 21 16:15:02.741 UTC
Monitor-session ses1
  Destination interface TenGigE0/0/0/9
  Source Interfaces
  -----------------
  TenGigE0/0/0/0
    Direction:    Rx-only
    Port level:   True
    ACL match:    Disabled
    IPv4 ACL:     Enabled (acl1, merge-group: 1,priority: 1)
    IPv6 ACL:     Disabled
    Portion:      Full packet
    Interval:     Mirror all packets
    Mirror drops: Disabled
    Status:       Operational

Monitor-session ses2
  Destination interface TenGigE0/0/0/1
  Source Interfaces
  -----------------
  TenGigE0/0/0/0
    Direction:    Rx-only
    Port level:   True
    ACL match:    Disabled
    IPv4 ACL:     Enabled (acl2)
    IPv6 ACL:     Disabled
    Portion:      Full packet
    Interval:     Mirror all packets
    Mirror drops: Disabled
    Status:       Operational

Monitor-session ses3
  Destination interface TenGigE0/0/0/2
  Source Interfaces
  -----------------
  TenGigE0/0/0/0
    Direction:    Rx-only
    Port level:   True
    ACL match:    Disabled
    IPv4 ACL:     Enabled (acl3)
    IPv6 ACL:     Disabled
    Portion:      Full packet
    Interval:     Mirror all packets
    Mirror drops: Disabled
    Status:       Operational
```

```
Monitor-session ses4
  Destination interface TenGigE0/0/0/6
  Source Interfaces
  -----------------
  TenGigE0/0/0/0
    Direction:    Rx-only
    Port level:   True
    ACL match:    Disabled
    IPv4 ACL:     Enabled (acl4)
    IPv6 ACL:     Disabled
    Portion:      Full packet
    Interval:     Mirror all packets
    Mirror drops: Disabled
    Status:       Operational
Router#
```

Multiple SPAN ACL sessions for MPLS

Table 29: Feature History Table

Feature Name	Release Information	Description
Multiple SPAN ACL sessions for MPLS	Release 24.4.1	Introduced in this release on: NCS 5500 fixed port routers; NCS 5500 modular routers (NCS 5500 line cards). This feature allows to configure multiple SPAN ACL sessions for MPLS on Layer 3 interfaces configured on the Label-Switched Paths (LSPs) to monitor the MPLS traffic based on the labels and the EXP bit. This feature verifies the overall network performance simultaneously from various network locations and ensures a better network visibility, network resource efficiency, and flexibility. This MPLS SPAN ACL configuration is supported only in the ingress direction. This feature introduces these changes: **CLI:** • **acl mpls** • **mpls access-list** **YANG Data Model:** `Cisco-IOS-XR-um-mpls-acl-cfg.yang` (see Github, YANG Data Models Navigator).

Starting from Cisco IOS XR Release 24.4.1, you can monitor the MPLS traffic by configuring multiple SPAN ACL sessions for MPLS. With this feature, the ingressing MPLS traffic is mirrored. This is achieved with the **monitor-session** *session-name* **ethernet direction rx-only port-level** configuration.

You should specify the monitor sessions to be used on the configured interfaces. You can configure a maximum of upto three sessions simultaneously.

You can use the SPAN session ID to distinguish between multiple SPAN sessions under the same source interface.

Benefits

- Improves flexibility of the associated user interface.
- Avoids redundancy.
- Provides backward compatibility.
- Minimises configuration size on the disk.
- Reduces process memory in both the shared plane and local plane for scale configurations.

Restrictions

- Supported only on the Physical and Bundle main interfaces.
- Supported only in the ingress (Rx) direction.
- Supports a maximum of three SPAN sessions.
- Supports only the GRE tunnel interfaces as the destination interfaces.
- Implicit null MPLS label packets cannot be captured using the MPLS ACL SPAN.

Configure multiple SPAN ACL sessions for MPLS

Define ACLs

This example defines multiple SPAN ACLs for the incoming (Rx) MPLS traffic or the MPLS packets captured.

```
/* Create multiple SPAN ACLs (mp1 and mp2) for mirroring MPLS traffic */
Router(config)# mpls access-list mp1
Router(config-mpls-acl)# 10 permit label1 2000  label2 3000  label3 4000  exp1 5 exp2 5
exp3 7
Router(config-mpls-acl)# exit
Router(config)# mpls access-list mp2
Router(config-mpls-acl)# 10 permit label3 9000  exp3 5
Router(config-mpls-acl)# exit
Router(config)# commit
```

Configure monitor sessions

This example configures a monitor session on the specified destination interface for the incoming (Rx) traffic.

```
RP/0/RP0/CPU#config
RP/0/RP0/CPU0:R1(config)#interface tunnel-ip41
RP/0/RP0/CPU0:R1(config-if)#tunnel source 11.11.11.11
RP/0/RP0/CPU0:R1(config-if)#tunnel destination 22.22.22.22
RP/0/RP0/CPU0:R1(config-if)#ipv4 address 41.41.41.2 255.255.255.0
RP/0/RP0/CPU0:R1(config-if)#tunnel mode gre ipv4
RP/0/RP0/CPU0:R1(config-if)#commit
RP/0/RP0/CPU0:R1(config-if)#exit
!
RP/0/RP0/CPU0:R1(config)#monitor-session S1 ethernet destination interface tunnel-ipv41
RP/0/RP0/CPU0:R1(config-if)#commit
!
```

Attach monitor session to source interface

This configuration attaches the MPLS SPAN ACL sessions to the specified source interface. Use the **direction** keyword so that only the ingress traffic is mirrored.

```
Router(config)# interface tenGigE 0/0/0/14
Router(config-if)# monitor-session S1 ethernet direction rx-only port-level
Router(config-if-mon)# acl mpls mp1
!!
```

Running configuration for source interface

This example shows the running configuration for the configured source interface.

```
RP/0/RP0/CPU0:ios# show running-config interface tenGigE 0/0/0/14
Mon Apr  1 13:16:47.430 UTC
interface TenGigE0/0/0/14
 ipv4 address 1.1.1.1 255.255.255.0
 ipv6 address 1111::1:1/96
 monitor-session S1 ethernet direction rx-only port-level
  acl mpls mp1
 !
 RP/0/RP0/CPU0:ios#
```

Verify the sessions

This example shows the details of the monitor sessions.

```
RP/0/RP0/CPU0:ios# show monitor-session status
Mon Apr  1 13:16:40.408 UTC
Monitor-session S1
Destination interface tunnel-ip41
================================================================================
Source Interface      Dir   Status
--------------------- ----  ------------------------------------------------
Te0/0/0/14 (port)     Rx    Operational
```

This example shows how to verify the traffic using the **show monitor-session** command.

```
RP/0/RP0/CPU0:ios# show monitor-session status detail
Mon Apr  1 13:19:11.124 UTC
Monitor-session S1
  Destination interface tunnel-ip41
  Source Interfaces
  -----------------
  TenGigE0/0/0/14
    Direction:     Rx-only
    Port level:    True
    ACL match:     Disabled
    IPv4 ACL:      Disabled
    IPv6 ACL:      Disabled
    MPLS ACL:      Enabled (mp1)
    Portion:       Full packet
    Interval:      Mirror all packets
    Mirror drops:  Disabled
    Status:        Operational

RP/0/RP0/CPU0:ios#
```

Monitor Multiple SPAN ACL and Security ACL Sessions

Table 30: Feature History Table

Feature Name	Release Information	Feature Description
Monitor Multiple SPAN ACL and Security ACL Sessions	Release 7.5.4	With this feature, you can use SPAN and security ACLs together to monitor multiple SPAN ACL sessions under the same source interface. SPAN ACL helps you to distribute the mirrored traffic over different destination interfaces. Security ACL allows selective incoming traffic.

Starting Cisco IOS XR Software Release 7.5.4 you can monitor multiple ERSPAN sessions using GREv4 under the same source interface. Multiple SPAN ACL monitor sessions configured on an interface allow you to choose the destination interface for the mirrored traffic. For the configuration of monitor sessions, you can use SPAN and security ACLs together.

The SPAN and security ACLs apply only in the ingress traffic.

Note ACL must be defined before attaching the ACL name to SPAN source interface.

Configure Multiple SPAN ACL and Security ACL Monitor Sessions

This example shows how to attach the SPAN and security ACLs to configure multiple monitoring sessions.

Configuration Example

Define IPv4 (v4-monitor-acl1) and IPv6 (v6-monitor-acl1) ACLs for the outgoing (Tx) traffic or packets captured.

```
/* Create a SPAN IPv4 ACL (v4-monitor-acl1) for traffic mirroring */
Router(config)# ipv4 access-list v4-monitor-acl1
Router(config-ipv4-acl)# 10 permit icmp net-group sip net-group dip capture
Router(config-ipv4-acl)# 20 permit udp net-group sip net-group dip port-group dport
Router(config-ipv4-acl)# 30 permit ipv4 net-group sip_traffic net-group dip_traffic capture
Router(config-ipv4-acl)# exit
Router(config)# commit
/*Create a SPAN IPv6 ACL (v6-monitor-acl1) for traffic mirroring */
Router(config)# ipv6 access-list v6-monitor-acl1
Router(config-ipv6-acl)# 10 permit icmpv6 net-group sip net-group dip
Router(config-ipv6-acl)# 20 permit udp net-group sip net-group dip port-group dport
Router(config-ipv6-acl)# 30 permit ipv6 net-group sip_traffic net-group dip_traffic capture
Router(config-ipv6-acl)# exit
Router(config)# commit
```

Use the following configuration to attach SPAN and security ACLs for traffic mirroring.

```
Router# config
/*Perform the following configurations to attach the SPAN ACL to an interface*/
```

```
Router(config-if)#monitor-session always-on-v4 ethernet direction rx-only port-level
Router(config-if-mon)#acl ipv4 v4-monitor-acl1
Router(config-if-mon)#acl ipv6 v6-monitor-acl1
Router(config-if-mon)#exit
Router(config-if)#monitor-session on-demand-v4 ethernet direction rx-only port-level
Router(config-if-mon)#acl ipv4 v4-monitor-acl2
Router(config-if-mon)#acl ipv6 v6-monitor-acl2
Router(config-if-mon)#exit
/*Perform the following configurations to attach the security ACL to an interface*/
Router(config-if)#ipv4 access-group sec_aclv4 ingress
Router(config-if)#ipv6 access-group sec_aclv6 ingress
Router(config-if)#commit
```

Running configuration

```
Router(config)#show running-config interface
monitor-session always-on-v4 ethernet direction rx-only port-level
  acl ipv4 v4-monitor-acl2
  acl ipv6 v6-monitor-acl2
!
monitor-session on-demand-v4 ethernet direction rx-only port-level
  acl ipv4 v4-monitor-acl2
  acl ipv6 v6-monitor-acl2
!
ipv4 access-group sec_aclv4 ingress
ipv6 access-group sec_aclv6 ingress
!
!
```

ACL-based Traffic Mirroring for Outgoing (Tx) Traffic on Cisco NCS 5700 Series Line Cards and Routers

Table 31: Feature History Table

Feature Name	Release Information	Description
Egress Hybrid ACL-based Traffic Mirroring on Cisco NCS 5700 Series Line Cards and Routers	Release 7.10.1	Introduced in this release on: NCS 5700 fixed port routers (select variants only*); NCS 5700 line cards [Mode: Native] (select variants only*) We've now made it possible for you to narrow down the outgoing (Tx) traffic that you want to mirror and troubleshoot the captured traffic for any anomalous or malicious activity. You can do this by enabling the **capture** option on an L3 interface that has a hybrid ACL configured and Egress Traffic Management (ETM) mode enabled. The traffic matching the rules defined in the egress hybrid ACL gets captured and mirrored. This feature introduces the following changes: **CLI**: The **capture** keyword is introduced in the **ipv4 access-list** and **ipv6 access-list** commands. * This feature is supported on: • NCS-57B1-5DSE-SYS • NCS-57C3-MODS-SYS • NC57-18DD-SE • NC57-36H-SE

With ACL-based traffic mirroring, you can create an ACL and attach that ACL to an L3 interface. The Tx traffic on that interface, when matches with the rules defined in the ACLs, are mirrored. The mirrored traffic is used to troubleshoot issues such as packet drops, packet fields getting modified, virus attacks, or any other network threat.

Prerequisites for ACL-based Traffic Mirroring for Outgoing (Tx) Traffic

To configure ACL-based traffic mirroring on Cisco NCS 5700 Series line cards and routers for Tx traffic, ensure that you perform the following prerequisites:

- You must have the native mode enabled. To enable the native mode, use the **hw-module profile npu native-mode-enable** command in the configuration mode. Ensure that you reload the router after configuring the native mode.
- To enable egress hybrid ACL, enable the **hw-module profile acl compress enable ingress** and **hw-module profile acl compress enable egress** commands.
- The SPAN source interface must have the ETM mode enabled. To enable the ETM mode, use the **controller optics***r*/*s*/*i*/*p***mode etm** command. For more information on the ETM mode, see the Configure Egress Traffic Management chapter.

Configure ACL-based Traffic Mirroring for Outgoing (Tx) Traffic

Perform the following steps to enable ACL-based traffic mirroring on Cisco NCS 5700 Series line cards and routers for outgoing (Tx) traffic:

1. Create an IPv4 or IPv6 ACL with **capture** option to define the traffic that you want to mirror.
2. Configure a source L3 interface for outgoing (Tx) traffic.
3. Start a monitor session, configure the destination interface, and the ACL to start capturing the outgoing (Tx) traffic.

Configuration Example

The following example displays the outgoing (Tx) traffic or packets captured for IPv4 (v4-acl-tx) and IPv6 (v6-acl-tx) ACLs:

```
/* Create a SPAN IPv4 ACL (v4-acl-tx) for traffic mirroring */
Router(config)# ipv4 access-list v4-acl-tx
Router(config-ipv4-acl)# 10 permit icmp net-group sip net-group dip capture
Router(config-ipv4-acl)# 20 permit udp net-group sip net-group dip port-group dport
Router(config-ipv4-acl)# 30 permit ipv4 net-group sip_traffic net-group dip_traffic capture

Router(config-ipv4-acl)# exit
Router(config)# commit

/*Create a SPAN IPv6 ACL (v6-acl-tx) for traffic mirroring */
Router(config)# ipv6 access-list v6-acl-tx
Router(config-ipv6-acl)# 10 permit icmpv6 net-group sip net-group dip
Router(config-ipv6-acl)# 20 permit udp net-group sip net-group dip port-group dport
Router(config-ipv6-acl)# 30 permit ipv6 net-group sip_traffic net-group dip_traffic capture
Router(config-ipv6-acl)# exit
Router(config)# commit

/* Start a monitor session on your source interface for incoming (Rx) traffic and specify
the destination interface*/
Router(config)# interface HundredGigE0/4/0/18
Router(config)# monitor-session mon1
Router(config-mon)# destination interface HundredGigE0/1/0/30
Router(config-mon)#commit
Router(config-mon)#exit

/* Configure the ACL on the source interface to capture the outgoing (Tx) traffic */
Router(config)# interface HundredGigE0/4/0/18
Router(config-if)# monitor-session mon1 ethernet direction tx-only port-level
acl
Router(config-if)# ipv4 access-group v4-acl-tx egress compress level 3
Router(config-if)# ipv6 access-group v6-acl-tx egress compress level 3
!
```

Running Configuration

Use the **show run monitor-session** to and **show running-config interface** commands to display a running configuration on your router.

```
Router#show run monitor-session mon1
monitor-session mon1 ethernet
 destination interface HundredGigE0/1/0/30
!

Router#show run interface hundredGigE 0/4/0/18
interface HundredGigE0/4/0/18
 ipv4 address 20.71.103.1 255.255.255.0
 ipv6 address abc::20:71:103:1/112
 monitor-session mon1 ethernet direction tx-only
  acl
 !
 encapsulation dot1ad 10 dot1q 201
 ipv4 access-group v4-acl-tx egress compress level 3
 ipv6 access-group v6-acl-tx egress compress level 3


Router#sh access-lists ipv4 v4-acl-tx
ipv4 access-list v4-acl-tx
 10 permit udp net-group sip port-group sport net-group dip-v4-acl-tx-cap capture
 20 permit udp net-group sip port-group sport net-group dip-v4-acl-tx-DNcap
 100 permit udp any any capture
 101 permit ipv4 any any
 102 permit tcp any any

Router#sh access-lists ipv6 v6-acl-tx
ipv6 access-list v6-acl-tx
 10 permit udp net-group sip-v6 port-group sport net-group dip-v6-acl-tx-cap-v6 capture
 20 permit udp net-group sip-v6 port-group sport net-group dip-v6-acl-tx-DNcap-v6
 100 permit udp any any
 101 permit ipv6 any any
 102 permit tcp any any


Router#sh access-lists ipv6 v6-acl-tx hardware egress location 0/4/CPU0
ipv6 access-list v6-acl-tx
 10 permit udp net-group sip-v6 port-group sport net-group dip-v6-acl-tx-cap-v6 capture
(2100 matches) (252004 bytes)
 20 permit udp net-group sip-v6 port-group sport net-group dip-v6-acl-tx-DNcap-v6
 100 permit udp any any
 101 permit ipv6 any any
 102 permit tcp any any

Router#sh access-lists ipv4 v4-acl-tx hardware egress location 0/4/CPU0
ipv4 access-list v4-acl-tx
 10 permit udp net-group sip port-group sport net-group dip-v4-acl-tx-cap capture (2095
matches) (209500 bytes)
 20 permit udp net-group sip port-group sport net-group dip-v4-acl-tx-DNcap
 100 permit udp any any capture
 101 permit ipv4 any any
 102 permit tcp any any
```

Verification

To verify that the outgoing (Tx) traffic is configured on the source interface, use the **show monitor-session status** command.

```
/* Verify the status of the outgoing (Tx) traffic on the source interface */
Router:ios#show monitor-session mon1 status
Monitor-session mon1
Destination interface HundredGigE0/1/0/30
================================================================================
Source Interface      Dir   Status
--------------------- ----  ------------------------------------------------
Hu0/4/0/18        Tx    Operational

Router#sh run monitor-session mon1
monitor-session mon1 ethernet
 destination interface HundredGigE0/1/0/30
!
```

To verify that the IPv4 and IPv6 ACL captures the ACL information, use the **show access-lists** [**ipv4** | **ipv6**] *acl-name* **hardware ingress span** [**detail** | **interface** | **location** | **sequence** | **verify**] **location** *x* command. Notice that the traffic or the packets are getting captured(256500356 matches) and also getting incremented.

```
/* Verification for IPv4 ACL */
Router#show access-lists ipv4 v4-acl-tx hardware egress location 0/4/CPU0
ipv4 access-list v4-acl-tx
 10 permit udp net-group sip port-group sport net-group dip capture (2095 matches) (209500
 bytes)
 20 permit udp net-group sip port-group sport net-group dip port-group dport
 100 permit udp any any capture
 101 permit ipv4 any any
 102 permit tcp any any
Router#show interface HundredGigE0/4/0/18
HundredGigE0/4/0/18 is up, line protocol is up
  Interface state transitions: 1
  Hardware is VLAN sub-interface(s), address is 00bc.602b.0a88
  Internet address is 20.71.103.1/24
  MTU 1522 bytes, BW 100000000 Kbit (Max: 100000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation 802.1ad-802.1Q Virtual LAN,  loopback not set,
  Last link flapped 12:12:06
  ARP type ARPA, ARP timeout 04:00:00
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     982 packets input, 86352 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 0 multicast packets
     4942 packets output, 523002 bytes, 0 total output drops
     Output 0 broadcast packets, 256 multicast packets

Router#show interfaces hundredGigE 0/4/0/18 accounting
HundredGigE0/4/0/18
  Protocol              Pkts In         Chars In     Pkts Out        Chars Out
  IPV4_UNICAST                0                0         2099           209900
  IPV6_UNICAST              489            44034         2103           252364
  ARP                         4              240            5              250
  IPV6_ND                   489            42078          745            61592


Router#show interfaces hundredGigE 0/1/0/30
HundredGigE0/1/0/30 is up, line protocol is up
  Interface state transitions: 3
```

```
  Hardware is HundredGigE, address is 00bc.602b.0908 (bia 00bc.602b.0908)
  Internet address is 20.21.3.1/30
  MTU 1514 bytes, BW 100000000 Kbit (Max: 100000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 100000Mb/s, 100GBASE-LR4, link type is force-up
  output flow control is off, input flow control is off
  loopback not set,
  Last link flapped 00:04:08
  ARP type ARPA, ARP timeout 04:00:00
  Last input never, output 00:00:05
  Last clearing of "show interface" counters never
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
     Received 0 broadcast packets, 0 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     4908 packets output, 519403 bytes, 0 total output drops
     Output 10 broadcast packets, 65 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
     3 carrier transitions
```

```
/* Verification for IPv6 ACL */
Router#show access-lists ipv6 v6-acl-tx hardware egress location 0/4/CPU0
ipv6 access-list v6-acl-tx
 10 permit udp net-group sip-v6 port-group sport net-group dip-v6-acl-tx capture (2100
matches) (252004 bytes)
 20 permit udp net-group sip-v6 port-group sport net-group dip-v6-DNacl-tx
 100 permit udp any any
 101 permit ipv6 any any
 102 permit tcp any any
```

Attaching the Configurable Source Interface

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface** *type number*

Example:

```
RP/0/RP0/CPU0:router(config)# interface HundredGigE 0/1/0/1
```

Enters interface configuration mode for the specified source interface. The interface number is entered in *rack*/*slot*/*module*/*port* notation. For more information about the syntax for the router, use the question mark (?) online help function.

Step 3 **ipv4 access-group** *acl-name* {**ingress** | **egress**}

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv4 access-group acl1 ingress
```

Controls access to an interface.

Step 4 **monitor-session** *session-name* **ethernet direction rx-onlyport-level acl**

Example:

```
RP/0/RP0/CPU0:router(config-if)# monitor-session mon1 ethernet direction rx-only port-level acl
RP/0/RP0/CPU0:router(config-if-mon)#
```

Attaches a monitor session to the source interface and enters monitor session configuration mode.

Note
rx-only specifies that only ingress traffic is replicated.

Step 5 **acl**

Example:

```
RP/0/RP0/CPU0:router(config-if-mon)# acl
```

Specifies that the traffic mirrored is according to the defined ACL.

Note
If an ACL is configured by name, then this step overrides any ACL that may be configured on the interface.

Step 6 **exit**

Example:

```
RP/0/RP0/CPU0:router(config-if-mon)# exit
RP/0/RP0/CPU0:router(config-if)#
```

Exits monitor session configuration mode and returns to interface configuration mode.

Step 7 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting (yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.

- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.

- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 8 **show monitor-session [session-name] status** [**detail**] [**error**]

Example:

```
RP/0/RP0/CPU0:router# show monitor-session status
```

Displays information about the monitor session.

ERSPAN

Encapsulated Remote Switched Port Analyzer (ERSPAN) transports mirrored traffic over an IP network. The traffic is encapsulated at the source router and is transferred across the network. The packet is decapsulated at the destination router and then sent to the destination interface.

Encapsulated Remote SPAN (ERSPAN) enables generic routing encapsulation (GRE) for all captured traffic and allows it to be extended across Layer 3 domains.

ERSPAN involves mirroring traffic through a GRE tunnel to a remote site. For more information on configuring the GRE tunnel that is used as the destination for the monitor sessions, see the chapter *Configuring GRE Tunnels*.

Note A copy of every packet includes the Layer 2 header if the ethernet keyword is configured. As this renders the mirrored packets unroutable, the end point of the GRE tunnel must be the network analyzer.

Introduction to ERSPAN Egress Rate Limit

With ERSPAN egress rate limit feature, you can monitor traffic flow through any IP network. This includes third-party switches and routers.

ERSAPN operates in the following modes:

- ERSPAN Source Session – box where the traffic originates (is SPANned).
- ERSPAN Termination Session or Destination Session – box where the traffic is analyzed.

This feature provides rate limiting of the mirroring traffic or the egress traffic. With rate limiting, you can limit the amount of egress traffic to a specific rate, which prevents the network and remote ERSPAN destination traffic overloading. Be informed, if the egress rate-limit exceeds then the system may cap or drop the monitored traffic.

You can configure the QoS parameters on the traffic monitor session.

- Traffic Class (0 through 7)
    - Traffic class 0 has the lowest priority and 7 the highest.

- The default traffic class is the same as that of the original traffic class.

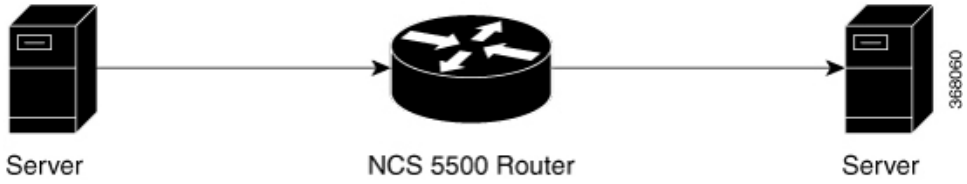
- The Discard Class (0 through 2):
  - The default is 0.
  - The discard class configuration is used in WRED.

Benefits

With ERSPAN Egress rate limit feature, you can limit the egress traffic or the mirrored and use the mirrored traffic for data analysis.

Topology

Figure 17: Topology for ERSPAN Egress Rate Limit



The encapsulated packet for ERSPAN is in ARPA/IP format with GRE encapsulation. The system sends the GRE tunneled packet to the destination box identified by an IP address. At the destination box, SPAN-ASIC decodes this packet and sends out the packets through a port. ERSPAN egress rate limit feature is applied on the router egress interface to rate limit the monitored traffic.

The intermediate switches carrying ERSPAN traffic from source session to termination session can belong to any L3 network.

Configure ERSPAN Egress Rate Limit

Use the following steps to configure ERSPAN egress rate limit:

```
monitor-session ERSPAN ethernet
destination interface tunnel-ip1
!

RP/0/RP0/CPU0:pyke-008#sh run int tunnel-ip 1

interface tunnel-ip1
ipv4 address 4.4.4.1 255.255.255.0
tunnel mode gre ipv4
tunnel source 20.1.1.1
tunnel destination 20.1.1.2
!

RP/0/RP0/CPU0:pyke-008#sh run int hundredGigE 0/0/0/16

interface HundredGigE0/0/0/16
ipv4 address 215.1.1.1 255.255.255.0
ipv6 address 3001::2/64
monitor-session ERSPAN ethernet direction rx-only port-level
  acl
!
ipv4 access-group ACL6 ingress
```

Running Configuration

```
!! Policy-map to be used with the ERSPAN Destination (egress interface)
!! Traffic class is set to 5. For packets in this class, apply shaping
!! as well as WRED.
class-map match-any TC5
 match traffic-class 5
 end-class-map
!
policy-map shape-foo
 class TC5
  random-detect discard-class 0 10000 bytes 40000 bytes
  random-detect discard-class 1 40000 bytes 80000 bytes
  random-detect discard-class 2 80000 bytes 200000 bytes
  shape average percent 15
 !
 class class-default
 !
 end-policy-map
!
!!GRE Tunnel Interface
interface Loopback49
 ipv4 address 49.49.49.49 255.255.255.255
!
interface tunnel-ip100
 ipv4 address 130.100.1.1 255.255.255.0
 tunnel mode gre ipv4
 tunnel source 49.49.49.49
 tunnel destination 10.8.1.2
!
!!ERSPAN Monitor Session with GRE tunnel as the Destination Interface, and with QoS
configuration
monitor-session FOO ethernet
 destination interface tunnel-ip100
 traffic-class 5
 discard-class 1
!
!!ERSPAN Source Interface
interface TenGigE0/6/0/4/0
 description connected to TGEN 9/5
 ipv4 address 10.4.90.1 255.255.255.0
 monitor-session FOO ethernet port-level
 !
!
!!ERSPAN Destination ip-tunnel00’s underlying interface, with egress policy-map shape-foo
attached
interface TenGigE0/6/0/9/0
 service-policy output shape-foo
 ipv4 address 10.8.1.1 255.255.255.0
```

Verification

```
RP/0/RP0/CPU0:ios#show monitor-session FOO status detail
Wed May  2 15:14:05.762 UTC
Monitor-session FOO
  Destination interface tunnel-ip100
  Source Interfaces
  -----------------
  TenGigE0/6/0/4/0
    Direction:  Both
    Port level: True
    ACL match:  Disabled
    Portion:    Full packet
    Interval:   Mirror all packets
```

```
    Status:     Operational
RP/0/RP0/CPU0:ios#
show monitor-session <sess-id> status internal

RP/0/RP0/CPU0:ios#show monitor-session FOO status internal
Wed May  2 15:13:06.063 UTC
Information from SPAN Manager and MA on all nodes:
Monitor-session FOO (ID 0x00000001) (Ethernet)
SPAN Mgr: Destination interface tunnel-ip100 (0x0800001c)
          Last error: Success
          Tunnel data:
            Mode: GREoIPv4
            Source IP: 49.49.49.49
            Dest IP: 10.8.1.2
            VRF:
            ToS: 0 (copied)
            TTL: 255
            DFbit: Not set
0/6/CPU0: Destination interface tunnel-ip100 (0x0800001c)
          Tunnel data:
            Mode: GREoIPv4
            Source IP: 49.49.49.49
            Dest IP: 10.8.1.2
            VRF:
            ToS: 0 (copied)
            TTL: 255
            DFbit: Not set

Information from SPAN EA on all nodes:
Monitor-session 0x00000001 (Ethernet)
0/6/CPU0: Name 'FOO', destination interface tunnel-ip100 (0x0800001c)
Platform, 0/6/CPU0:

  Dest Port: 0xe7d

  ERSPAN Encap:
    Tunnel ID: 0x4001380b
    ERSPAN Tunnel ID: 0x4001380c
    IP-NH Grp key: 0x3140000cc5
    IP-NH hdl: 0x308a5fa5e0
    IP-NH IFH: 0x30002a0
    IP-NH IPAddr: 10.4.91.2

  NPU   MirrorRx     MirrorTx
  00    0x00000003   0x00000004
  01    0x00000003   0x00000004
  02    0x00000003   0x00000004
  03    0x00000003   0x00000004
  04    0x00000003   0x00000004
  05    0x00000003   0x00000004
RP/0/RP0/CPU0:ios#
```

ERSPAN Traffic to a Destination Tunnel in a Default VRF

Table 32: Feature History Table

Feature Name	Release Information	Description
ERSPAN Traffic to a Destination Tunnel in a Default VRF	Release 6.1.3	Encapsulated Remote Switched Port Analyzer (ERSPAN) now transports mirrored traffic through GRE tunnels that belongs to the default VRF thus ensuring a network design with a single Layer 3 device. This feature enables the tunnels to be grouped under the default VRF domain towards which you can segregate the traffic.

Running Configuration

The following example shows a tunnel interface configured with endpoints in a default VRF (**vrf: green**):

```
Router#show run int tunnel-ip 2
Thu Feb  3 06:18:28.075 UTC
interface tunnel-ip2
 ipv4 address 102.1.1.100 255.255.255.0
 tunnel tos 32
 tunnel mode gre ipv4
 tunnel source 120.1.1.100
 tunnel vrf green
 tunnel destination 120.1.1.1
```

```
Router#show monitor-session status
Thu Feb  3 06:18:11.061 UTC
Monitor-session ERSPAN-2
Destination interface tunnel-ip2
================================================================
Source Interface      Dir   Status
--------------------- ----  ------------------------------------------------------
Te0/0/0/5 (port)      Rx    Operational
```

Verification

The following CLI output shows how to verify the default VRF configuration:

```
Router#show monitor-session ERSPAN-2 status internal
Thu Feb  3 06:19:50.014 UTC

Information from SPAN Manager and MA on all nodes:
Monitor-session ERSPAN-2 (ID 0x00000003) (Ethernet)
SPAN Mgr: Destination interface tunnel-ip2 (0x20008024)
          Last error: Success
          Tunnel data:
            Mode: GREoIPv4
            Source IP: 120.1.1.100
            Dest IP: 120.1.1.1
            VRF: green
            VRF TBL ID: 0
```

```
ToS: 32
TTL: 255
DFbit: Not set
```

ERSPAN Traffic to a Destination Tunnel in a Non-Default VRF

Table 33: Feature History Table

Feature Name	Release Information	Description
ERSPAN Traffic to a Destination Tunnel in a Non-Default VRF	Release 7.5.3	The tunnels are grouped under the VRFs and you can segregate the traffic towards a specific VRF domain. Encapsulated Remote Switched Port Analyzer (ERSPAN) now transports mirrored traffic through GRE tunnels with multiple VRFs, helping you design your network with multiple Layer 3 partitions. In earlier releases, ERSPAN transported mirrored traffic through GRE tunnels that belonged to only default VRF.

Here, the tunnel interface, where the traffic mirroring is destined, is now in a VRF.

The traffic coming out of the interfaces of a router do not have any grouping. By configuring a specific VRF, you can now identify the incoming traffic group.

Configuration

Use the following command to configure a specific VRF:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface tunnel-ip 2
RP/0/RP0/CPU0:router(config)# tunnel vrf red
```

For more information on enabling the tunnel mode in GRE, see Configuring GRE Tunnels.

Configuration example

The following example shows a tunnel interface configured with endpoints in a non-default VRF (**vrf: red**):

```
Router#show run int tunnel-ip 2
Thu Feb  3 06:18:28.075 UTC
interface tunnel-ip2
 ipv4 address 102.1.1.100 255.255.255.0
 tunnel tos 32
 tunnel mode gre ipv4
 tunnel source 120.1.1.100
 tunnel vrf red
 tunnel destination 120.1.1.1
```

```
Router#show monitor-session status
Thu Feb  3 06:18:11.061 UTC
Monitor-session ERSPAN-2
```

```
Destination interface tunnel-ip2
================================================================
Source Interface      Dir   Status
--------------------- ----  ------------------------------------------------
Te0/0/0/5 (port)      Rx    Operational
```

Verification

The following CLI output shows how to verify, if the configured tunnel VRF is programmed in the session:

```
Router#show monitor-session ERSPAN-2 status internal
Thu Feb  3 06:19:50.014 UTC

Information from SPAN Manager and MA on all nodes:
Monitor-session ERSPAN-2 (ID 0x00000003) (Ethernet)
SPAN Mgr: Destination interface tunnel-ip2 (0x20008024)
          Last error: Success
          Tunnel data:
            Mode: GREoIPv4
            Source IP: 120.1.1.100
            Dest IP: 120.1.1.1
            VRF: red
            VRF TBL ID: 0
            ToS: 32
            TTL: 255
            DFbit: Not set
```

DSCP Marking on Egress GRE Tunnel in ERSPAN

Table 34: Feature History Table

Feature Name	Release Information	Feature Description
DSCP Marking on Egress GRE Tunnel in ERSPAN	Release 7.5.4	You can now set or modify Differentiated Service Code Point (DSCP) value on the ERSPAN GRE tunnel header. This feature allows you to control the QoS for your network's ERSPAN GRE tunnel traffic and eases the effort to control your customers' bandwidth across next-hop routers.

Starting Cisco IOS XR Release 7.5.4, you can set or modify DSCP marking on ERSPAN GRE tunnels. ERSPAN uses GRE encapsulation to route SPAN capture traffic.

Configure DSCP Marking on Egress GRE Tunnel in ERSPAN

Configuration Example

This example shows how you can configure DSCP Marking on Egress GRE tunnel in ERSPAN.

```
Router#configure terminal
Router(config)#interface tunnel-ip1
Router(config-if)#tunnel tos 96
Router(config-if)#tunnel mode gre ipv4
Router(config-if)#tunnel source 192.0.2.1
Router(config-if)#tunnel destination 192.0.2.254
```

Note You can configure DSCP value on both IPv4 and IPv6 headers.

Running Configuration

```
interface tunnel-ip1
 tunnel tos 96
 tunnel mode gre ipv4
 tunnel source 192.0.2.1
 tunnel destination 192.0.2.254
!
```

Verification

You can use the following commands to verify that tos value is configured:

```
Router#show run interface tunnel-ip 1
interface tunnel-ip1
 ipv4 address 192.0.2.0/24
 tunnel tos 96
 tunnel mode gre ipv4
 tunnel source 192.0.2.1
 tunnel vrf red
 tunnel destination 192.0.2.254

Router#show monitor-session ERSPAN-2 status internal

Information from SPAN Manager and MA on all nodes:
Monitor-session ERSPAN-2 (ID 0x00000003) (Ethernet)
SPAN Mgr: Destination interface tunnel-ip1 (0x20008024)
          Last error: Success
          Tunnel data:
            Mode: GREoIPv4
            Source IP: 192.0.2.1
            Dest IP: 192.0.2.254
            VRF: red
            VRF TBL ID: 0
            ToS: 96
            TTL: 255
            DFbit: Not set
```

SPAN over Pseudowire

Pseudo-wire traffic mirroring (known as PW-SPAN) is an extra functionality on the existing SPAN solutions. The existing SPAN solutions are monitored on a destination interface or through a GRE tunnel or RSPAN. In PW-SPAN, the traffic mirroring destination port is configured to be a pseudo-wire rather than a physical port. Here, the designated traffic on the source port is mirrored over the pseudo-wire to a central location. This allows the centralization of expensive network traffic analysis tools.

Because the pseudo-wire carries only mirrored traffic, this traffic is unidirectional. Incoming traffic from the remote provider edge is not allowed. Typically, a monitor session should be created with a destination pseudo-wire. This monitor session is one of the L2VPN xconnect segments. The other segment of the L2VPN VPWS is a pseudowire.

Configure SPAN over Pseudowire

Use the following steps to configure SPAN over Pseudowire:

Configure SPAN monitor session

```
RP/0/RP0/CPU0:router#config
RP/0/RP0/CPU0:router(config)#monitor-session M1
RP/0/RP0/CPU0:router(config-mon)#destination pseudowire
RP/0/RP0/CPU0:router(config-mon)#commit
```

Configure SPAN source

```
RP/0/RP0/CPU0:router#config
Fri Sep  6 03:49:59.312 UTC
RP/0/RP0/CPU0:router(config)#interface Bundle-Ether100
RP/0/RP0/CPU0:router(config-if)#monitor-session M1 ethernet port-level
RP/0/RP0/CPU0:router(config-if-mon)#commit
```

Configure l2vpn xconnect

```
RP/0/RP0/CPU0:router(config)#l2vpn
RP/0/RP0/CPU0:router(config-l2vpn)#pw-class span
RP/0/RP0/CPU0:router(config-l2vpn-pwc)#encapsulation mpls
RP/0/RP0/CPU0:router(config-l2vpn-pwc-mpls)#transport-mode ethernet
RP/0/RP0/CPU0:router(config-l2vpn)#xconnect group 1
RP/0/RP0/CPU0:router(config-l2vpn-xc)#p2p 2
RP/0/RP0/CPU0:router(config-l2vpn-xc-p2p)#monitor-session M1
RP/0/RP0/CPU0:router(config-l2vpn-xc-p2p)#neighbor ipv4 10.10.10.1 pw-id 2
RP/0/RP0/CPU0:router(config-l2vpn-xc-p2p)#pw-class span
RP/0/RP0/CPU0:router(config-l2vpn-xc-p2p)#commit
```

Verify SPAN over Pseudowire

The following examples show how to verify SPAN over Pseudowire configuration.

To check monitor session status:

```
RP/0/RP0/CPU0:router#show run monitor-session M1
monitor-session M1 ethernet
 destination pseudowire

RP/0/RP0/CPU0:router#show monitor-session M1 status
Monitor-session M1
Destination pseudowire
Source Interface      Dir   Status
BE100 (port)          Both  Operational
BE400 (port)          Both  Operational

RP/0/RP0/CPU0:router#show monitor-session M1 status detail
Monitor-session M1
  Destination pseudowire
  Source Interfaces
  -----------------
  Bundle-Ether100
    Direction:  Both
    Port level: True
    ACL match:  Disabled
    Portion:    Full packet
    Interval:   Mirror all packets
    Status:     Operational
  Bundle-Ether400
    Direction:  Both
    Port level: True
    ACL match:  Disabled
    Portion:    Full packet
    Interval:   Mirror all packets
    Status:     Operational
```

To check underlying l2vpn xconnect:

```
RP/0/RP0/CPU0:router#show run l2vpn
l2vpn
 pw-class span
  encapsulation mpls
   transport-mode ethernet
  !
  !
  p2p 2
   monitor-session M1
   neighbor ipv4 10.10.10.1 pw-id 2
   pw-class span
   !
  !
  p2p 10
   monitor-session M2
   neighbor ipv4 10.10.10.1 pw-id 10
    pw-class span
   !
  !
 !
!
RP/0/RP0/CPU0:router#show l2vpn xconnect
Fri Sep  6 03:41:15.691 UTC
Legend: ST = State, UP = Up, DN = Down, AD = Admin Down, UR = Unresolved,
        SB = Standby, SR = Standby Ready, (PP) = Partially Programmed

XConnect                    Segment 1                       Segment 2
Group      Name       ST    Description            ST       Description             ST
------------------------    ------------------------------  ------------------------------
1          2          UP    M1                     UP       10.10.10.1         2      UP

------------------------------------------------------------------------------------------
1          10         UP    M2                     UP       10.10.10.1         10     UP

------------------------------------------------------------------------------------------
```

Traffic Mirroring for Incoming and Outgoing Traffic Separately over Pseudowire

Table 35: Feature History Table

Feature Name	Release	Description
Traffic Mirroring for Incoming and Outgoing Traffic Separately over Pseudowire	Release 7.11.1	Introduced in this release on: NCS 5500 fixed port routers; NCS 5700 fixed port routers; NCS 5700 line cards [Mode: Native] You can now distribute the monitoring load by separating the Rx and Tx traffic mirroring over the pseudowire. Earlier, you could mirror the entire traffic without distinguishing between Rx and Tx directions. The separation of traffic direction gives the flexibility of monitoring and analyzing the nature of data being sent and received using independent network traffic analysis tools. The separation also helps in distributing the monitoring load and eases troubleshooting. The feature modifies the **monitor-session** command. The keywords **destination rx** and **destination tx** of the command are extended to monitor session configuration mode. Earlier, this configuration resulted in verification failure.

Feature Name	Release	Description
Port Mirroring Enhancements on NC57 Line Cards	Release 7.4.1	This feature allows you to mirror the incoming and outgoing traffic from source ports to separate destinations on NC57 line cards. With one destination for incoming traffic and one destination for outgoing traffic enables you to analyze the incoming and outing traffic separately or together. This feature supports up to 24 monitor sessions with single destination or incoming-outgoing traffic to separate destinations. The following keywords are added to the **monitor-session (interface)** command, to define the incoming (**rx**) and outgoing (**tx**) destinations: • **rx [interface]** • **tx [interface]**

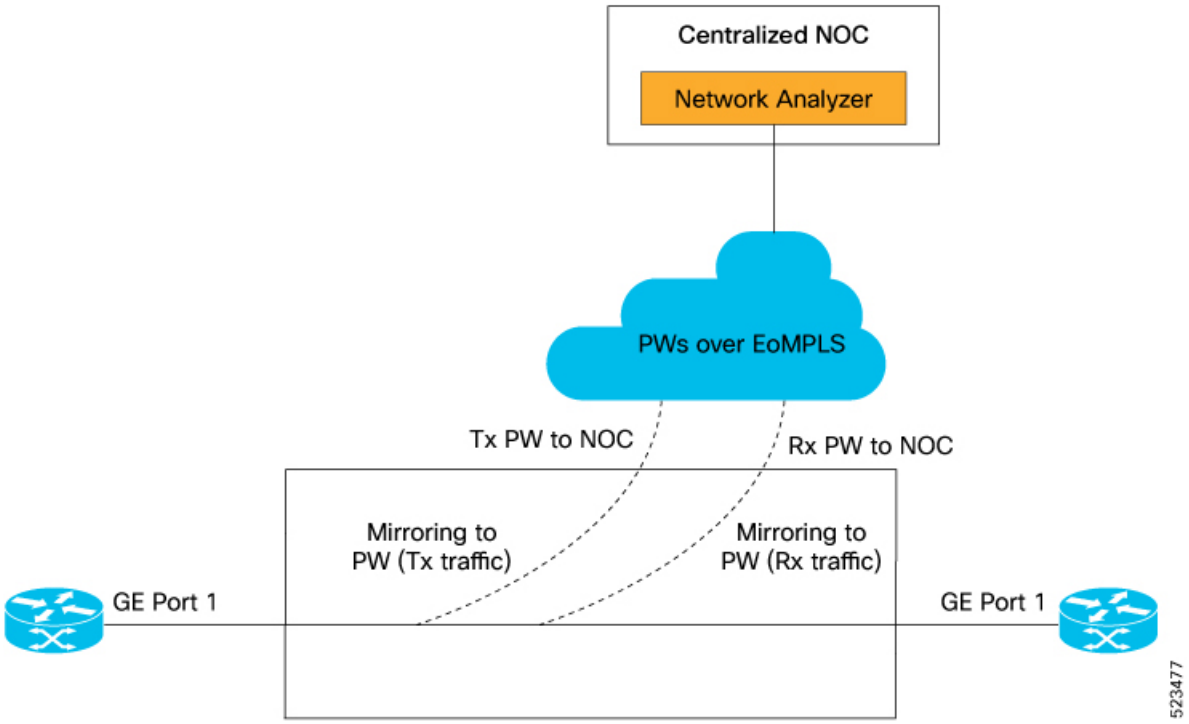
Pseudowire Traffic Mirroring also known as PW-SPAN involves replicating designated traffic from the source port to a central location through the pseudowire. The transmission within the pseudowire follows a unidirectional flow, originating from the source port and terminating at the destination network analyzer. Previously, you could not send Rx and Tx mirrored traffic to separate Rx and Tx PW-SPAN destinations. The entire traffic is mirrored to the destination through pseudowire, which is less effective in monitoring and troubleshooting network issues. Resource allocation of monitoring tools is also not optimized, especially when the monitoring requirement for one direction is different from the other direction.

This feature allows separate Rx and Tx mirror destinations within a single session to optimize resource allocation when the monitoring requirement for one direction is different from the other direction.

Topology

Using this topology, let's understand how incoming and outgoing traffic are mirrored separately over pseudowire.

Figure 18: Mirroring Topology



- This topology uses pseudowires provisioned over EoMPLS.
- Two pseudowires, Rx PW and Tx PW, mirror incoming (Rx) and outgoing (Tx) traffic separately to a centralized Network Operations Center (NOC).
- The network analyzer hosted in the NOC receives the separately mirrored traffic for analysis.

You can provision pseudowires using L2VPN point-to-point cross-connect. The SPAN session supports configuring the session ID and traffic direction to allow multiple mirror destinations within the same SPAN session. After you configure traffic mirroring, traffic is duplicated from the selected pseudowires to the specified destination port without affecting the normal traffic forwarding in the network.

The destination port or monitoring tool captures mirrored traffic from the specified pseudowires, facilitating pseudowire traffic monitoring, analysis, and troubleshooting. The segregation of Rx and Tx monitoring enhances the ability to identify and isolate differences or performance problems. By identifying the root cause network problems can be resolved with greater efficiency and effectiveness.

Configure Traffic Mirroring for Incoming and Outgoing Traffic Separately over Pseudowire

Perform the following tasks to configure Rx and Tx pseudowire destinations:

- Create a pseudowire monitor session to replicate Ethernet traffic.
- Configure the destination for Rx and Tx traffic.
- Create an L2VPN cross-connect corresponding to the monitor session and define point-to-point forwarding details for Rx and Tx.
- Define bundle-ether interfaces for Rx and Tx directions.

```
Router(config)#monitor-session pw-span2 ethernet
Router(config-mon)#destination rx pseudowire
Router(config-mon)#destination tx pseudowire
Router(config-mon)#exit

Router(config)#l2vpn
Router(config-l2vpn)#xconnect group pw-span2
Router(config-l2vpn-xc)#p2p rx2
Router(config-l2vpn-xc-p2p)#monitor-session pw-span2 rx
Router(config-l2vpn-xc-p2p)#neighbor ipv4 100.2.1.11 pw-id 21
Router(config-l2vpn-xc-p2p-pw)#mpls static label local 1421 remote 1521
Router(config-l2vpn-xc-p2p-pw)#pw-class pw
Router(config-l2vpn-xc-p2p-pw)#exit
Router(config-l2vpn-xc-p2p)#exit
Router(config-l2vpn-xc)#p2p tx2
Router(config-l2vpn-xc-p2p)#monitor-session pw-span2 tx
Router(config-l2vpn-xc-p2p)#neighbor ipv4 100.1.1.22 pw-id 22
Router(config-l2vpn-xc-p2p-pw)#mpls static label local 1422 remote 1522
Router(config-l2vpn-xc-p2p-pw)#pw-class pw
Router(config-l2vpn-xc-p2p-pw)#exit
Router(config-l2vpn-xc-p2p)#exit
Router(config-l2vpn-xc)#exit
Router(config-l2vpn)#exit

Router(config)#interface Bundle-Ether1
Router(config-if)#ipv4 address 20.1.1.1 255.255.255.252
Router(config-if)#ipv6 address abc::20:1:1:1/126
Router(config-if)#lacp mode active
Router(config-if)#lacp period short

Router(config-if)#monitor-session pw-span2
Router(config-if-mon)#exit
Router(config-if)#exit

Router(config)#interface Bundle-Ether101
Router(config-if)#ipv4 address 20.1.4.1 255.255.255.252
Router(config-if)#ipv6 address abc::20:1:4:1/126
Router(config-if)#lacp mode active
Router(config-if)#lacp period short

Router(config-if)#monitor-session pw-span2
Router(config-if-mon)#exit
Router(config-if)#exit
Router(config-if)#load-interval 30
Router(config)#exit
```

Running Configuration

The following example shows the running configuration.

```
Router#sh run monitor-session pw-span2
Wed Sep 23 11:06:28.607 UTC
monitor-session pw-span2 ethernet
 destination rx pseudowire
 destination tx pseudowire
!

Router#sh run l2vpn xconnect group pw-span2
!l2vpn
l2vpn
 xconnect group pw-span2
  p2p rx2
   monitor-session pw-span2 rx
   neighbor ipv4 100.2.1.11 pw-id 21
    mpls static label local 1421 remote 1521
```

```
    pw-class pw
   !
  !
  p2p tx2
   monitor-session pw-span2 tx
   neighbor ipv4 100.1.1.22 pw-id 22
    mpls static label local 1422 remote 1522
    pw-class pw
   !
  !
 !
!

Router#sh run interface bundle-ether 1
interface Bundle-Ether1
 ipv4 address 20.1.1.1 255.255.255.252
 ipv6 address abc::20:1:1:1/126
 lacp mode active
 lacp period short
 monitor-session pw-span2
 !
!

Router#sh run interface bundle-ether 101
interface Bundle-Ether101
 ipv4 address 20.1.4.1 255.255.255.252
 ipv6 address abc::20:1:4:1/126
 lacp mode active
 lacp period short
 monitor-session pw-span2
 !
 load-interval 30
!
```

Verification

Verify that both Rx and Tx traffic is operational.

```
show monitor-session status
Monitor-session pw-span2
rx destination pseudowire
tx destination pseudowire
================================================================================
Source Interface      Dir   Status
--------------------- ----  ------------------------------------------------
BE1                   both    Operational
BE101                 both    Operational
```

SPAN-to-File

SPAN-to-File is an extension of the pre-existing SPAN feature that allows network packets to be mirrored to a file instead of an interface. This simplifies the analysis of the packets at a later stage. The file format is PCAP, which helps that data to be used by tools, such as tcpdump or Wireshark.

Warning Be cautious when you apply this feature to files located on interfaces with high traffic.

When a file is configured as a destination for a SPAN session, a buffer is created on each node to which the network packets are logged. The buffer is for all packets on the node regardless of which interface they are from, that is, multiple interfaces may be providing packets for the same buffer. The buffers are deleted when

the session configuration is removed. The file is written by each node to a location on the active RP which contains the node ID of the node on which the buffer was located.

If multiple interfaces are attached to a session, then interfaces on the same node are expected to have their packets sent to the same file. Bundle interfaces can be attached to a session with a file destination, which is similar to attaching individual interfaces.

SPAN-to-File Enhancements

Table 36: Feature History Table

Feature Name	Release Information	Feature Description
SPAN-to-File supports pcap and pcapng File Format for NCS 5700	Release 24.3.1	Introduced in this release on: NCS 5700 fixed port routers and NCS 5700 line cards [Mode: Native]. SPAN-to-File extends support to both pcap and pcap Next Generation (pcapng) file format on the Cisco NCS 5700 series routers and line cards in Native mode.
SPAN Mirror First	Release 7.5.2	With your knowledge of expected packet header size, you can now mirror only the first N bytes of a packet where N can have possible values from 1 through 10000. This allows only the packet headers to be mirrored and not the user payload, ensuring the privacy and security of user data. It also reduces the load on network resources by processing only a few bytes to identify issues in the network. With the introduction of this feature, you can use the **mirror first** option in the global configuration mode of the **monitor-session** command.
SPAN-to-File - PCAPng File Format	Release 7.3.1	PCAPng is the next generation of packet capturing format that contains data packets captured over a network and stored in a standard format. The PCAPng file contains different types of information blocks, such as the section header, interface description, enhanced packet, simple packet, name resolution, and interface statistics. These blocks can be used to rebuild the captured packets into recognizable data. The PCAPng file format: • Provides the capability to enhance and extend the existing capabilities of data storage over time • Allows you to merge or append data to an existing file. • Enables to read data independently from network, hardware, and operating system of the machine that made the capture.

Configure SPAN-to-File

Use the following command to configure SPAN to File:

```
monitor-session <name> [ethernet|ipv4|ipv6|mpls-ipv4|mpls-ipv6]
    destination file [size <kbytes>] [buffer-type linear]
```

The `monitor-session <name> [ethernet|ipv4|ipv6|mpls-ipv4|mpls-ipv6]` part of the command creates a monitor-session with the specified name and class and is a pre-existing chain point from the current SPAN feature. The `destination file [size <kbytes>] [buffer-type linear]` part of the command adds a new "file" option to the existing "destination".

`destination file` has the following configuration options:

- Buffer size.
- Two types of buffer:
  - Circular: Once the buffer is full, the start is overwritten.
  - Linear: Once the buffer is full, no further packets are logged.

Note The default buffer-type is circular. Only linear buffer is explicitly configurable. Changing any of the parameters (buffer size or type) recreates the session, and clears any buffers of packets.

All configuration options which are applied to an attachment currently supported for other SPAN types should also be supported by SPAN to file. This may include:

- ACLs
- Write only first X bytes of packet.
- Mirror interval from 512 to 16k.

Note These options are implemented by the platform when punting the packet.

Once a session has been created, then interfaces may be attached to it using the following configuration:

```
interface GigabitEthernet 0/0/0/0
    monitor-session <name> [ethernet|ipv4|ipv6|mpls-ipv4|mpls-ipv6]
```

The attachment configuration is unchanged by SPAN-to-File feature.

Note Once the SPAN-to-File session is attached to source interface, mirroring starts and packets are punted from NPU to CPU and dropped at CPU until the **packet-collection start action** command is executed.

Configuration Examples

To configure a `mon1` monitor session, use these commands:

```
monitor-session mon1 ethernet
          destination file size 230000
         !
```

In the above example, omitting the `buffer-type` option results in default circular buffer.

To configure a `mon2` monitor session with the `linear` buffer type, use these commands:

```
monitor-session mon2 ethernet
          destination file size 1000 buffer-type linear
         !
```

To attach monitor session to a physical or bundle interface, use these commands:

```
interface Bundle-Ether1
monitor-session ms7 ethernet
!
```

To configure a `mon3` monitor session with the `mirror first` option, use these commands:

```
monitor-session mon3 ethernet
mirror first 101
!
```

Running Configuration

```
!! IOS XR Configuration 7.1.1.124I
!! Last configuration change at Tue Nov 26 19:29:05 2019 by root
!
hostname OC
logging console informational
!
monitor-session mon2 ethernet
 destination file size 1000 buffer-type linear

!
interface Bundle-Ether1
monitor-session ms7 ethernet
end
```

Verification

To verify packet collection status:

```
RP/0/RP0/CPU0:router#show monitor-session status
Monitor-session mon1
Destination File - Packet collecting
=============================================
Source Interface      Dir   Status
--------------------- ----  ------------------
Hu0/9/0/2             Rx    Operational

Monitor-session mon2
Destination File - Packet collecting
=========================================
Source Interface      Dir   Status
--------------------- ----  --------------
BE2.1                 Rx    Operational
```

If packet collection is not active, the following line is displayed:

```
Monitor-session mon2
Destination File - Not collecting
```

Here, `Status-Operational` and `Destination File - Not collecting` indicates that mirroring has started and packets are being punted from NPU to CPU but getting dropped at CPU until the **packet-collection start action** command is executed.

Action Commands for SPAN-to-File

Action commands are added to start and stop network packet collection. The commands may only be run on sessions where the destination is a file. The action command auto-completes names of globally configured SPAN to File sessions. See the table below for more information on action commands.

Table 37: Action Commands for SPAN-to-File

Action	Command	Description
Start	`monitor-session <name> packet-collection start`	Issue this command to start writing packets for the specified session to the configured buffer. Once the SPAN is configured and operational, the packets are punted to CPU and dropped by CPU until the `monitor-session <name> packet-collection start` command is executed.
Stop	`monitor-session <name> packet-collection stop [ discard-data | write directory <dir> filename <filename> ]`	Issue this command to stop writing packets to the configured buffer. • `discard-data`: Specify this option to clear the buffer. • `discard-data`: Specify this option to write the buffer to the disk before it is cleared. The buffer is written in .pcap format in this location: `/<directory>/<node_id>/<filename>.pcap`. The .pcap extension that the user adds to the filename is removed automatically to avoid a duplicate file extension.

File Mirroring

Prior to Cisco IOS XR Software Release 7.2.1, the router did not support file mirroring from active RP to standby RP. Administrators had to manually perform the task or use EEM scripts to sync files across active RP and standby RP. Starting with Cisco IOS XR Software Release 7.2.1, the file mirroring feature enables the router to copy files or directories automatically from `/harddisk:/mirror` location in active RP to `/harddisk:/mirror` location in standby RP or RSP without user intervention or EEM scripts.

Two new CLIs have been introduced for the file mirroring feature:

- **`mirror enable`**

  The `/harddisk:/mirror` directory is created by default, but file mirroring functionality is only enabled by executing the `mirror enable` command from configuration terminal. Status of the mirrored files can be viewed with `show mirror status` command.

- **mirror enable checksum**

  The `mirror enable checksum` command enables MD5 checksum across active to standby RP to check integrity of the files. This command is optional.

Configure File Mirroring

File mirroring has to be enabled explicitly on the router. It is not enabled by default.

```
RP/0/RSP0/CPU0:router#show run mirror

Thu Jun 25 10:12:17.303 UTC
mirror enable
mirror checksum
```

Following is an example of copying running configuration to `harddisk:/mirror` location:

```
RP/0/RSP0/CPU0:router#copy running-config harddisk:/mirror/run_config
Wed Jul  8 10:25:51.064 PDT
Destination file name (control-c to abort): [/mirror/run_config]?
Building configuration..
32691 lines built in 2 seconds (16345)lines/sec
[OK]
```

Verification

To verify the syncing of file copied to mirror directory, use the `show mirror` command.

```
RP/0/RSP0/CPU0:router#show mirror
Wed Jul  8 10:31:21.644 PDT
% Mirror rsync is using checksum, this show command may take several minutes if you have
many files. Use Ctrl+C to abort
MIRROR DIR: /harddisk:/mirror/
% Last sync of this dir ended at Wed Jul  8 10:31:11 2020
Location   |Mirrored |MD5 Checksum                    |Modification Time
-------------------------------------------------------------------------
run_config |yes      |76fc1b906bec4fe08ecda0c93f6c7815 |Wed Jul  8 10:25:56 2020
```

If checksum is disabled, `show mirror` command displays the following output:

```
RP/0/RSP0/CPU0:router#show mirror
Wed Jul 8 10:39:09.646 PDT
MIRROR DIR: /harddisk:/mirror/
% Last sync of this dir ended at Wed Jul  8 10:31:11 2020
Location   |Mirrored |Modification Time
----------------------------------------
run_config |yes         |Wed Jul  8 10:25:56 2020
```

If there is a mismatch during the syncing process, use `show mirror mismatch` command to verify.

```
RP/0/RP0/CPU0:router# show mirror mismatch
Wed Jul  8 10:31:21.644 PDT
 MIRROR DIR: /harddisk:/mirror/
 % Last sync of this dir ended at Wed Jul  8 10:31:11 2020
 Location  |Mismatch Reason     |Action Needed
-----------------------------------------------
 test.txt  |newly created item. |send to standby
```

Forward-Drop Packets Mirroring

In a network, packets are forwarded from one device to another until they reach their destination. However, in some cases, routers may drop packets during this forwarding process. These packets are known as forward-drop packets.

Packets can be dropped for several reasons such as congestion on the network, errors in the packet header or payload, blocking by firewall, and so on. These forward-drop packets are typically discarded before they can reach their intended destination, and may have to be re-transmitted by the source device. This feature supports mirroring of these forward-drop packets at the ingress (Rx direction) to another destination. When a global forward-drop session is configured for the router, the forward-drop packets at the ingress are mirrored or copied to the configured destination. You can configure the mirror destination as a file (for SPAN-to-file sessions) or an IPv4 GRE tunnel ID (for ERSPAN).

Mirror Forward-Drop Packets

Table 38: Feature History Table

Feature Name	Release Information	Description
Mirror Forward-Drop Packets	Release 7.5.4	Mirroring forward-drop packets feature copies or mirrors the packets that are dropped during the forwarding process at the router ingress to a configured destination. These mirrored packets can be captured and analyzed using network monitoring tools. The analysis of dropped packets helps you understand the types of traffic that are blocked, analyze potential security threats, troubleshoot, and optimize network performance. This feature introduces the following changes: • **CLI: drops** • **YANG Data Model:**New XPath for Cisco-IOS-XR-um-monitor-session-cfg.yang (see GitHub, YANG Data Models Navigator)

Mirroring forward-drop packets to a suitable destination for analysis can help in the following:

- Network visibility: By mirroring and analyzing forward-drop packets, network administrators gain better visibility into the types of traffic that are blocked by the firewalls.
- Threat detection: As the original dropped packet is forwarded without any change, it helps in identifying the source of potential security threats.
- Troubleshooting: Analyzing forward-drop packets helps in troubleshooting network issues that may be causing the packet drop. This helps in taking proactive measures to avoid escalation of the issue.

Configure Forward-Drop Mirroring

Perform the following tasks on the router to configure a global session for mirroring forward-drop packets:

1. Configure the tunnel mode.
2. Configure the tunnel source.

3. Configure the tunnel destination.
4. Configure a traffic mirroring session.
5. Associate a destination interface with the traffic mirroring session.
6. Run **drops** command to start mirroring forward-drop packets.

This example shows how to configure a global traffic mirroring session for forward-drop packets.

```
Router(config)# interface tunnel-ip 2
Router(config-if)# tunnel mode gre ipv4
Router(config-if)# tunnel source 20.20.20.20
Router(config-if)# tunnel destination 192.1.1.3
Router(config-if)!
Router(config)# monitor-session mon2 ethernet
Router(config)#destination interface tunnel-ip2
Router(config)#drops packet-processing rx
Router(config)#!
```

Running Configuration

This section shows forward-drop running configuration.

```
RP/0/RSP0/CPU0:router#sh running-config
interface tunnel-ip 2
tunnel mode gre ipv4
tunnel source 20.20.20.20
tunnel destination 192.1.1.3
!
monitor-session mon2 ethernet
destination interface tunnel-ip2
drops packet-processing rx
!
```

Verification

Verify the forward-drop packets are mirrored using the **show monitor-session** command.

```
Router#show monitor-session mon2 status detail
Mon Aug 15 19:14:31.975 UTC
Monitor-session mon2
   Destination interface tunnel-ip2
   All forwarding drops:
      Direction: Rx
Source Interfaces
-----------------
```

Troubleshoot Traffic Mirroring

When you encounter any issue with traffic mirroring, begin troubleshooting by checking the output of the **show monitor-session status** command. This command displays the recorded state of all sessions and source interfaces:

```
# show monitor-session status
Monitor-session 5
rx destination interface tunnel-ip5
tx destination is not specified
================================================================================
```

```
Source Interface  Dir  Status
------------------- ---- ------------------------------------------------------
Te0/0/0/23 (port) Rx   Operational
```

In the preceding example, the line marked as `<Session status>` can indicate one of these configuration errors:

Session Status	Explanation
Session is not configured globally	The session does not exist in global configuration. Review the **sho** command output and ensure that a session with a correct name has configured.
Destination interface <intf> (<down-state>)	The destination interface is not in Up state in the Interface Manage can verify the state using the **show interfaces** command. Check th configuration to determine what might be keeping the interface from up (for example, a sub-interface needs to have an appropriate encaps configured).

The <Source interface status> can report these messages:

Source Interface Status	Explanation
Operational	Everything appears to be working correctly in traffic mirroring PI. follow up with the platform teams in the first instance, if mirroring operating as expected.
Not operational (Session is not configured globally)	The session does not exist in global configuration. Check the **show** command output to ensure that a session with the right name has b configured.
Not operational (destination not known)	The session exists, but it either does not have a destination interface s or the destination interface named for the session does not exist. For e if the destination is a sub-interface that has not been created.
Not operational (source same as destination)	The session exists, but the destination and source are the same inte traffic mirroring does not work.
Not operational (destination not active)	The destination interface or pseudowire is not in the Up state. See corresponding *Session status* error messages for suggested resoluti
Not operational (source state <down-state>)	The source interface is not in the Up state. You can verify the state the **show interfaces** command. Check the configuration to see wha be keeping the interface from coming up (for example, a sub-interfa to have an appropriate encapsulation configured).
Error: see detailed output for explanation	Traffic mirroring has encountered an error. Run the **show monitor status detail** command to display more information.

The **show monitor-session status detail** command displays full details of the configuration parameters and any errors encountered. For example:

RP/0/RP0/CPU0:router **show monitor-session status detail**

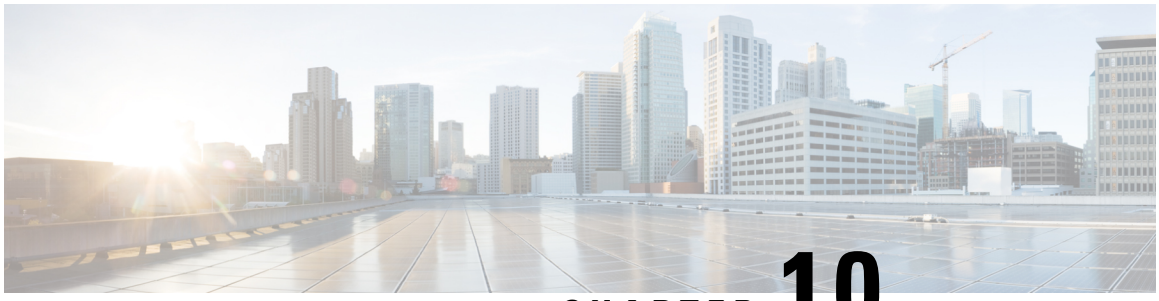
```
Monitor-session sess1
```

```
 Destination interface is not configured
 Source Interfaces
 -----------------
 TenGigE0/0/0/1
  Direction: Both
  ACL match: Disabled
  Portion:  Full packet
  Status:  Not operational (destination interface not known)
 TenGigE0/0/0/2
  Direction: Both
  ACL match: Disabled
  Portion:  First 100 bytes
  Status: Not operational (destination interface not known). Error: 'Viking SPAN PD' detected
 the 'warning' condition 'PRM connection
          creation failure'.
Monitor-session foo
 Destination next-hop TenGigE 0/0/0/0
 Source Interfaces
 -----------------
 TenGigE 0/1/0/0.100:
  Direction: Both
  Status:  Operating
 TenGigE 0/2/0/0.200:
  Direction: Tx
  Status:  Error: <blah>

Monitor session bar
 No destination configured
 Source Interfaces
 -----------------
 TenGigE 0/3/0/0.100:
  Direction: Rx
  Status:  Not operational(no destination)
```

Here are additional trace and debug commands:

```
RP/0/RP0/CPU0:router# show monitor-session trace ?

 platform  Enable platform trace
 process   Filter debug by process(cisco-support)

RP/0/RP0/CPU0:router# show monitor-session trace platform ?

 errors  Display error traces(cisco-support)
 events  Display event traces(cisco-support)

RP/0/RP0/CPU0:router#show monitor-session trace platform events location all ?

usrtdir  Specify directory to collect unsorted traces(cisco-support)
|        Output Modifiers
<cr>

RP/0/RP0/CPU0:router#show monitor-session trace platform errors location all ?

usrtdir  Specify directory to collect unsorted traces(cisco-support)
|        Output Modifiers
<cr>

RP/0/RP0/CPU0:router# debug monitor-session process ?

  all  All SPAN processes(cisco-support)
  ea   SPAN EA(cisco-support)
  ma   SPAN MA(cisco-support)
```

```
  mgr  SPAN Manager(cisco-support)


RP/0/RP0/CPU0:router# debug monitor-session process all

RP/0/RP0/CPU0:router# debug monitor-session process ea

RP/0/RP0/CPU0:router# debug monitor-session process ma

RP/0/RP0/CPU0:router# show monitor-session process mgr

 detail  Display detailed output
 errors  Display only attachments which have errors
 internal Display internal monitor-session information
 |     Output Modifiers

RP/0/RP0/CPU0:router# show monitor-session status

RP/0/RP0/CPU0:router# show monitor-session status errors

RP/0/RP0/CPU0:router# show monitor-session status internal

RP/0/RP0/CPU0:router# show tech-support span ?

 file       Specify a valid file name (e.g. disk0:tmp.log)
 list-CLIs  list the commands that would be run (don't execute)(cisco-support)
 location   Specify a location(cisco-support)
 rack       Specify a rack(cisco-support)
 time-out   per show command timeout configuration(cisco-support)
 <cr>
```



CHAPTER 10

Configuring Virtual Loopback and Null Interfaces

This module describes the configuration of loopback and null interfaces. Loopback and null interfaces are considered virtual interfaces.

A virtual interface represents a logical packet switching entity within the router. Virtual interfaces have a global scope and do not have an associated location. Virtual interfaces have instead a globally unique numerical ID after their names. Examples are Loopback 0, Loopback 1, and Loopback 99999. The ID is unique per virtual interface type to make the entire name string unique such that you can have both Loopback 0 and Null 0.

Loopback and null interfaces have their control plane presence on the active route switch processor (RSP). The configuration and control plane are mirrored onto the standby RSP and, in the event of a failover, the virtual interfaces move to the ex-standby, which then becomes the newly active RSP.

- Information About Configuring Virtual Interfaces, on page 297

Information About Configuring Virtual Interfaces

To configure virtual interfaces, you must understand the following concepts:

Virtual Loopback Interface Overview

A virtual loopback interface is a virtual interface with a single endpoint that is always up. Any packet transmitted over a virtual loopback interface is immediately received by the same interface. Loopback interfaces emulate a physical interface.

In Cisco IOS XR Software, virtual loopback interfaces perform these functions:

- Loopback interfaces can act as a termination address for routing protocol sessions. This allows routing protocol sessions to stay up even if the outbound interface is down.
- You can ping the loopback interface to verify that the router IP stack is working properly.

In applications where other routers or access servers attempt to reach a virtual loopback interface, you must configure a routing protocol to distribute the subnet assigned to the loopback address.

Packets routed to the loopback interface are rerouted back to the router or access server and processed locally. IP packets routed out to the loopback interface but not destined to the loopback interface are dropped. Under these two conditions, the loopback interface can behave like a null interface.

Prerequisites for Configuring Virtual Interfaces

You must be in a user group associated with a task group that includes the proper task IDs. The command reference guides include the task IDs required for each command. If you suspect user group assignment is preventing you from using a command, contact your AAA administrator for assistance.

Configuring Virtual Loopback Interfaces

This task explains how to configure a basic loopback interface.

Restrictions

The IP address of a loopback interface must be unique across all routers on the network. It must not be used by another interface on the router, and it must not be used by an interface on any other router on the network.

SUMMARY STEPS

1. **configure**
2. **interface loopback** *instance*
3. **ipv4 address** *ip-address*
4. **end** or **commit**
5. **show interfaces***type instance*

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface loopback** *instance*

Example:

```
RP/0/RP0/CPU0:router#(config)# interface Loopback 3
```

Enters interface configuration mode and names the new loopback interface.

Step 3 **ipv4 address** *ip-address*

Example:

```
RP/0/RP0/CPU0:router(config-if)# ipv4 address 100.100.100.69 255.255.255.255
```

Assigns an IP address and subnet mask to the virtual loopback interface using the **ipv4 address** configuration command.

Step 4 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-if)# end
```

or

```
RP/0/RP0/CPU0:router(config-if)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 5 **show interfaces***type instance*

Example:

```
RP/0/RP0/CPU0:router# show interfaces Loopback0
```

(Optional) Displays the configuration of the loopback interface.

Example

This example shows how to configure a loopback interface:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface Loopback0
RP/0/RP0/CPU0:router(config-if)# ipv4 address 100.100.100.69 255.255.255.255
RP/0/RP0/CPU0:router(config-if)# ipv6 address 100::69/128
RP/0/RP0/CPU0:router(config-if)# end
Uncommitted changes found, commit them? [yes]: yes
RP/0/RP0/CPU0:router# show interfaces Loopback0

Loopback0 is up, line protocol is up
  Interface state transitions: 1
  Hardware is Loopback interface(s)
  Internet address is 100.100.100.69/32
  MTU 1500 bytes, BW 0 Kbit
     reliability Unknown, txload Unknown, rxload Unknown
  Encapsulation Loopback,  loopback not set,
  Last link flapped 01:57:47
  Last input Unknown, output Unknown
```

```
Last clearing of "show interface" counters Unknown
Input/output data rate is disabled.
```

Null Interface Overview

A null interface functions similarly to the null devices available on most operating systems. This interface is always up and can never forward or receive traffic; encapsulation always fails. The null interface provides an alternative method of filtering traffic. You can avoid the overhead involved with using access lists by directing undesired network traffic to the null interface.

The only interface configuration command that you can specify for the null interface is the **ipv4 unreachables** command. With the **ipv4 unreachables** command, if the software receives a non-broadcast packet destined for itself that uses a protocol it does not recognize, it sends an Internet Control Message Protocol (ICMP) protocol unreachable message to the source. If the software receives a datagram that it cannot deliver to its ultimate destination because it knows of no route to the destination address, it replies to the originator of that datagram with an ICMP host unreachable message. By default **ipv4 unreachables** command is enabled. If we do not want ICMP to send protocol unreachable, then we need to configure using the **ipv4 icmp unreachable disable** command.

The Null 0 interface is created by default during boot process and cannot be removed. The **ipv4 unreachables** command can be configured for this interface, but most configuration is unnecessary because this interface just discards all the packets sent to it.

The Null 0 interface can be displayed with the **show interfaces null0** command.

Configuring Null Interfaces

This task explains how to configure a basic null interface.

SUMMARY STEPS

1. **configure**
2. **interface null 0**
3. **end** or **commit**
4. **show interfaces null 0**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **interface null 0**

Example:

```
RP/0/RP0/CPU0:router(config)# interface null 0
```

Enters the null 0 interface configuration mode.

Step 3 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-null0)# end
```

or

```
RP/0/RP0/CPU0:router(config-null0)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

```
Uncommitted changes found, commit them before
exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 4 **show interfaces null 0**

Example:

```
RP/0/RP0/CPU0:router# show interfaces null 0
```

Verifies the configuration of the null interface.

Example

This example shows how to configure a null interface:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface Null 0
RP/0/RP0/CPU0:router(config-null0)# ipv4 icmp unreachables disable
RP/0/RP0/CPU0:router(config-null0)# end
Uncommitted changes found, commit them? [yes]: yes
RP/0/RP0/CPU0:router# show interfaces Null 0

Null0 is up, line protocol is up
Interface state transitions: 1
```

```
Hardware is Null interface
Internet address is Unknown
MTU 1500 bytes, BW 0 Kbit
reliability 255/255, txload Unknown, rxload Unknown
Encapsulation Null, loopback not set,
Last link flapped 4d20h
Last input never, output never
Last clearing of "show interface" counters 05:42:04
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
0 packets input, 0 bytes, 0 total input drops
0 drops for unrecognized upper-level protocol
Received 0 broadcast packets, 0 multicast packets
0 packets output, 0 bytes, 0 total output drops
Output 0 broadcast packets, 0 multicast packets
```

Configuring Virtual IPv4 Interfaces

This task explains how to configure an IPv4 virtual interface.

SUMMARY STEPS

1. **configure**
2. **ipv4 virtual address** *ipv4-*
3. **end** or **commit**

DETAILED STEPS

Procedure

Step 1 **configure**

Example:

```
RP/0/RP0/CPU0:router# configure
```

Enters global configuration mode.

Step 2 **ipv4 virtual address** *ipv4-*

Example:

```
RP/0/RP0/CPU0:router(config)# ipv4 virtual address 10.3.32.154/8
```

Defines an IPv4 virtual address for the management Ethernet interface.

Step 3 **end** or **commit**

Example:

```
RP/0/RP0/CPU0:router(config-null0)# end
```

or

```
RP/0/RP0/CPU0:router(config-null0)# commit
```

Saves configuration changes.

- When you issue the **end** command, the system prompts you to commit changes:

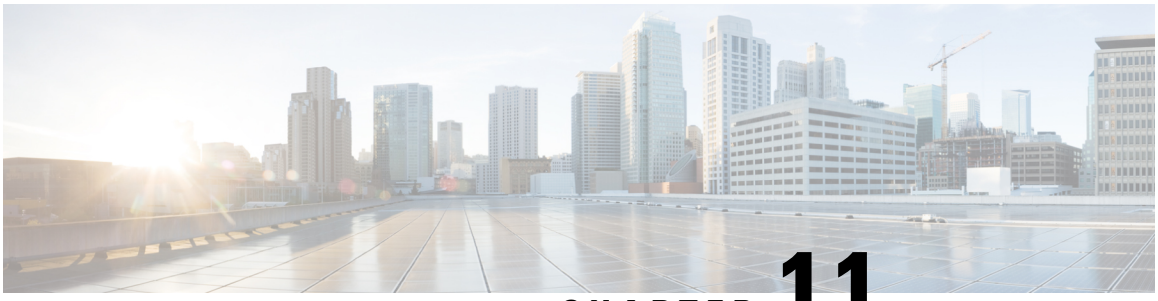
```
Uncommitted changes found, commit them before
exiting(yes/no/cancel)?
[cancel]:
```

- Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
- Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
- Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Example

This is an example for configuring a virtual IPv4 interface:

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# ipv4 virtual address 10.3.32.154/8
RP/0/RP0/CPU0:router(config-null0)# commit
```



CHAPTER 11

Configuring GRE Tunnels

Generic Routing Encapsulation (GRE) is a tunneling protocol that provides a simple generic approach to transport packets of one protocol over another protocol by means of encapsulation. This module provides information about how to configure a GRE tunnel.

Configuring GRE Tunnels

Table 39: Feature History Table

Feature Name	Release Information	Feature Description
GRE over HSRP and VRRP	Release 24.4.1	Introduced in this release on: NCS 5500 fixed port routers; NCS 5500 modular routers(NCS 5500 line cards) You can enhance network resilience, flexibility, and efficiency using GRE encapsulation with HSRP and VRRP. This capability provides network redundancy and high availability by allowing GRE tunnels to operate seamlessly over redundant paths, ensuring uninterrupted service during failovers. The protocol independence of GRE facilitates the integration of different network segments without compatibility issues, while its scalability supports the easy expansion of network connectivity across multiple remote sites. Additionally, leveraging existing infrastructure with GRE minimizes the need for new investments, making it cost-effective. GRE also supports network segmentation and better traffic management, enhancing Quality of Service (QoS).

Tunneling provides a mechanism to transport packets of one protocol within another protocol. Generic Routing Encapsulation (GRE) is a tunneling protocol that provides a simple generic approach to transport packets of one protocol over another protocol with encapsulation. GRE encapsulates a payload, that is, an inner packet that needs to be delivered to a destination network inside an outer IP packet. The GRE tunnel behave as virtual point-to-point link that have two endpoints identified by the tunnel source and tunnel destination address. The tunnel endpoints send payloads through GRE tunnels by routing encapsulated packets through intervening IP networks. Other IP routers along the way do not parse the payload (the inner packet); they only parse the outer

IP packet as they forward it towards the GRE tunnel endpoint. Upon reaching the tunnel endpoint, GRE encapsulation is removed and the payload is forwarded to the packet's ultimate destination.

Encapsulation by the outer packet takes place at the tunnel source whereas decapsulation of the outer packet takes place at the tunnel destination. Encapsulation and decapsulation data is collected periodically or on demand. Encapsulation statistics provide us the number of packets encapsulated at the tunnel source. Decapsulation statistics provide us the number of packets that are decapsulated at the tunnel destination. This data is stored as statistics in logical tables that are based on statistics type in the route processor. The different statistics types include L2 Interface TX Stats, L3 Interface TX Stats, TRAP stats, and so on. Encapsulation statistics can help you to infer the source of the traffic, and decapsulation statistics provide you the destination of the traffic. Decapsulation statistics also help you to detect the type of traffic as well.

L3VPN over GRE is supported for all the Cisco NCS 5700 fixed port routers and NCS 5700 line cards [Mode: Native]. For more information, refer to *L3VPN over GRE Tunnels* section in the *L3VPN Configuration Guide for Cisco NCS 5500 Series Routers*.

Guidelines and Restrictions for Configuring GRE Tunnels

The following restrictions apply while configuring GRE tunnels:

- The router supports up to 500 GRE tunnels.
- Only up to 16 unique source IP addresses are supported for the tunnel source.
- 2-pass to Single-pass migration, which means converting the same GRE tunnel, is not possible in a single configuration step. You must first delete the 2-pass tunnel and then add the Single-pass tunnel.
- Configurable MTU is not supported on Single-pass GRE interface, but supported on 2-pass GRE interface.
- From Release 24.2.11, the Cisco NCS 5700 fixed port routers and from Release 24.2.1, NCS 5700 line cards [Mode: Native] support L3VPN over GRE, but it is not supported in the Cisco NCS 5500 fixed port routers.
- From Release 24.4.1, the Cisco NCS 5500 fixed port routers and NCS 5500 line cards support GRE over HSRP and VRRP in scale mode. Previously, GRE over HSRP and VRRP was supported only in the Cisco NCS 5700 fixed port routers and NCS 5700 line cards.
- The Cisco NCS 5500 series router support only IPv4 GRE tunnels. IPv6 GRE tunnels are not supported.
- The IPv4 GRE tunnels supports IPv4 and IPv6 payloads.
- To use the outer IPv4 GRE header for IP tunnel decapsulation in the hashing algorithm for ECMP and bundle member selection, use the **hw-module profile load-balance algorithm** command.

Table 40: GRE Tunnels with Supported MTU and TOS Hardware Profiles

Supported Hardware	Profile Type	Maximum Supported Profile
NC55-36x100G NC55-18H18F NC55-24x100G-SE NC55-24H12F-SE NC55-36x100G-S NC55-6x200-DWDM-S	MTU	3
NC55-36x100G-A-SE NC55-MOD-A-S NC55-MOD-A-SE-S NC55-32T16Q4H	MTU	3
NC57-24DD NC57-18DD-SE NC57-36H-SE NC57-36H6D NC57-MOD-S	MTU	7
NC55-36x100G NC55-18H18F NC55-24x100G-SE NC55-24H12F-SE NC55-36x100G-S NC55-6x200-DWDM-S	TOS	8
NC55-36x100G-A-SE NC55-MOD-A-S NC55-MOD-A-SE-S NC55-32T16Q4H	TOS	8

Note If the configured MTU and Tunnel TOS profile exceeds the supported hardware limit, the system displays SDK-Out of Memory error.

Configuration Example

Configuring a GRE tunnel involves creating a tunnel interface and defining the tunnel source and destination. This example shows how to configure a GRE tunnel between Router1 and Router2. You need to configure tunnel interfaces on both the routers. Tunnel source IP address on Router1 will be configured as the tunnel destination IP address on Router2. Tunnel destination IP address on Router1 will be configured as the tunnel source IP address on Router2. In this example, OSPF is used as the routing protocol between the two routers. You can also configure BGP or IS-IS as the routing protocol.

```
RP/0/RP0/CPU0:Router1# configure
RP/0/RP0/CPU0:Router1(config)#  interface tunnel-ip 30
RP/0/RP0/CPU0:Router1(config-if)# tunnel mode gre ipv4
RP/0/RP0/CPU0:Router(config-if)# ipv4 address 10.1.1.1 255.255.255.0
RP/0/RP0/CPU0:Router1(config-if)# tunnel source 192.168.1.1
RP/0/RP0/CPU0:Router1(config-if)# tunnel destination 192.168.2.1
RP/0/RP0/CPU0:Router1(config-if)# exit
RP/0/RP0/CPU0:Router1(config)# interface Loopback 0
RP/0/RP0/CPU0:Router1(config-if)# ipv4 address 10.10.10.1
RP/0/RP0/CPU0:Router1(config-if)# exit
RP/0/RP0/CPU0:Router1(config)# router ospf 1
RP/0/RP0/CPU0:Router1(config-ospf)# router-id 192.168.4.1
RP/0/RP0/CPU0:Router1(config-ospf)# area 0
RP/0/RP0/CPU0:Router1(config-ospf-ar)# interface tunnel-ip 30
RP/0/RP0/CPU0:Router1(config-ospf-ar)#  interface Loopback 0
RP/0/RP0/CPU0:Router1(config-ospf-ar)# commit

RP/0/RP0/CPU0:Router2# configure
RP/0/RP0/CPU0:Router2(config)#  interface tunnel-ip 30
RP/0/RP0/CPU0:Router2(config-if)# tunnel mode gre ipv4
RP/0/RP0/CPU0:Router2(config-if)# ipv4 address 10.1.1.2 255.255.255.0
RP/0/RP0/CPU0:Router2(config-if)# tunnel source 192.168.2.1
RP/0/RP0/CPU0:Router2(config-if)# tunnel destination 192.168.1.1
RP/0/RP0/CPU0:Router2(config-if)# exit
RP/0/RP0/CPU0:Router2(config)# interface Loopback 0
RP/0/RP0/CPU0:Router2(config-if)# ipv4 address 2.2.2.2
RP/0/RP0/CPU0:Router2(config)# router ospf 1
RP/0/RP0/CPU0:Router2(config-ospf)# router-id 192.168.3.1
RP/0/RP0/CPU0:Router2(config-ospf)# area 0
RP/0/RP0/CPU0:Router2(config-ospf-ar)# interface tunnel-ip 30
RP/0/RP0/CPU0:Router2(config-ospf-ar)# interface Loopback 0
RP/0/RP0/CPU0:Router2(config-if)# commit
```

Single Pass GRE Encapsulation Allowing Line Rate Encapsulation

Single Pass GRE Encapsulation Allowing Line Rate Encapsulation feature, also known as Prefix-based GRE Tunnel Destination for Load Balancing feature, enables line rate GRE encapsulation traffic and enables flow entropy. Data-plane forwarding performance supports full line rate, which is adjusted to consider added encapsulation. GRE tunnel goes down if the destination is not available in RIB. Routing over GRE Single-pass tunnel is not supported in Release 6.3.2, so the traffic that is eligible for GRE encapsulation is identified using an ACL filter that is based on GRE encapsulation. GRE tunnel destination address is an anycast address. All of the GRE encapsulation must be assigned based upon either an ACL or a policy-map, or both. Destinations may be individual addresses or /28 prefixes.

Configure GRE Single-Pass Entropy

Perform the following tasks to configure the GRE Single-Pass Entropy feature:

- GRE Single-pass
- GRE Entropy(ECMP/UCMP)

```
/* GRE Single-Pass */

Router# configure
Router(config)# interface tunnel-ip30016
Router(config-if)# ipv4 address 216.1.1.1 255.255.255.0
Router(config-if)# ipv6 address 216:1:1::1/64
Router(config-if)# ipv6 enable
Router(config-if)# tunnel mode gre ipv4 encap
Router(config-if)# tunnel source Loopback22
Router(config-if)# tunnel destination 170.170.170.22
Router(config-if)# commit
Router(config-if)# exit

/* GRE Entropy(ECMP/UCMP)*/

ECMP (ISIS)

Router# configure
Router(config)# router isis core
Router(config)# apply-group ISIS-INTERFACE
Router(config-isis)# is-type level-2-only
Router(config-isis)# net 49.1111.0000.0000.002.00
Router(config-isis)# nsr
Router(config-isis)# log adjacency changes
Router(config-isis)# address-family ipv4 unicast
Router(config-isis-af)# metric-style wide
Router(config-isis-af)# metric 2
Router(config-isis-af)# mpls traffic-eng level-2-only
Router(config-isis-af)# mpls traffic-eng router-id Loopback0
Router(config-isis-af)# maximum-paths 5
Router(config-isis-af)# commit
!

/* UCMP(ISIS) */

Router# configure
Router(config)# router isis core
Router(config)# apply-group ISIS-INTERFACE
Router(config-isis)# is-type level-2-only
Router(config-isis)# net 49.1111.0000.0000.002.00
Router(config-isis)# nsr
Router(config-isis)# log adjacency changes
Router(config-isis)# address-family ipv4 unicast
Router(config-isis-af)# metric-style wide
Router(config-isis-af)# ucmp
Router(config-isis-af)# metric 2
Router(config-isis-af)# mpls traffic-eng level-2-only
Router(config-isis-af)# mpls traffic-eng router-id Loopback0
Router(config-isis-af)# maximum-paths 5
Router(config-isis-af)# redistribute connected
Router(config-isis-af)# commit
Router(config-isis-af)# exit
!
```

```
Router# configure
Router(config)# interface Bundle-Ether3
Router(config-if)# apply-group ISIS-INTERFACE
Router(config-if)# address-family ipv4 unicast
Router(config-af)# metric 20
Router(config-af)# commit
Router(config-af)# exit
!

Router# configure
Router(config)# interface Bundle-Ether111
Router(config-if)# apply-group ISIS-INTERFACE
Router(config-if)# address-family ipv4 unicast
Router(config-af)# metric 15
Router(config-af)# commit
Router(config-af)# exit
!

/* ECMP(OSPF) */

Router# configure
Router(config)# router ospf 3
Router(config-ospf)# nsr
Router(config-ospf)# maximum paths 5
Router(config-ospf)# address-family ipv4 unicast
Router(config-ospf-af)# area 0
Router(config-ospf-af-ar)# interface Bundle-Ether3
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface Bundle-Ether4
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface Bundle-Ether111
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface Bundle-Ether112
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface Loopback23
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface HundredGigE0/7/0/23
Router(config-ospf-af-ar-if)# commit
Router(config-ospf-af-ar-if)# exit


/* UCMP(OSPF) */

Router# configure
Router(config)# router ospf 3
Router(config-ospf)# nsr
Router(config-ospf)# maximum paths 5
Router(config-ospf)# ucmp
Router(config-ospf)# address-family ipv4 unicast
Router(config-ospf-af)# area 0
Router(config-ospf-af-ar)# interface Bundle-Ether3 cost 2
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface Bundle-Ether4
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface Bundle-Ether111
```

```
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface Bundle-Ether112 cost 2
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface Loopback23
Router(config-ospf-af-ar-if)# exit
!
Router(config-ospf-af-ar)# interface HundredGigE0/7/0/23
Router(config-ospf-af-ar-if)# commit
Router(config-ospf-af-ar-if)# exit


/* ECMP(BGP) */
Router# configure
Router(config)# router bgp 800
Router(config-bgp)# bgp bestpath as-path multipath-relax
Router(config-bgp)# address-family ipv4 unicast
Router(config-bgp-af)# network 170.170.170.3/32
Router(config-bgp-af)# network 170.170.170.10/32
Router(config-bgp-af)# network 170.170.170.11/32
Router(config-bgp-af)# network 170.170.172.3/32
Router(config-bgp-af)# network 180.180.180.9/32
Router(config-bgp-af)# network 180.180.180.20/32
Router(config-bgp-af)# network 180.180.180.21/32
Router(config-bgp-af)# network 180.180.180.24/32
Router(config-bgp-af)# network 180.180.180.25/32
Router(config-bgp-af)# commit
!
Router# configure
Router(config)# router bgp 800
Router(config-bgp)# neighbor 4.1.1.2
Router(config-bgp-nbr)# remote-as 300
Router(config-bgp-nbr)# address-family ipv4 unicast
Router(config-bgp-nbr-af)# address-family ipv4 unicast
Router(config-bgp-nbr-af)# route-policy pass-all in
Router(config-bgp-nbr-af)# route-policy pass-all out
Router(config-bgp-nbr-af)# commit
!

/* UCMP(BGP) */

Router# configure
Router(config)# router bgp 800
Router(config-bgp)# bgp bestpath as-path multipath-relax
Router(config-bgp)# address-family ipv4 unicast
Router(config-bgp-af)# maximum-paths ebgp 5
Router(config-bgp-af)# network 180.180.180.9/32
Router(config-bgp-af)# network 180.180.180.20/32
Router(config-bgp-af)# network 180.180.180.21/32
Router(config-bgp-af)# network 180.180.180.24/32
Router(config-bgp-af)# network 180.180.180.25/32
Router(config-bgp-af)# commit
!
Router# configure
Router(config)# router bgp 800
Router(config-bgp)# neighbor 7.1.5.2
Router(config-bgp-nbr)# remote-as 4000
Router(config-bgp-nbr)# address-family ipv4 unicast
Router(config-bgp-nbr-af)# address-family ipv4 unicast
Router(config-bgp-nbr-af)# route-policy TRANSIT0_IN in
Router(config-bgp-nbr-af)# route-policy pass-all out
Router(config-bgp-nbr-af)# next-hop-self
```

```
Router(config-bgp-nbr-af)# commit
!
Router# configure
Router(config)# router bgp 800
Router(config-bgp)# 4.1.111.2
Router(config-bgp-nbr)# remote-as 4000
Router(config-bgp-nbr)# address-family ipv4 unicast
Router(config-bgp-nbr-af)# address-family ipv4 unicast
Router(config-bgp-nbr-af)# route-policy TRANSIT0_IN in
Router(config-bgp-nbr-af)# route-policy pass-all out
Router(config-bgp-nbr-af)# next-hop-self
Router(config-bgp-nbr-af)# commit
!

/* Configure roupte policy */

Router# configure
Router(config)# route-policy TRANSIT0_IN
Router(config-rpl)# if destination in (170.170.170.24/32) then
Router(config-rpl-if)# set extcommunity bandwidth (2906:1250000)
Router(config-rpl-if)# else
Router(config-rpl-else)# pass
Router(config-rpl-else)# endif
Router(config-rpl)# end-policy
!

Router# configure
Router(config)# route-policy TRANSIT1_IN
Router(config-rpl)# if destination in (170.170.170.24/32) then
Router(config-rpl-if)# set extcommunity bandwidth (2906:37500000
Router(config-rpl-if)# else
Router(config-rpl-else)# pass
Router(config-rpl-else)# endif
Router(config-rpl)# end-policy
```

Running Configuration

```
/* GRE Single-Pass configuration */

interface tunnel-ip30016
ipv4 address 216.1.1.1 255.255.255.0
ipv6 address 216:1:1::1/64
ipv6 enable
tunnel mode gre ipv4 encap
tunnel source Loopback22
tunnel destination 170.170.170.22
!

/* GRE Entropy(ECMP/UCMP) */

ECMP (ISIS)

router isis core
apply-group ISIS-INTERFACE
is-type level-2-only
net 49.1111.0000.0000.002.00
nsr
log adjacency changes
address-family ipv4 unicast
metric-style wide
```

```
metric 2
mpls traffic-eng level-2-only
mpls traffic-eng router-id Loopback0
maximum-paths 5
!

/* UCMP(ISIS) */

router isis core
apply-group ISIS-INTERFACE
is-type level-2-only
net 49.1111.0000.0000.002.00
nsr
log adjacency changes
address-family ipv4 unicast
metric-style wide
ucmp
metric 2
mpls traffic-eng level-2-only
mpls traffic-eng router-id Loopback0
maximum-paths 5
redistribute connected
!
interface Bundle-Ether3
apply-group ISIS-INTERFACE
address-family ipv4 unicast
metric 20
!

interface Bundle-Ether111
apply-group ISIS-INTERFACE
address-family ipv4 unicast
metric 15
!

!

/* ECMP(OSPF) */

router ospf 3
nsr
maximum paths 5
address-family ipv4 unicast
area 0
interface Bundle-Ether3
!
interface Bundle-Ether4
!
interface Bundle-Ether111
!
interface Bundle-Ether112
!
interface Loopback23
!
interface HundredGigE0/7/0/23
!
!
!
/* UCMP (OSPF) */

router ospf 3
nsr
maximum paths 5
ucmp
```

```
address-family ipv4 unicast
area 0
interface Bundle-Ether3
cost 2
!
interface Bundle-Ether4
!
interface Bundle-Ether111
!
interface Bundle-Ether112
cost 2
!
interface Loopback23
!
interface HundredGigE0/7/0/23
!
!
!

/* ECMP(BGP)*/

router bgp 800
bgp bestpath as-path multipath-relax
address-family ipv4 unicast
maximum-paths ebgp 5
network 170.170.170.3/32
network 170.170.170.10/32
network 170.170.170.11/32
network 170.170.172.3/32
network 180.180.180.9/32
network 180.180.180.20/32
network 180.180.180.21/32
network 180.180.180.24/32
network 180.180.180.25/32
!
neighbor 4.1.1.2
remote-as 300
address-family ipv4 unicast
route-policy PASS-ALL in
route-policy PASS-ALL out
next-hop-self
!
!

/* UCMP(BGP) */

router bgp 800
bgp bestpath as-path multipath-relax
address-family ipv4 unicast
maximum-paths ebgp 5
network 180.180.180.9/32
network 180.180.180.20/32
network 180.180.180.21/32
network 180.180.180.24/32
network 180.180.180.25/32
!

neighbor 7.1.5.2
remote-as 4000
address-family ipv4 unicast
route-policy TRANSIT0_IN in
route-policy PASS-ALL out
next-hop-self
!
```

```
!
neighbor 4.1.111.2
remote-as 4000
address-family ipv4 unicast
route-policy TRANSIT1_IN in
route-policy PASS-ALL out
next-hop-self
!
!

/* Configure roupte policy */

route-policy TRANSIT0_IN
if destination in (170.170.170.24/32) then
set extcommunity bandwidth (2906:1250000)
else
pass
endif
end-policy
!
route-policy TRANSIT1_IN
if destination in (170.170.170.24/32) then
set extcommunity bandwidth (2906:37500000)
else
pass
endif
end-policy
!
```

Verification

Verify if the tunnel mode GRE encapsulation is enabled.

```
Router# show int tunnel-ip2

interface tunnel-ip2
 ipv4 address 80.80.82.1 255.255.255.0
 ipv6 address 2000:80:80:82::1/64
 load-interval 30
 tunnel mode gre ipv4 encap
 tunnel source Loopback4
 tunnel destination 11.4.2.2
!

RP/0/RP0/CPU0:PE1_5516#show int tunnel-ip2
tunnel-ip2 is up, line protocol is up
  Interface state transitions: 1
  Hardware is Tunnel
  Internet address is 80.80.82.1/24
  MTU 1500 bytes, BW 100 Kbit (Max: 100 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation TUNNEL_IP,  loopback not set,
  Last link flapped 1d18h
  Tunnel TOS 0
  Tunnel mode GRE IPV4, encap
  Keepalive is disabled.
  Tunnel source 11.11.12.1 (Loopback4), destination 11.4.2.2/32
  Tunnel TTL 255
  Last input never, output never
  Last clearing of "show interface" counters 14:53:37
  30 second input rate 0 bits/sec, 0 packets/sec
  30 second output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 total input drops
     0 drops for unrecognized upper-level protocol
```

```
    Received 0 broadcast packets, 0 multicast packets
    0 packets output, 0 bytes, 0 total output drops
    Output 0 broadcast packets, 0 multicast packets
```

Verify if the tunnel mode GRE encapsulation and decapsulation are enabled.

```
Router# sh interfaces tunnel-ip 5 accounting
Wed May 16 01:50:57.258 UTC
tunnel-ip5
  Protocol              Pkts In         Chars In     Pkts Out        Chars Out
  IPV4_UNICAST              489            55746            0                0
  IPV6_UNICAST              489            55746            0                0
  MPLS                      587            69266            0                0
```

Verify if the recycle of the packets are not done under Recycle VoQ: 48:

```
 Router# show tunnel ip ea summary location 0/7/CPU0

Number of tunnel updates to retry: 0
Number of tunnel updates retried: 0
Number of tunnel retries failed: 0
Platform:
Recycle VoQ: 48
          ReceivedBytes   ReceivedPackets    ReceivedKbps
          DroppedBytes    DroppedPackets     DroppedKbps

NPU 0:0      0               0                  0
             0               0                  0
1            0               0                  0
             0               0                  0
2            0               0                  0
             0               0                  0
3            0               0                  0
             0               0                  0
...
NPU 1:0      0               0                  0
             0               0                  0
1            0               0                  0
             0               0                  0
2            0               0                  0
             0               0                  0
3            0               0                  0
             0               0                  0

NPU 2:0      0               0                  0
             0               0                  0
1            0               0                  0
             0               0                  0
2            0               0                  0
             0               0                  0
3            0               0                  0
             0               0                  0
```

Verify if the tunnel mode GRE encapsulation is enabled.

```
Router# show interfaces tunnel-ip * brief

Thu Sep 7 00:04:39.125 PDT
Intf Intf LineP Encap MTU BW
Name     State    State   Type       (byte) (Kbps)
--------------------------------------------------------------------------------
ti30001  down     down    TUNNEL_IP   1500   100
ti30002  up       up      TUNNEL_IP   1500   100
```

Verify the tunnel endpoint route in RIB.

```
Router# show route 10.1.1.1

Routing entry for 10.0.0.0/8
Known via "static", distance 1, metric 0 (connected)
Installed Oct 2 15:50:56.755 for 00:39:24
Routing Descriptor Blocks
directly connected, via tunnel-ip109
Route metric is 0, Wt is 1
No advertising protos.
```

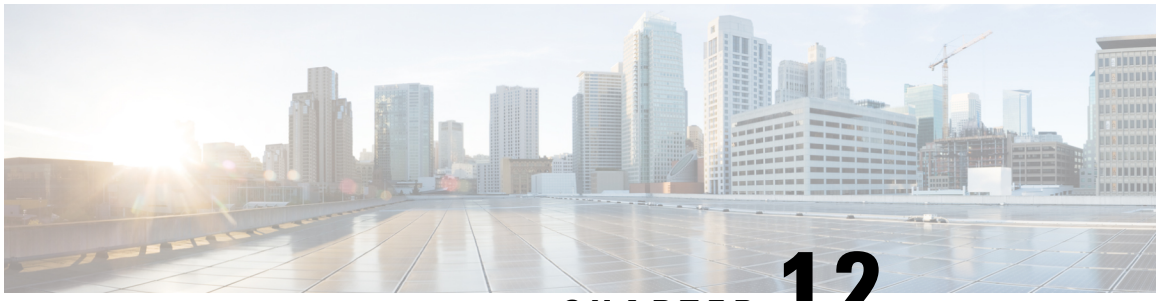
Verify if the tunnel mode GRE encapsulation is enabled.

```
Router# show tunnel ip ea database tunnel-ip 109 location 0/7/CPU0

----- node0_0_CPU0 -----
tunnel ifhandle 0x80022cc
tunnel source 161.115.1.2
tunnel destination 162.1.1.1/32
tunnel transport vrf table id 0xe0000000
tunnel mode gre ipv4, encap
tunnel bandwidth 100 kbps
tunnel platform id 0x0
tunnel flags 0x40003400
IntfStateUp
BcStateUp
Ipv4Caps
Encap
tunnel mtu 1500
tunnel tos 0
tunnel ttl 255
tunnel adjacency flags 0x1
tunnel o/p interface handle 0x0
tunnel key 0x0, entropy length 0 (mask 0xffffffff)
tunnel QT next 0x0
tunnel platform data (nil)
Platform:
Handle: (nil)
Decap ID: 0
Decap RIF: 0
Decap Recycle Encap ID: 0x00000000
Encap RIF: 0
Encap Recycle Encap ID: 0x00000000
Encap IPv4 Encap ID: 0x4001381b
Encap IPv6 Encap ID: 0x00000000
Encap MPLS Encap ID: 0x00000000
DecFEC DecRcyLIF DecStatsId EncRcyLIF
```

Verify if the QoS table is updated properly.

```
Router# show controllers npu stats voq base 48 instance all location
0/0/CPU0
Asic Instance = 0
VOQ Base = 48
       ReceivedPkts    ReceivedBytes    DroppedPkts    DroppedBytes
-------------------------------------------------------------------
COS0 =   0              0               0              0
COS1 =   0              0               0              0
COS2 =   0              0               0              0
COS3 =   0              0               0              0

Asic Instance = 1
VOQ Base = 48
       ReceivedPkts    ReceivedBytes    DroppedPkts    DroppedBytes
-------------------------------------------------------------------
COS0 =   0              0               0              0
```

```
COS1 =   0              0               0              0
COS2 =   0              0               0              0
COS3 =   0              0               0              0

Asic Instance = 2
VOQ Base = 48
       ReceivedPkts    ReceivedBytes    DroppedPkts    DroppedBytes
-------------------------------------------------------------------
COS0 =   0              0               0              0
COS1 =   0              0               0              0
COS2 =   0              0               0              0
COS3 =   0              0               0              0
```



CHAPTER 12

Configuring IP-in-IP Tunnels

This chapter provides conceptual and configuration information for IP-in-IP tunnels.

IP-in-IP Tunnels

Table 41: Feature History Table

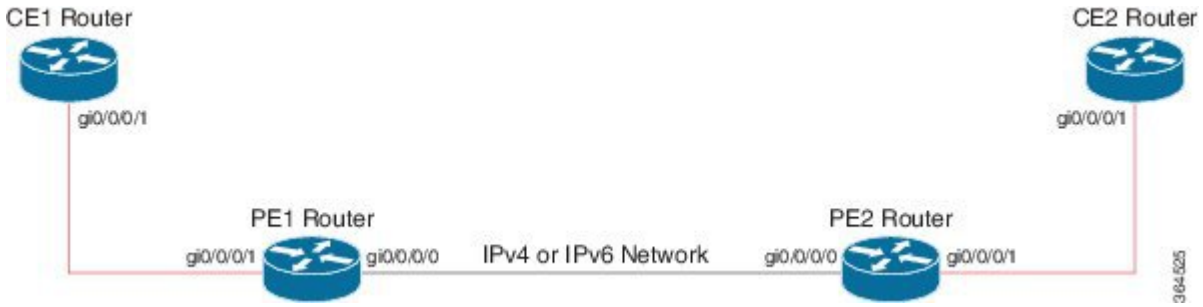
Feature Name	Release Information	Feature Description
Descapsulating IPv4 packets with IPv6 Outer Header	Release 7.5.4	With this release, decapsulation of IPv4 and IPv6 packets with IPv6 outer headers are supported. This decapsulation is supported only with **tunnel source direct** option and not with **tunnel source** with IPv6 address. This feature helps the administrators to take advantage of the benefits of IPv6, such as improved routing and security, without having to upgrade their entire network to IPv6.

Tunneling provides a mechanism to transport packets of one protocol within another protocol. IP-in-IP tunneling refers to the encapsulation and decapsulation of an IP packet as a payload in another IP packet. Cisco NCS 5500 Routers support IP-in-IP decapsulation with all possible combinations of IPv4 and IPv6; that is, IPv4 over IPv4, IPv6 over IPv4, IPv4 over IPv6, and IPv6 over IPv6. For example, an IPv4 over IPv6 refers to an IPv4 packet as a payload encapsulated within an IPv6 packet and routed across an IPv6 network to reach the destination IPv4 network, where it is decapsulated.

IP-in-IP tunneling can be used to connect remote networks securely or provide virtual private network (VPN) services.

The following example provides configurations for an IPv4 or IPv6 tunnel, with the transport VRF as the default VRF for the following simplified network topology.

Figure 19: IP-in-IP Tunnel Network Topology



Configuration Example for IPv4 Tunnel

PE1 Router Configuration	PE2 Router Configuration
interface GigabitEthernet0/0/0/0 !! Link between PE1-PE2 ipv4 address 100.1.1.1/24 ! interface GigabitEthernet0/0/0/1 !! Link between CE1-PE1 ipv4 address 20.1.1.1/24 ipv6 address 20::1/64 ! interface tunnel-ip 1 ipv4 address 10.1.1.1/24 ipv6 address 10::1/64 tunnel mode ipv4 tunnel source GigabitEthernet0/0/0/0 tunnel destination 100.1.1.2 ! router static address-family ipv4 unicast 30.1.1.0/24 tunnel-ip1 address-family ipv6 unicast 30::0/64 tunnel-ip1 ! ! !	interface GigabitEthernet0/0/0/0 !! Link between PE1-PE2 ipv4 address 100.1.1.2/24 ! interface GigabitEthernet0/0/0/1 !! Link between PE2-CE2 ipv4 address 30.1.1.1/24 ipv6 address 30::1/64 ! interface tunnel-ip 1 ipv4 address 10.1.1.2/24 ipv6 address 10::2/64 tunnel mode ipv4 tunnel source GigabitEthernet0/0/0/0 tunnel destination 100.1.1.1 ! router static address-family ipv4 unicast 20.1.1.0/24 tunnel-ip1 address-family ipv6 unicast 20::0/64 tunnel-ip1 ! ! !
CE1 Router Configuration	**CE2 Router Configuration**
interface GigabitEthernet0/0/0/1 !! Link between CE1-PE1 ipv4 address 20.1.1.2 255.255.255.0 ipv6 address 20::2/64 ! router static address-family ipv4 unicast 30.1.1.0/24 20.1.1.1 address-family ipv6 unicast 30::0/64 20::1 ! !	interface GigabitEthernet0/0/0/1 !! Link between CE2-PE2 ipv4 address 30.1.1.2 255.255.255.0 ipv6 address 30::2/64 ! router static address-family ipv4 unicast 20.1.1.0/24 30.1.1.1 address-family ipv6 unicast 20::0/64 30::1 ! !

Configuration Example for IPv6 Tunnel

PE1 Router Configuration	PE2 Router Configuration
interface GigabitEthernet0/0/0/0 !! Link between PE1-PE2 ipv6 address 100::1/64 ! interface GigabitEthernet0/0/0/1 !! Link between CE1-PE1 vrf RED ipv4 address 20.1.1.1/24 ipv6 address 20::1/64 ! interface tunnel-ip 1 vrf RED ipv4 address 10.1.1.1/24 ipv6 address 10::1/64 tunnel mode ipv6 tunnel source GigabitEthernet0/0/0/0 tunnel destination 100::2 ! vrf RED address-family ipv6 unicast import route-target 2:1 ! export route-target 2:1 ! address-family ipv4 unicast import route-target 2:1 ! export route-target 2:1 ! router static vrf RED address-family ipv4 unicast 30.1.1.0/24 tunnel-ip1 address-family ipv6 unicast 30::0/64 tunnel-ip1 ! ! !	interface GigabitEthernet0/0/0/0 !! Link between PE1-PE2 ipv6 address 100::2/64 ! interface GigabitEthernet0/0/0/1 !! Link between PE2-CE2 vrf RED ipv4 address 30.1.1.1/24 ipv6 address 30::1/64 ! interface tunnel-ip 1 vrf RED ipv4 address 10.1.1.2/24 ipv6 address 10::2/64 tunnel mode ipv6 tunnel source GigabitEthernet0/0/0/0 tunnel destination 100::1 ! vrf RED address-family ipv6 unicast import route-target 2:1 ! export route-target 2:1 ! address-family ipv4 unicast import route-target 2:1 ! export route-target 2:1 ! router static vrf RED address-family ipv4 unicast 20.1.1.0/24 tunnel-ip1 address-family ipv6 unicast 20::0/64 tunnel-ip1 ! ! !
CE1 Router Configuration	CE2 Router Configuration
interface GigabitEthernet0/0/0/1 !! Link between CE1-PE1 ipv4 address 20.1.1.2 255.255.255.0 ipv6 address 20::2/64 ! router static address-family ipv4 unicast 30.1.1.0/24 20.1.1.1 address-family ipv6 unicast 30::0/64 20::1 ! !	interface GigabitEthernet0/0/0/1 !! Link between CE2-PE2 ipv4 address 30.1.1.2 255.255.255.0 ipv6 address 30::2/64 ! router static address-family ipv4 unicast 20.1.1.0/24 30.1.1.1 address-family ipv6 unicast 20::0/64 30::1 ! !

• IP-in-IP Decapsulation, on page 322

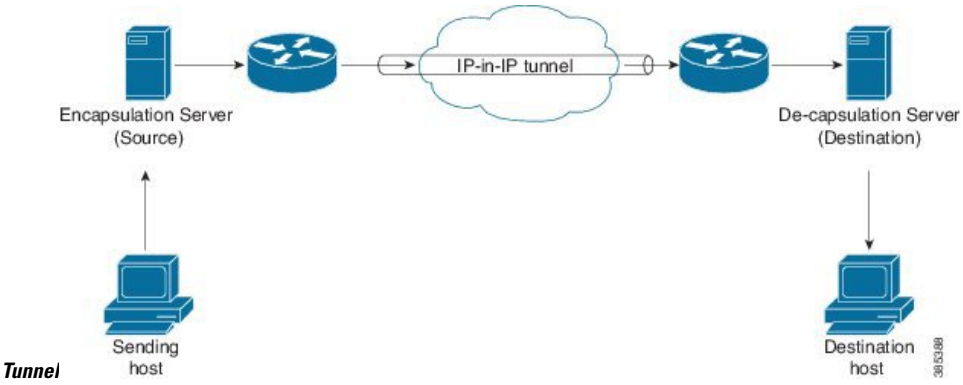
IP-in-IP Decapsulation

Encapsulation of datagrams in a network is done for multiple reasons, such as when a source server wants to influence the route that a packet takes to reach the destination host. The source server is also known as the encapsulation server.

IP-in-IP encapsulation involves the insertion of an outer IP header over the existing IP header. The source and destination address in the outer IP header point to the endpoints of the IP-in-IP tunnel. The stack of IP headers is used to direct the packet over a predetermined path to the destination, provided the network administrator knows the loopback addresses of the routers transporting the packet. This tunneling mechanism can be used for determining availability and latency for most network architectures. It is to be noted that the entire path from source to the destination does not have to be included in the headers, but a segment of the network can be chosen for directing the packets.

The following illustration describes the basic IP-in-IP encapsulation and decapsulation model.

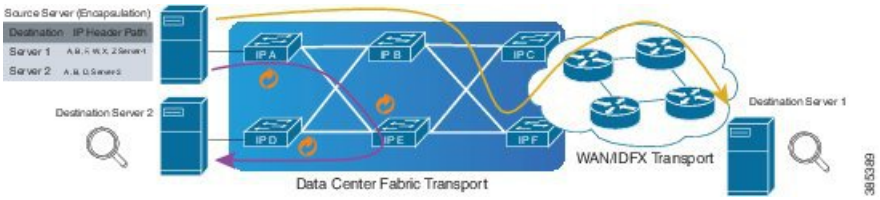
Figure 20: Basic Encapsulation and Decapsulation with an IP-in-IP



Use Case: Configure IP-in-IP Decapsulation

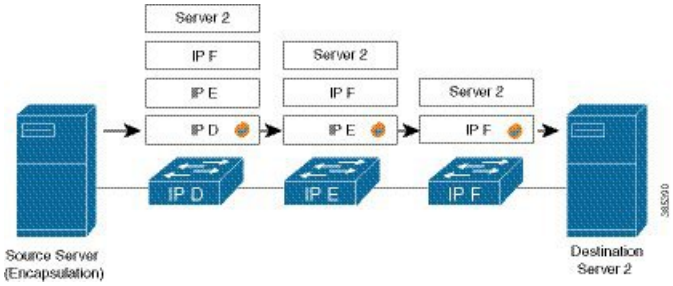
The following topology describes a use case where IP-in-IP encapsulation and decapsulation are used for different segments of the network from source to destination. The IP-in-IP tunnel consists of multiple routers that are used to decapsulate and direct the packet through the data center fabric network.

Figure 21: IP-in-IP Decapsulation Through a Data Center Network



The following illustration shows how the stacked IPv4 headers are de-capsulated as they traverse through the de-capsulating routers.

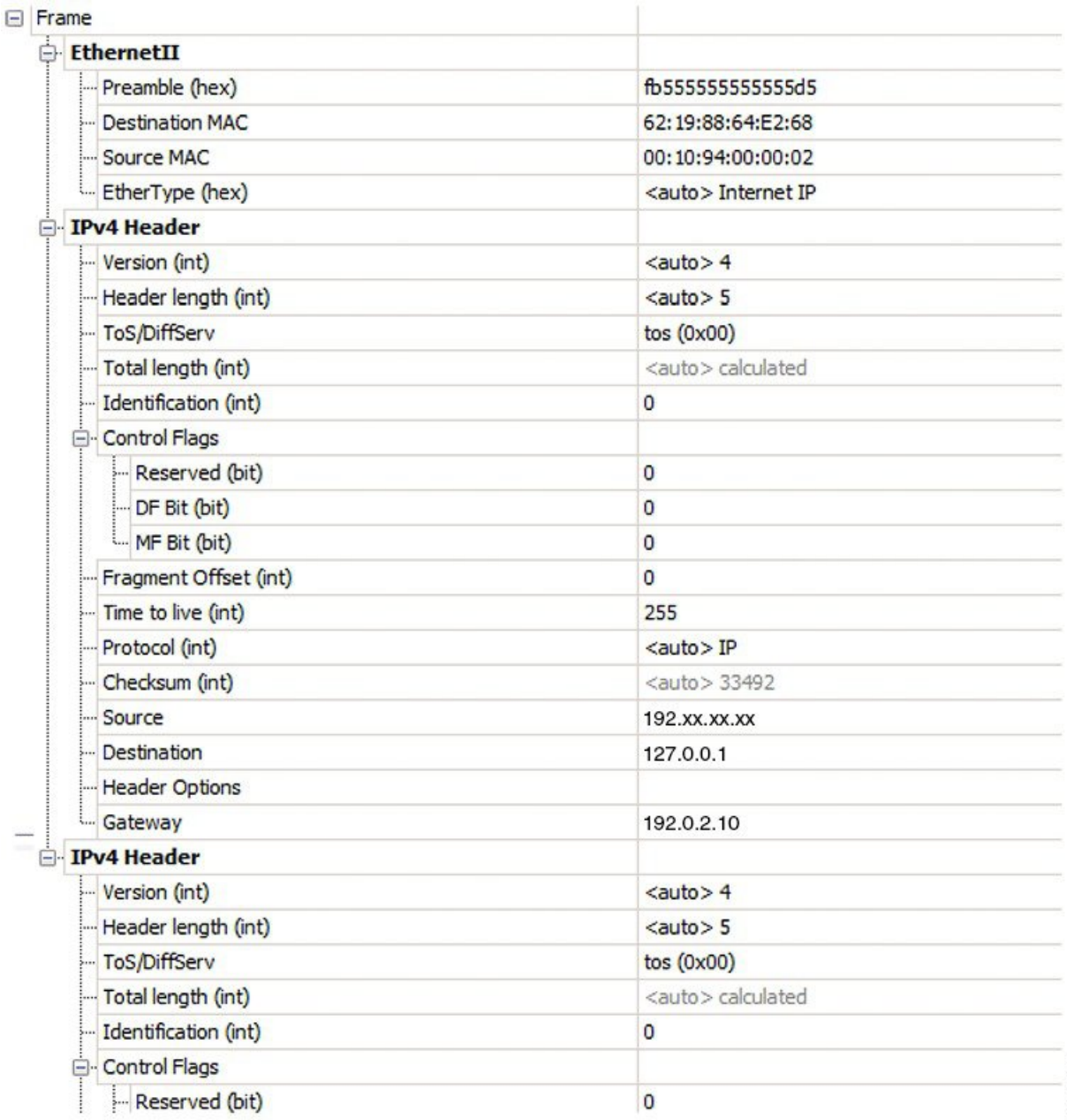
Figure 22: IP Header Decapsulation



Stacked IP Header in an Encapsulated Packet

The encapsulated packet has an outer IPv4 header that is stacked over the original IPv4 header, as shown in the following illustration.

Encapsulated Packet



Frame	
EthernetII	
Preamble (hex)	fb555555555555d5
Destination MAC	62:19:88:64:E2:68
Source MAC	00:10:94:00:00:02
EtherType (hex)	<auto> Internet IP
IPv4 Header	
Version (int)	<auto> 4
Header length (int)	<auto> 5
ToS/DiffServ	tos (0x00)
Total length (int)	<auto> calculated
Identification (int)	0
Control Flags	
Reserved (bit)	0
DF Bit (bit)	0
MF Bit (bit)	0
Fragment Offset (int)	0
Time to live (int)	255
Protocol (int)	<auto> IP
Checksum (int)	<auto> 33492
Source	192.xx.xx.xx
Destination	127.0.0.1
Header Options	
Gateway	192.0.2.10
IPv4 Header	
Version (int)	<auto> 4
Header length (int)	<auto> 5
ToS/DiffServ	tos (0x00)
Total length (int)	<auto> calculated
Identification (int)	0
Control Flags	
Reserved (bit)	0

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Configuration

You can use the following sample configuration on the routers to decapsulate the packet as it traverses the IP-in-IP tunnel:

```
RP/0/RP0/CPU0:router(config)# interface tunnel-ip 10
RP/0/RP0/CPU0:router(config-if)# tunnel mode ipv4 decap
RP/0/RP0/CPU0:router(config-if)# tunnel source loopback 0
RP/0/RP0/CPU0:router(config-if)# tunnel destination 10.10.1.2/32
```

- **tunnel-ip**: configures an IP-in-IP tunnel interface.

- **ipv4 unnumbered loopback address**: enables ipv4 packet processing without an explicit address, except for loopback address.
- **tunnel mode ipv4 decap**: enables IP-in-IP decapsulation.
- **tunnel source**: indicates the source address for the IP-in-IP decap tunnel w.r.t the router interface.
- **tunnel destination**: indicates the destination address for the IP-in-IP decap tunnel w.r.t the router interface.

Running Configuration

```
RP/0/RP0/CPU0:router# show running-config interface tunnel-ip 10
...
interface tunnel-ip 10
tunnel mode ipv4 decap
tunnel source Loopback 0
tunnel destination 10.10.1.2/32
```

This completes the configuration of IP-in-IP decapsulation.

Decapsulation Using Tunnel Source Direct

Table 42: Feature History Table

Feature Name	Release Information	Feature Description
Decapsulating Using Tunnel Source Direct	Release 7.5.3	Tunnel source direct allows you to decapsulate the tunnels on any L3 interface on the router. You can use the **tunnel source direct** configuration command to choose the specific IP Equal-Cost Multipath (ECMP) links for troubleshooting, when there are multiple IP links between two devices.

To debug faults in various large networks, you may have to capture and analyze the network traffic at a packet level. In datacenter networks, administrators face problems with the volume of traffic and diversity of faults. To troubleshoot faults in a timely manner, DCN administrators must identify affected packets inside large volumes of traffic. They must track them across multiple network components, analyze traffic traces for fault patterns, and test or confirm potential causes.

In some networks, IP-in-IP decapsulation is currently used in network management, to verify ECMP availability and to measure the latency of each path within a datacenter.

The Network Management System (NMS) sends IP-in-IP (IPv4 or IPv6) packets with a stack (multiple) of predefined IPv4 or IPv6 headers (device IP addresses). The destination device at each hop removes the outside header, performs a lookup on the next header, and forwards the packets if a route exists.

Using the **tunnel source direct** command, you can choose the specific IP Equal-Cost Multipath (ECMP) links for troubleshooting, when there are multiple IP links between two devices.

Tip You can programmatically configure and manage the Ethernet interfaces using `openconfig-ethernet-if.yang` and `openconfig-interfaces.yang` OpenConfig data models. To get started with using data models, see the *Programmability Configuration Guide for Cisco NCS 5500 Series Routers*.

Guidelines and Limitations

The following guidelines are applicable to this feature.

- The **tunnel source direct** command is only compatible with 'tunnel mode decap' for IP-in-IP decapsulation.
- The source-direct tunnel is always operationally `up` unless it is administratively shut down. The directly connected interfaces are identified using the **show ip route direct** command.
- All Layer 3 interfaces that are configured on the device are supported.
- Platform can accept and program only certain number of IP addresses. The number of IP addresses depends on the make of the platform linecard (LC). Each LC can have different number of Network Processor (NP) slices and interfaces.
- Only one source-direct tunnel per address-family is supported for configuration.
- Source-direct and regular decap tunnels can't co-exist for a specific address-family. Any configuration that attempts to enable both is automatically rejected, and an error message is displayed to indicate the conflict.
- Inline modification of an existing regular decap tunnel (**tunnel source** *interface | IP address*) to a source-direct tunnel (**tunnel source direct**), or changing a source-direct tunnel to a regular decap tunnel, is not supported. Commit-replace may fail if the same tunnel-id is used as part of the commit-replace operation. You must delete the tunnel and recreate it.

The following functionalities are not supported for the **tunnel source direct** option.

- GRE tunneling mode.
- VRF (only default VRF is supported).
- ACL and QoS on the tunnels.
- Tunnel encapsulation.
- Tunnel NetIO DLL: Decapsulation is not supported if the packet is punted to slow path.

Configure Decapsulation Using Tunnel Source Direct

Configuration

The **tunnel source direct** configures IP-in-IP tunnel decapsulation on any directly connected IP addresses. This option is now supported only when the IP-in-IP decapsulation is used to source route the packets through the network.

This example shows how to configure IP-in-IP tunnel decapsulation on directly connected IP addresses:

```
Router# configure terminal
Router(config)#interface Tunnel4
```

```
  Router(config)#tunnel mode ipv4 decap
  Router(config)#tunnel source direct
  Router(config)#no shutdown
```

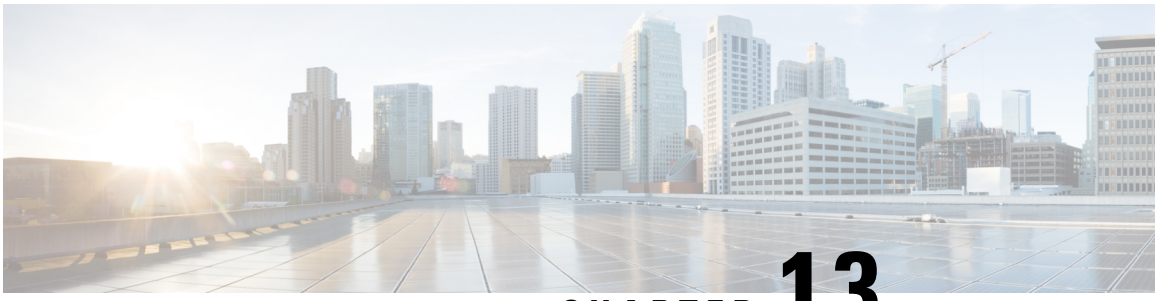
This example shows how to configure IP-in-IP tunnel decapsulation on IPv6 enabled networks:

```
Router# configure terminal
Router(config)#interface Tunnel6
  Router(config)#tunnel mode ipv6 decap
  Router(config)#tunnel source direct
  Router(config)#no shutdown
```

Verifying the Configuration

The following example shows how to verify IP-in-IP tunnel decapsulation with **tunnel source direct** option:

```
Router#show running-config interface tunnel 1
interface Tunnel1
  tunnel mode ipv6ipv6 decapsulate-any
  tunnel source direct
  no shutdown

Router#show interface tunnel 1
Tunnel1 is up    Admin State: up
MTU 1460 bytes, BW 9 Kbit
Tunnel protocol/transport IPv6/DECAPANY/IPv6
Tunnel source - direct
Tx    0 packets output, 0 bytes    Rx    0 packets input, 0 bytes
```



CHAPTER 13

Understand Generic UDP Encapsulation

UDP encapsulation is a technique of adding network headers to the packets and then encapsulating the packets within the User Datagram Protocol (UDP).

Encapsulating packets using UDP facilitates efficient transport across networks. By leveraging Receive Side Scaling (RSS) and Equal Cost Multipath (ECMP) routing, UDP provides significant performance benefits for load-balancing. The use of the UDP source port provides entropy to ECMP hashing and provides the ability to use the IP source or destination, and the L4 Port for load-balancing entropy.

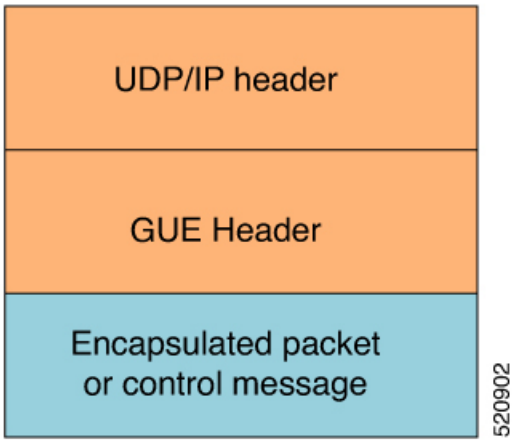
Traditional mechanisms like Generic Routing Encapsulation (GRE) can only handle the outer Source IP address and parts of the destination address and may not provide sufficient load balance entropy.

Generic UDP Encapsulation (GUE) is a UDP-based network encapsulation protocol that encapsulates IPv4 and IPv6 packets. GUE provides native UDP encapsulation and defines an additional header, that helps to determine the payload carried by the IP packet. The additional header can include items such as a virtual networking identifier, security data for validating or authenticating the GUE header, congestion control data, and so on.

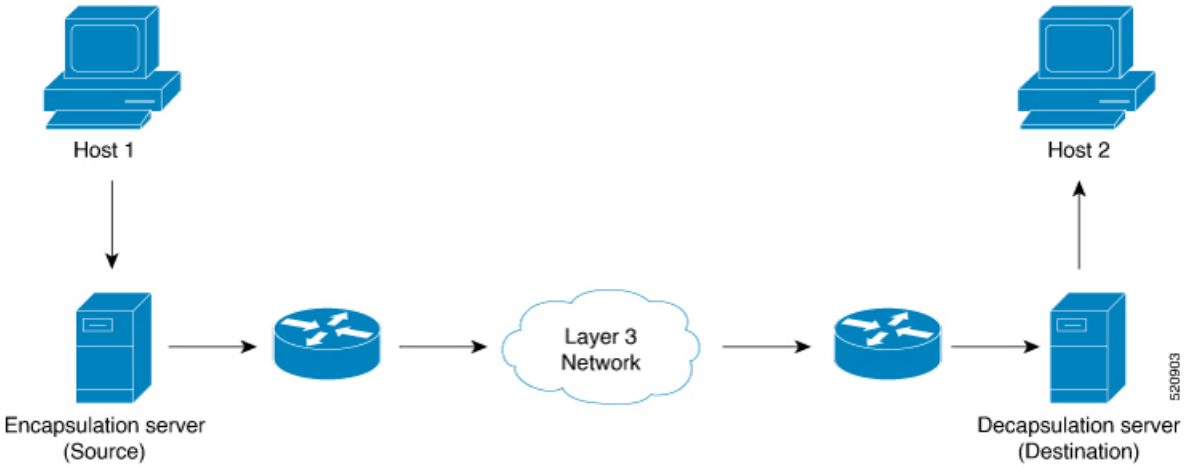
In GUE, the payload is encapsulated in an IP packet that can be IPv4 or IPv6 Carrier. The UDP header is added to provide extra hashing parameters, and optional payload demultiplexing. At the decapsulation node, the Carrier IP and UDP headers are removed, and the packet is forwarded based on the inner payload.

A GUE packet has the general format:

Figure 23: GUE Packet Format



For example, if the data stream is sent from Host 1 to Host 2. The server acts as a GUE encapsulator that is sending the packets from Host 1. The server, on the other end receiving the data, validates the data for the valid carrier IP and UDP header and decapsulates the data.



GUE has various variants, but variant 1 of GUE allows direct encapsulation of IPv4 and IPv6 in UDP. This technique saves encapsulation overhead on links for the use of IP encapsulation, and also need not allocate a separate UDP port number for IP-over-UDP encapsulation.

Variant 1 has no GUE header, but a UDP packet carries an IP packet. The first two bits of the UDP payload is the GUE variant field and match with the first 2 bits of the version number in the IP header.

Benefits of using GUE

- Allows direct encapsulation of payloads like IPv4 and IPv6 in the UDP packet.
  - You can use UDP port for demultiplexing payloads.
  - You can use a single UDP port allowing systems to employ parsing models to identify payloads.
- Leverages the UDP header for entropy labels by encoding a tuple-based source port.
- Leverages source IP addresses for load-balance encoding. Destination also could be terminated based on a subnet providing additional bits for entropy.
- Avoids special handling for tranist nodes because they only see an IP-UDP packet with some payload..
- Eases implementation of UDP tunneling with GUE. This is because of the direct encapsulation method of the payloads into UDP.

- Restrictions, on page 330
- Configure GUE, on page 331
- Flexible Assignment of UDP Port Numbers for Decapsulation, on page 333

Restrictions

- Supports Generic UDP Decapsulation for variant 1 only.
- Receives IPv4 packets with the defined GUE port of 6080.

- Decapsulates IPv6 packets with the defined GUE port of 6615.
- Receives MPLS packets with the UDPoMPLS port of 6635
- Range of source or destination ports is not supported.
- Range, Source, or Destination addresses are not supported, but subnet mask enteries are allowed.
- Destination Port is mandatory to perform decapsulation.
- Terminating GRE after GUE or GUE after GRE is not supported.
- Terminating a label such as a VPN Deaggregation after GUE termination is not supported.
- Slow path support is not supported. To resolve the inner IP Adjacency, use the **cef proactive-arp-nd enable** command.
- Running the **clear all** command doesn't clear the interface of all its existing configurations.

Configure GUE

Use the following configuration work flow to configure GUE, which is required to decode an incoming GUE packet on router:

1. Configure a traffic class: Create a traffic class and specify various criteria for classifying packets using the match commands, and an instruction on how to evaluate these match commands.
2. Configure a policy map: Define a policy map and associate the traffic class with the traffic policy.
3. Apply the policy per VRF basis, and apply this policy on all the interfaces that are part of the VRF.

Configuration Example

1. Configure a traffic class:

```
Router# configure
Router(config)# class-map type traffic match-all gre-1
Router(config-cmap)# match destination-address ipv4 225.100.20.0 255.255.255.0
Router(config-cmap)# match protocol gre
Router(config-cmap)# end-class-map
Router(config)# commit

Router(config)# class-map type traffic match-all udp-v4
Router(config-cmap)# match destination-address ipv4 220.100.20.0 255.255.255.0
Router(config-cmap)# match source-address ipv4 210.100.20.0 255.255.255.0
Router(config-cmap)# match protocol udp
Router(config-cmap)# match destination-port 6080
Router(config-cmap)# end-class-map
Router(config)# commit

Router(config)# class-map type traffic match-all udp-mpls1
Router(config-cmap)# match destination-address ipv4 220.100.20.0 255.255.255.0
Router(config-cmap)# match source-address ipv4 210.100.20.0 255.255.255.0
Router(config-cmap)# match destination-port 6635
Router(config-cmap)# end-class-map
Router(config)# commit
```

```
Router(config)# class-map type traffic match-all udp-v6
Router(config-cmap)# match destination-address ipv4 220.100.20.0 255.255.255.0
Router(config-cmap)# match source-address ipv4 210.100.20.0 255.255.255.0
Router(config-cmap)# match protocol udp
Router(config-cmap)# match destination-port 6615
Router(config-cmap)# end-class-map
Router(config)# commit
```

2. Define a policy map and associate the traffic class with the traffic policy:

```
Router(config)# policy-map type pbr magic-decap
Router(config-pmap)# class type traffic gre-1
Router(config-pmap-c)# decapsulate gre
Router(config-pmap-c)# exit

Router(config-pmap)# class type traffic udp-v4
Router(config-pmap-c)# decapsulate gue variant 1
Router(config-pmap-c)# exit

Router(config-pmap)# class type traffic udp-v6
Router(config-pmap-c)# decapsulate gue variant 1
Router(config-pmap-c)# exit
!
Router(config-pmap)# class type traffic udp-mpls1
Router(config-pmap-c)# decapsulate gue variant 1
Router(config-pmap-c)# exit

Router(config-pmap)# class type traffic class-default
Router(config-pmap-c)# exit

Router(config-pmap)# end-policy-map
Router(config)# commit
Router(config)# exit
```

3. Apply the policy per VRF basis:

```
Router# configure
Router(config)# vrf-policy
Router(config-vrf-policy)# vrf default address-family ipv4 policy type pbr input magic-decap
Router(config-vrf-policy)# commit
```

Configure Generic UDP Decapsulation for Load Balancing

On transit routers, the outer IP for hashing is used to encode the entropy parameters. But at the terminating or decapsulating router, the payload is used for hashing. However, you can use the outer IP at the decapsulating router as well, as payloads may have limited entropy. To enable the outer IP based hashing on the decapsulation router, use this command:

```
Router(config)# hw-module profile load-balance algorithm ip-tunnel
Router(config)# commit
```

Note Unlike other **hw-module** commands, the **hw-module profile load-balance algorithm ip-tunnel** command requires a reload of the system.

Flexible Assignment of UDP Port Numbers for Decapsulation

Table 43: Feature History Table

Feature Name	Release Information	Feature Description
Flexible Assignment of UDP Port Numbers for Decapsulation	Release 7.3.3	This feature gives you the flexibility to assign UDP port numbers from 1000 through 6400, through which IPv4, IPv6, and MPLS packets can be decapsulated. Such flexibility allows you to segregate the ingress traffic based on a QoS policy. In earlier releases, you could assign only default ports for decapsulation. The following command is introduced for this feature: `hw-module profile gue udp-dest-port ipv4 <port number> ipv6 <port number> mpls <port number>`

This feature provides decapsulation support for GUE packets. In GUE, the payload is encapsulated in an IP packet—IPv4 or IPv6 carrier. The UDP header is added to provide extra hashing parameters and optional payload demultiplexing. At the decapsulation node, the carrier IP and UDP headers are removed, and the packet is forwarded based on the inner payload. Prior to Release 7.3.3, packets were decapsulated using UDP port numbers 6080, 6615, and 6635 for IPv4, IPv6, and MPLS payloads respectively. Starting from Release 7.3.3, you can assign UDP port numbers from 1000 through 64000 to decapsulate IPv4, IPv6, and MPLS packets.

Guidelines for Setting up Decapsulation Using Flexible Port Numbers

Apply these guidelines while assigning flexible port numbers for decapsulation:

Packet	IPv4	IPv6	MPLS
UDP Outer Header	Configure IPv4 port on the hardware module.	Configure IPv6 port on the hardware module.	Configure MPLS port on the hardware module.
Encapsulation Outer Header	Configure an IPv4 encapsulation outer header that matches with the class map source.		
Inner Payload	Note that packets are forwarded based on the inner IPv4 payload.	Note that packets are forwarded based on the inner IPv6 payload.	Note that packets are forwarded based on the inner MPLS payload.

Note

- During the decapsulation of the IPv4, IPv6, and MPLS packets, the following headers are removed:
  - The UDP outer header
  - The IPv4 encapsulation outer header
- Select different values for each of these protocols. Valid port numbers are from 1000 through 64000.

Outer-Header Hashing Support for IPoGREoGUE and MPLSoGREoUDP Flows

Table 44: Feature History Table

Feature Name	Release Information	Feature Description
Outer-header hashing support for IPoGREoGUE and MPLSoGREoUDP flows.	Release 7.5.3	This feature specifies the hashing only on outer IP (L3 and L4) headers for IPoGREoGUE and MPLSoGREoUDP flows. You must enable **ip-tunnel** mode for GUE decapsulation. This feature enables load-balancing control across the L3 and L4 headers and allows full utilization of the paths. Example for the two flows: • Eth + Ipv4 + UDP + IPv4 + GRE + IPv4 + UDP or TCP • Eth + Ipv4 + UDP + IPv4 + GRE + MPLS + IPv4 + UDP or TCP

- GUE transit functionality, wherein the router forwards the traffic, works in both default and **ip-tunnel** mode.
- When the **ip-tunnel** mode is enabled for load balancing, the “outer” header is used for hashing. This includes the outer IP SRC/DST and the outer UDP SRC port.
- For more information on hashing, refer Understand Generic UDP Encapsulation.
- For configuring **ip-tunnel** mode, use the following command:

```
Router(config)# hw-module profile load-balance algorithm ip-tunnel
Router(config)# commit
```

Note Unlike other **hw-module** commands, the **hw-module profile load-balance algorithm ip-tunnel** command, requires a reload of the system.

Restrictions

- GUE transit functionality is supported in both default and **ip-tunnel** mode.
- GUE decapsulation functionality is only supported with **ip-tunnel** mode.
- GUE decapsulation is supported only for IPv4 carrier packets.

  Example: Outer header as IPv4 and UDP.
- GUE decapsulation is not supported for IPv6 and MPLS carrier packets.

  Example: Outer header as IPv6 and UDP.

Running Configuration

For configuration steps see, Configure GUE.

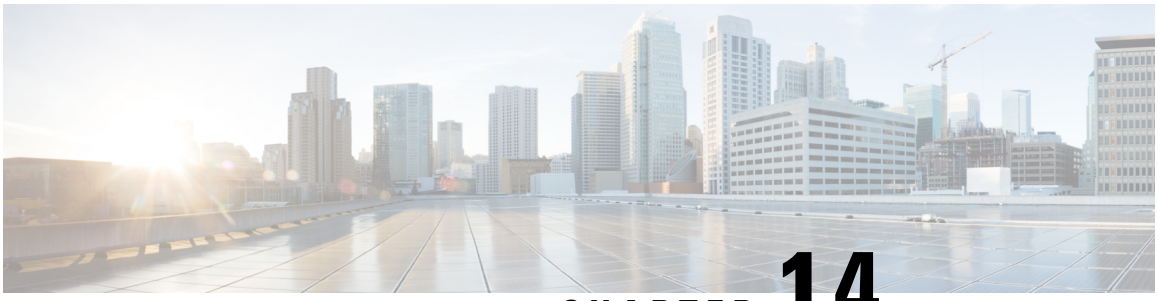
```
Router# show running-config class-map
class-map type traffic match-all gre-1
match destination-address ipv4 225.100.20.0 255.255.255.0
match protocol gre
 end-class-map
!
class-map type traffic match-all udp-v4
match destination-address ipv4 220.100.20.0 255.255.255.0
match source-address ipv4 210.100.20.0 255.255.255.0
match protocol udp
 match destination-port 6080
 end-class-map
!
class-map type traffic match-all udp-v6
match destination-address ipv4 220.100.20.0 255.255.255.0
match source-address ipv4 210.100.20.0 255.255.255.0
match protocol udp
 match destination-port 6615
 end-class-map
!
class-map type traffic match-all gue_ipv4
match destination-address ipv4 120.0.0.0 255.255.0.0
match source-address ipv4 96.0.0.0 224.0.0.0
match protocol udp
 match destination-port 6080
 end-class-map
!
class-map type traffic match-all udp-mpls1
match destination-address ipv4 220.100.20.0 255.255.255.0
match source-address ipv4 210.100.20.0 255.255.255.0
match protocol udp
 match destination-port 6635
 end-class-map
!

Router# show running-config policy-map
policy-map type pbr magic-decap
```

```
class type traffic gre-1
  decapsulate gre
!
 class type traffic udp-v4
  decapsulate gue variant 1
!
 class type traffic udp-v6
  decapsulate gue variant 1
!
 class type traffic udp-mpls1
  decapsulate gue variant 1
!
 class type traffic class-default
 !
 end-policy-map
!

Router# show running-config vrf-policy
vrf-policy
vrf default address-family ipv4 policy type pbr input magic-decap
!
```

Verification

Run the **show ofa objects sys location 0/0/CPU0 | inc gue** command in the XR Config mode to verify that the unique GUE port numbers have been configured to decapsulate IPv4, IPv6, and MPLS payloads.

```
Router#show ofa objects sys location 0/0/CPU0 | inc gue
uint32_t gue_ipv4_port => 1001
uint32_t gue_ipv6_port => 1002
uint32_t gue_mpls_port => 1003
```



CHAPTER 14

Configuring 400G Digital Coherent Optics

Table 45: Feature History Table

Feature Name	Release Information	Description
Support for DP04QSDD-ER1 optical module	Release 7.10.1	Introduced in this release on: NCS 5500 modular routers; NCS 5500 line cards(select variants only*) This release introduces support for the Cisco DP04QSDD-ER1 Ethernet variant optical module. The Cisco DP04QSDD-ER1 optical module is an enhanced version of the currently available QDD-400G-ZR Optical Module. It leverages the same operational modes while providing an extended range of up to 40km using 16QAM transmission. * The DP04QSDD-ER1 optical module is supported on Cisco NCS 5500 Series Modular Chassis through the NC57-18DD-SE line card.

Feature Name	Release Information	Description
Extended Support for DP04QSDD-HE0 optical module	Release 7.10.1	Introduced in this release on: NCS 5500 modular routers (select variants only*); NCS 5700 fixed port routers (select variants only*); NCS 5700 line cards [Mode: Compatibility; Native] (select variants only*) This release introduces support for the Cisco 400G QSFP-DD High-Power (Bright) Optical Module, Ethernet Variant on the following routers and line cards- * Routers: • NCS-57B1-6D24H-S • NCS-57B1-5D24-SE • NCS-57C1-48Q6-S • NCS-57D2-18DD-S • NCS-55A2 via NC57-MPA-2D4H-S • NC55-MOD via NC57-MPA-2D4H-S * Line cards: • NC57-24DD • NC57-18DD-SE • NC57-36H6D-S • NC57-48Q2D-S • NCS-57B1-6D24H-S • NC57-MOD-S via NC57-MPA-2D4H-S
Support for DP04QSDD-HE0 optical module	Release 7.9.1	This release introduces support for the Cisco 400G QSFP-DD High-Power (Bright) Optical Module, Ethernet Variant. The Cisco 400G QSFP-DD High-Power (Bright) Optical module is an enhanced version of the currently available QSFP-DD ZR+ Optical Module, leveraging the same operational modes but providing as a major enhancement the increase of the Tx Optical Power up to +1dBm.

Feature Name	Release Information	Description
oFEC Traffic Configuration for QDD-400G-ZRP-S	Release 7.9.1	QDD-400G-ZRP-S optical module can now support the following oFEC traffic configurations: • 400G-TXP-1x1 DAC-16 QAM • 3x100G-MXP-1x1 DAC-8 QAM • 2x100G-MXP-1x1.25 DAC-8 QAM • 2x100G-MXP-1x1.25 DAC-16 QAM This increases the interoperability of the QDD-400G-ZRP-S optical module across network components supporting these formats.

The following 400G Digital Coherent QSFP-DD optical modules are supported:

- QDD-400G-ZR-S
- QDD-400G-ZRP-S
- DP04QSDD-HE0
- DP04QSDD-ER1

Note

- The information in this chapter applies to all supported 400G Digital Coherent QSFP-DD optical modules unless otherwise specified.
- To determine the transceivers that Cisco hardware device supports, refer to the Transceiver Module Group (TMG) Compatibility Matrix tool.

This chapter describes the 400G Digital Coherent QSFP-DD optical modules and their supported configurations.

Table 46: Hardware and Software Support

Hardware PID	Optics PID	Minimum IOS XR Software Release
NC57-18DD-SE	DP04QSDD-ER1	Release 7.10.1
NC55-MOD-A-SE-S	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.9.1
NC55-MOD-A-S	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.9.1

NC57-MPA-2D4H-S	QDD-400G-ZR-S QDD-400G-ZRP-S DP04QSDD-HE0	Release 7.9.1
NCS-57C3-MODS-SYS	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.8.1
NCS-57C3-MOD-SYS	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.8.1
NCS-57D2-18DD-SYS	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.8.1
	DP04QSDD-HE0	Release 7.10.1
NC57-MOD-S	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.8.1
	DP04QSDD-HE0	Release 7.10.1
NCS-57C1-48Q6D-S	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.5.2
NC57-48Q2D-S	DP04QSDD-HE0	Release 7.10.1
NCS-57B1-5D24-SE	DP04QSDD-HE0	Release 7.10.1
NCS-57C1-48Q6-S	DP04QSDD-HE0	Release 7.10.1
NC57-18DD-SE	DP04QSDD-HE0	Release 7.10.1
NCS-57B1-6D24H-S	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.3.2
	DP04QSDD-HE0	Release 7.10.1
NC57-24DD	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.3.2
	DP04QSDD-HE0	Release 7.10.1
NC57-18DD-SE	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.3.2
NC57-36H6D-S	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.3.2
	DP04QSDD-HE0	Release 7.10.1

NCS-57B1-5D24H-SE	QDD-400G-ZR-S QDD-400G-ZRP-S	Release 7.3.2

The 400G Digital Coherent QSFP-DD optical modules enable wavelength-division multiplexing (WDM) functionality in the router. These optical modules are DWDM C-band (196.1 THz to 191.3 THz) tunable optical modules. They can be used in both transponder and muxponder modes.

Cisco IOS XR software creates optics and coherent DSP controllers to configure and monitor the performance of the 400G Digital Coherent QSFP-DD optical modules. Optics controllers are used to configure and monitor optical parameters, such as frequency, chromatic dispersion, transmitted output power, modulation, and so on. Coherent DSP controllers are used to monitor network performance parameters like pre- and post-forward error correction (FEC) bit-error rate (pre-FEC BER, post-FEC BER), error corrected bits (EC-BITS), and so on. Forward error correction (FEC) is configured using optical controllers and monitored using coherent DSP controllers.

The 400G Digital Coherent QSFP-DD optical modules support traffic configuration and firmware download. The Cisco IOS XR software collects performance monitoring data and alarms using versatile DOM (VDM).

Due to more power consumption by the 400G Digital Coherent QSFP-DD optical modules, the Cisco IOS XR software operates the fans at an higher speed to cool these optical modules.

The 400G Digital Coherent QSFP-DD optical module configuration is divided into the following categories:

- Traffic configuration – Comprises configuring DAC rate, muxponder mode, modulation, and FEC parameters. Applicable for optics controllers:
  - Configuring DAC Rate, on page 361
  - Configuring Muxponder Mode, on page 354
  - Configuring Modulation, on page 359
  - Configuring FEC, on page 362
- Optical configuration – Comprises configuring frequency, chromatic dispersion, and optical transmit power. Applicable for optics controllers:
  - Configuring Frequency, on page 348
  - Configuring Chromatic Dispersion, on page 350
  - Configuring Optical Transmit Power, on page 352
- Performance monitoring (PM) – Enables or disables performance monitoring in optical modules. You can also configure PM parameters that comprise signal power, chromatic dispersion, optical signal-to-noise ratio (OSNR), and differential group delay (DGD). Applicable for optics controllers and coherent DSP controllers:
  - Configuring Performance Monitoring, on page 366
  - Configuring PM Parameters, on page 366
- Loopback configuration – Configures loopback. Applicable for coherent DSP controller:
  - Configuring Loopback, on page 364

- Alarms threshold configuration – Configures thresholds for monitoring alarms that include optical signal-to-noise ratio (OSNR), differential group delay (DGD), chromatic dispersion (cd high and low), and so on. Applicable for optics controllers:
  - Configuring Alarms Threshold, on page 369

The following table contains the possible traffic configuration values for the 400G Digital Coherent QSFP-DD optical modules, in the transponder and muxponder mode:

Table 47: 400G Digital Coherent QSFP-DD Traffic Configuration Values

Optical Module	Client Speed	Trunk Speed	Frequency	FEC	Modulation	DAC-Rate	Chromatic Dispersion (CD)	Transmitted (Tx) Power
QDD-400G-ZR-S	1x400, 4x100	400G	C-Band, 196.1 To 191.3 THz	cFEC	16QAM	1x1	-2400 to +2400	Each optical module has its own transmitting (TX) power range. You can change the transmitting (TX) power value based on the module capability.

Optical Module	Client Speed	Trunk Speed	Frequency	FEC	Modulation	DAC-Rate	Chromatic Dispersion (CD)	Transmitted (Tx) Power
QDD-400G-ZRS	1x400, 4x100, 3x100, 2x100, 1x100	400G, 300G, 200G, 100G	C-Band, 196.1 To 191.3 THz	oFEC, cFEC	16QAM, 8QAM, QPSK	1x1.25, 1x1	-160000 to +160000	Each optical module has its own transmitting (TX) power optimal values. You can change the transmitting (TX) power value based on the module capability.
DP04QSDD-HE0	1x400, 4x100, 3x100, 2x100, 1x100	400G, 300G, 200G, 100G	C-Band, 196.1 To 191.3 THz	oFEC, cFEC	16QAM, 8QAM, QPSK	1x1.25, 1x1.5	-160000 to +160000	Each optical module has its own transmitting (TX) power optimal values. You can change the transmitting (TX) power value based on the module capability.

Optical Module	Client Speed	Trunk Speed	Frequency	FEC	Modulation	DAC-Rate	Chromatic Dispersion (CD)	Transmitted (Tx) Power
DP04QSDD-HE0	1x400	1x400	C-Band, 193.70 THz	oFEC, cFEC	16QAM	1x1, 1x2	-2400 to +2400	Each optical module has its own transmitting (TX) power range. You can change the transmitting (TX) power value based on the module capability.

Restrictions and Limitations

- DP04QSDD-HE0 optical modules are supported on the NCS-57C3-MOD-SYS and NCS-57C3-MODS-SYS routers using NC57-MPA-2D4H-S MPA.
- 400G Digital Coherent QSFP-DD optical modules are supported on all 400G ports of the MPA (NC57-MPA-2D4H-S) available on the NC55-MOD-A-S and NC55-MOD-A-SE-S line cards.
- 400G Digital Coherent QSFP-DD optical modules are supported on all 400G ports of the MPA (NC57-MPA-2D4H-S) available on the NCS-55A2-MOD-S and NCS-55A2-MOD-SE-S routers.
- 400G Digital Coherent QSFP-DD optical modules are supported on all 400G ports of NC57-MOD-S line cards.
- 400G Digital Coherent QSFP-DD optical modules are supported on all 400G ports of fixed-port routers.
- 400G Digital Coherent QSFP-DD optical modules are supported only on 400G even-numbered ports (at the top row) of the line cards. In addition, the following points describe the limitations of specific line cards:
  - NC57-24DD: All twelve 400G even-numbered ports support 400G Digital Coherent QSFP-DD optical modules.
  - NC57-18DD-SE: Up to a maximum of six 400G Digital Coherent QSFP-DD optical modules are supported in the 400G even-numbered ports.
  - NC57-36H6D-S: Up to a maximum of six 400G Digital Coherent QSFP-DD optical modules are supported in the 400G even-numbered ports.
- The following platform combination doesn't support native 400G speed but can operate in 4x100G mode:

- NCS-57C3-MOD-S/-SE-S with NC57-MPA-2D4H-S in MPA slot1
- NC55-MOD-A-SE-S with NC57-MPA-2D4H-S
- NCS-55A2-MOD-S/-HD-S/-HX-S with NC57-MPA-2D4H-S

FPD Upgrades Enabled for QDD-400G-ZR-S and QDD-400G-ZRP-S Optical Modules

Table 48: Feature History Table

Feature Name	Release Information	Feature Description
FPD Upgrades Enabled for QDD-400G-ZR-S and QDD-400G-ZRP-S Optical Modules	Release 7.3.2	This feature allows you to perform Field Programmable Device (FPD) upgrades on the QDD-400G-ZR-S and QDD-400G-ZRP-S optical modules to ensure they have the latest fixes and features. For more information about the optic module portfolio, see the Cisco 400G Digital Coherent Optics QSFP-DD Optical Modules Data Sheet.

Although an FPD upgrade is not mandatory in this release, we recommend upgrading the FPD to the latest version in the subsequent releases to ensure that all the latest fixes and features are enabled on the optical modules.

The QDD-400G-ZR-S and QDD-400G-ZRP-S optical modules have two internal FPD image banks: image banks A and B. These image banks contain running and programmed FPD versions, which are fetched during boot-up. The active image is fetched from bank A, while the standby image is fetched from bank B. To upgrade the optical modules, you must perform the FPD upgrade twice, once for the active image bank and once for the standby image bank. After each upgrade, you must disable and re-enable the QDD-400G-ZR-S and QDD-400G-ZRP-S optical modules using the **controller optics** command to activate the latest firmware.

See the ***Upgrading Field-Programmable Device*** chapter in the *System Management Configuration Guide for Cisco NCS 5500 Series Routers* for details on the procedure to upgrade the FPD.

QDD-400G-ZR-S Transponder and Muxponder Configuration Values

The following table contains the possible Transponder and Muxponder configuration values for the QDD-400G-ZR-S optical module:

Table 49: QDD-400G-ZR-S Transponder and Muxponder Configuration Values

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
400G-TXP	1 client, 400G speed	1 trunk, 400G	16 QAM	cFEC	1x1
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G	16 QAM	cFEC	1x1

DP04QSDD-ER1 Transponder and Muxponder Configuration Values

The following table contains the possible Transponder and Muxponder configuration values for the DP04QSDD-ER1 optical module:

Table 50: DP04QSDD-ER1 Transponder and Muxponder Configuration Values

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
400G-TXP	1 client, 400G speed	1 trunk, 400G	16 QAM	cFEC	1x1
400G-TXP	1 client, 400G speed	1 trunk, 400G	16 QAM	oFEC	1x2

QDD-400G-ZRP-S Transponder and Muxponder Configuration Values

The following table contains the possible Transponder and Muxponder configuration values for the QDD-400G-ZRP-S optical module:

Table 51: QDD-400G-ZRP-S Transponder and Muxponder Configuration Values

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1
4x100G-MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1.25
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	QPSK	oFEC	1x1.5
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	8 QAM	oFEC	1x1.25

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	16 QAM	oFEC	1x1.25
1x100G-MXP	1 client, 100G speed	1 trunk, 100G speed	QPSK	oFEC	1x1.5

DP04QSDD-HE0 Transponder and Muxponder Configuration Values

The following table contains the possible Transponder and Muxponder configuration values for the DP04QSDD-HE0 optical module:

Table 52: DP04QSDD-HE0 Transponder and Muxponder Configuration Values

TXP/MXP	Client	Trunk	Modulation	FEC	DAC Rate
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1.5
400G-TXP	1 Client, 400G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.5
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.25
4x100G- MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	cFEC	1x1.5
4x100G-MXP	4 clients, 100G speed	1 trunk, 400G speed	16 QAM	oFEC	1x1.5
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1.25
3x100G-MXP	3 clients, 100G speed	1 trunk, 300G speed	8 QAM	oFEC	1x1.5
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	QPSK	oFEC	1x1.5
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	8 QAM	oFEC	1x1.25
2x100G-MXP	2 clients, 100G speed	1 trunk, 200G speed	16 QAM	oFEC	1x1.25
1x100G-MXP	1 client, 100G speed	1 trunk, 100G speed	QPSK	oFEC	1x1.5

- Configuring Frequency, on page 348

Configuring Frequency

You can configure frequency on optics controllers. You can select any C band frequency between the range 196.1 to 191.3 THz, in both ITU and NON-ITU channels.

Note The 100MHz-grid keyword accepts only frequency values as user input. The 50GHz-grid keyword accepts frequency, ITU-channel, or wavelength values as user input. The Cisco IOS XR software then caculates the frequency for a given wavelength or ITU-channel.

Frequency Configuration Example

The following example shows how to configure frequency on the optics controller:

```
Router#config
Router(config)#controller optics 0/2/0/16
Router(config-Optics)#dwdm-carrier 100MHz-grid frequency 1921500
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration:

```
Router#show run controller optics 0/2/0/16
Fri May 28 01:42:32.488 UTC
controller Optics0/2/0/16
 dwdm-carrier 100MHz-grid frequency 1921500
 cd-low-threshold -5000
 cd-high-threshold -5000
!
```

Verification

This example shows how to verify the frequency configuration:

```
Router#show controller optics 0/2/0/16
Fri May 28 01:47:23.953 UTC
 Controller State: Up
```

```
Transport Admin State: In Service
Laser State: Off
LED State: Off
FEC State: FEC ENABLED
Optics Status
        Optics Type:  QSFPDD 400G ZRP
        DWDM carrier Info: C BAND, MSA ITU Channel=80, Frequency=192.15THz,
        Wavelength=1560.200nm
        Alarm Status:
        -------------
        Detected Alarms: None
        LOS/LOL/Fault Status:
        Alarm Statistics:
        -------------
        HIGH-RX-PWR = 0            LOW-RX-PWR = 0
        HIGH-TX-PWR = 0            LOW-TX-PWR = 0
        HIGH-LBC = 0               HIGH-DGD = 0
        OOR-CD = 0                 OSNR = 0
        WVL-OOL = 0                MEA  = 0
        IMPROPER-REM = 0
        TX-POWER-PROV-MISMATCH = 0
        Laser Bias Current = 0.0 mA
        Actual TX Power = -40.00 dBm
        RX Power = -40.00 dBm
        RX Signal Power = -40.00 dBm
        Frequency Offset = 0 MHz
        Laser Temperature = 0.00 Celsius
        Laser Age = 0 %
        DAC Rate = 1x1.25
        Performance Monitoring: Enable
        THRESHOLD VALUES
        ----------------
        Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
        ------------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         13.0      -24.0          10.0        -22.0
        Tx Power Threshold(dBm)          0.0      -16.0          -2.0        -14.0
        LBC Threshold(mA)               0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)       80.00      -5.00         75.00         0.00
        Voltage Threshold(volt)         3.46       3.13          3.43         3.16
        LBC High Threshold = 98 %
        Configured Tx Power = -10.00 dBm
        Configured CD High Threshold = -5000 ps/nm
        Configured CD lower Threshold = -5000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 80.00 ps
        Baud Rate =  60.1385459900 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 0 ps/nm
        Configured CD-MIN -26000 ps/nm  CD-MAX 26000 ps/nm
        Second Order Polarization Mode Dispersion = 0.00 ps^2
        Optical Signal to Noise Ratio = 0.00 dB
        Polarization Dependent Loss = 0.00 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 0.00 ps
        Temperature = 21.00 Celsius
        Voltage = 3.42 V
Transceiver Vendor Details
        Form Factor            : QSFP-DD
        Optics type            : QSFPDD 400G ZRP
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E30-19E
        Rev Number             : 10
        Serial Number          : ACA244900GN
```

```
        PID                   : QDD-400G-ZRP-S
        VID                   : ES03
        Firmware Version      : 161.06
        Date Code(yy/mm/dd)   : 20/12/08
!
```

Configuring Chromatic Dispersion

You can configure chromatic dispersion on optics controllers. When you configure the maximum and minimum values for chromatic dispersion for any data rate, ensure that the minimum difference between the configured values is equal to or greater than 1000 ps/nm.

The following table lists the default CD search range:

Table 53: Default CD Search Range

Muxponder Rate	FEC Value	Default CD Search Range (Min-Max)
400	OFEC	-26000 to +26000
400	CFEC	-2400 to +2400
300	OFEC	-50000 to +50000
200	OFEC	-50000 to +50000
100	OFEC	-80000 to +80000

Note For **cd-max** and **cd-min** range details, see the controller optics command.

Chromatic Dispersion Configuration Example

This example shows how to configure chromatic dispersion on the optics controller:

```
Router#configure
Router(config)#controller optics 0/0/0/13
Router(config-Optics)#cd-max 4000
Router(config-Optics)#cd-min -4000
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration for the optics controller:

```
Router#show run controller optics 0/0/0/13
Thu May 13 12:24:42.353 UTC
controller Optics0/0/0/13
 cd-min -4000
 cd-max 4000
 !
```

Verification

This example shows how to verify the configured chromatic dispersion values for the optics controller:

```
Router#show controller optics 0/0/0/13
 Controller State: Up
 Transport Admin State: In Service
 Laser State: On
 LED State: Green
 FEC State: FEC ENABLED
 Optics Status
         Optics Type:  QSFPDD 400G ZR
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm
         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
         Alarm Statistics:
         -------------
         HIGH-RX-PWR = 0            LOW-RX-PWR = 0
         HIGH-TX-PWR = 0            LOW-TX-PWR = 0
         HIGH-LBC = 0               HIGH-DGD = 0
         OOR-CD = 0                 OSNR = 35
         WVL-OOL = 0                MEA  = 0
         IMPROPER-REM = 0
         TX-POWER-PROV-MISMATCH = 0
         Laser Bias Current = 0.0 %
         Actual TX Power = -7.87 dBm
         RX Power = -8.27 dBm
         RX Signal Power = -8.43 dBm
         Frequency Offset = 130 MHz
         Performance Monitoring: Enable
         THRESHOLD VALUES
         ----------------
         Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
         ------------------------  ----------  ---------  ------------  -----------
         Rx Power Threshold(dBm)          1.9      -28.2           0.0        -25.0
         Tx Power Threshold(dBm)          0.0      -15.0          -2.0        -16.0
         LBC Threshold(mA)               0.00       0.00          0.00         0.00
         Temp. Threshold(celsius)       80.00      -5.00         75.00        15.00
         Voltage Threshold(volt)         3.46       3.13          3.43         3.16
         LBC High Threshold = 98 %
         Configured Tx Power = -6.00 dBm
         Configured CD High Threshold = 80000 ps/nm
         Configured CD lower Threshold = -80000 ps/nm
         Configured OSNR lower Threshold = 9.00 dB
         Configured DGD Higher Threshold = 80.00 ps
         Baud Rate =  59.8437500000 GBd
         Modulation Type: 16QAM
         Chromatic Dispersion 0 ps/nm
         Configured CD-MIN -4000 ps/nm  CD-MAX 4000 ps/nm
         Second Order Polarization Mode Dispersion = 5.00 ps^2
         Optical Signal to Noise Ratio = 36.30 dB
         Polarization Dependent Loss = 0.40 dB
         Polarization Change Rate = 0.00 rad/s
         Differential Group Delay = 4.00 ps
         Temperature = 54.00 Celsius
         Voltage = 3.37 V
 Transceiver Vendor Details
         Form Factor            : QSFP-DD
         Optics type            : QSFPDD 400G ZR
         Name                   : CISCO-ACACIA
         OUI Number             : 7c.b2.5c
         Part Number            : DP04QSDD-E20-19E
         Rev Number             : 10
```

```
Serial Number          : ACA2447003L
PID                    : QDD-400G-ZR-S
VID                    : ES03
Firmware Version       : 61.12
Date Code(yy/mm/dd)    : 20/12/02
```

Configuring Optical Transmit Power

You can set the transmit power of the optical signal.

Each 400G Digital Coherent QSFP-DD optical module has its own optical transmit (TX) power range. User can change the optical transmit (TX) power value based on the module capability. For "Transmitter specifications", see the following data sheets:

- *Cisco 400G Digital Coherent Optics QSFP-DD Optical Modules Data Sheet*
- *Cisco 400G QSFP-DD High-Power (Bright) Optical Module Data Sheet*

Table 54: Optical Transmit Power Values

Optical Module	Trunk Speed	Optical Transmit Power (Tx) Shaping	Interval	Supported Range of Optical Transmit Power (Tx) Values (in units of 0.1dBm)[1]		
				Minimum Value	Maximum Value - Typical	Maximum Value - Worst Case
QDD-400G-ZR-S	400G	No	1	-150	-100	-100
QDD-400G-ZRP-S	400G	Yes	1	-150	-110	-130
	300G			-150	-104	-119
	200G			-150	-90	-105
	100G			-150	-59	-75
DP04QSDD-HE0	400G	Yes	1	-100	20	10
	300G					
	200G					
	100G					
DP04QSDD-ER1	400G	No	1	-90	-40	-70

1. The default optical transmit power (Tx) value is -10 dBm, however with TX shaping enabled the maximum power in 1x400G, 4x100G, 3x100G, 2x100G, and 1x100G modes may be less than -10 dBm.

Transmitting Power Configuration Example

The following example shows how to configure the optical transmit (TX) power on the optics controller:

```
Router#config
Router(config)#controller optics 0/2/0/16
```

```
Router(config-Optics)#transmit-power -125
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration for the optics controller:

```
Router#show run controller optics 0/2/0/16
Thu May 13 12:52:35.020 UTC
controller Optics0/0/0/1
 cd-min -4000
 cd-max 4000
 transmit-power -125
!
```

Verification

This example shows how to verify the configured optical transmit power for the optics controller:

```
Router#show controller optics 0/2/0/16
Fri May 28 02:52:06.182 UTC
 Controller State: Up
 Transport Admin State: In Service
 Laser State: Off
 LED State: Off
 FEC State: FEC ENABLED
 Optics Status
         Optics Type:  QSFPDD 400G ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=80, Frequency=192.15THz,
         Wavelength=1560.200nm
         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
         Alarm Statistics:
         -------------
         HIGH-RX-PWR = 0            LOW-RX-PWR = 0
         HIGH-TX-PWR = 0            LOW-TX-PWR = 0
         HIGH-LBC = 0               HIGH-DGD = 0
         OOR-CD = 0                 OSNR = 0
         WVL-OOL = 0                MEA  = 0
         IMPROPER-REM = 0
         TX-POWER-PROV-MISMATCH = 0
         Laser Bias Current = 0.0 mA
         Actual TX Power = -40.00 dBm
         RX Power = -40.00 dBm
         RX Signal Power = -40.00 dBm
         Frequency Offset = 0 MHz
         Laser Temperature = 0.00 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25
         Performance Monitoring: Enable
         THRESHOLD VALUES
         ----------------
         Parameter                High Alarm  Low Alarm  High Warning  Low Warning
         -----------------------  ----------  ---------  ------------  -----------
         Rx Power Threshold(dBm)         13.0      -24.0          10.0        -22.0
         Tx Power Threshold(dBm)          0.0      -16.0          -2.0        -14.0
         LBC Threshold(mA)               0.00       0.00          0.00         0.00
         Temp. Threshold(celsius)       80.00      -5.00         75.00         0.00
         Voltage Threshold(volt)         3.46       3.13          3.43         3.16
         LBC High Threshold = 98 %
         Configured Tx Power = -12.50 dBm
```

```
        Configured CD High Threshold = -5000 ps/nm
        Configured CD lower Threshold = -5000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 80.00 ps
        Baud Rate =  60.1385459900 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 0 ps/nm
        Configured CD-MIN -4000 ps/nm  CD-MAX 4000 ps/nm
        Second Order Polarization Mode Dispersion = 0.00 ps^2
        Optical Signal to Noise Ratio = 0.00 dB
        Polarization Dependent Loss = 0.00 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 0.00 ps
        Temperature = 20.00 Celsius
        Voltage = 3.41 V
Transceiver Vendor Details
        Form Factor            : QSFP-DD
        Optics type            : QSFPDD 400G ZRP
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E30-19E
        Rev Number             : 10
        Serial Number          : ACA244900GN
        PID                    : QDD-400G-ZRP-S
        VID                    : ES03
        Firmware Version       : 161.06
        Date Code(yy/mm/dd)    : 20/12/08
```

Configuring Muxponder Mode

By default, the Cisco IOS XR software configures the 400G Digital Coherent QSFP-DD optical modules in the 400G transponder mode.

However, you can configure muxponder mode on optics controllers. Based on the muxponder mode, you can choose the modulation.

Table 55: Supported Ports and Command for Configuring Muxponder Mode

Platforms with 400G Direct Ports	Direct Ports (n) with 400G	ZR/ZRP	Bright ZRP	Mode	Command
NC57-24DD	n = 0,2,4,6,8,10,12,14,16,18,20,22	7.3.2/7.5.1	7.10.1	400G	*Default*
NC57-18DD-SE	n = 18,20,22	7.3.2/7.5.1	7.10.1	4x100G	**controller optics** *0/x/0/n* **breakout** *4x100*
NC57-MOD-S	n = 8,9	7.8.1	7.10.1	3x100G	**controller optics** *0/x/0/n* **breakout** *3x100*
NC57-48Q2D-(S/SE-S)	n = 48,49	7.10.1	7.10.1	2x100G	**controller optics** *0/x/0/n* **breakout** *2x100*
NCS-57B1-6D24H-S	n = 24,25,26,27,28,29	7.3.2/7.5.1	7.10.1	1x100G	**controller optics** *0/x/0/n* **breakout** *1x100*

NCS-57B1-5D24H-SE	n = 24,25,26,27,28	7.3.2 7.5.1	7.10.1		
NCS-57C1-48Q6D-S	n = 0,2,4	7.5.2 7.7.1	7.10.1		
Platforms with Flex Port Pairs	**Port Pairs (n,n+1) sharing 400G**	**ZR/ZRP**	**Bright ZRP**	**Mode**	**Command**
NC57-18DD-SE (max 6 ZR or 3 ZRP)	n = 0,2,4,6,8,10,12,14,16,24,26,28	7.3.2 7.5.1	7.10.1	400G	**hw-module port-range** *n n+1* **location** *0/x/CPU0* **mode** *400*
NC57-36H6D-S	n = 24,26,28,30,32,34	7.3.2 7.5.1	7.10.1	4x100G	**hw-module port-range** *n n+1* **location** *0/x/CPU0* **mode** *4x100*
				3x100G	**hw-module port-range** *n n+1* **location** *0/x/CPU0* **mode** *3x100*
				2x100G	**hw-module port-range** *n n+1* **location** *0/x/CPU0* **mode** *2x100-pam4*
				1x100G	**hw-module port-range** *n n+1* **location** *0/x/CPU0* **mode** *1x100*
Platforms with Flex Port Quads	**Port Quads (n - n+3) sharing 400G, Direct Ports m with 400G**	**ZR/ZRP**	**Bright ZRP**	**Mode**	**Command**
NCS-57D2-18DD-S	n = 0,4,8,12,16,20,24,28,32,36,40,44,48,52,56,60, m = 64,65	7.8.1	7.10.1	400G	**controller optics** *0//0/0/{n | m}* **speed** *400*
				4x100G	**controller optics** *0//0/0/{n | m}* **speed** *4x100*
				3x100G	**controller optics** *0//0/0/{n | m}* **speed** *3x100*
				2x100G	**controller optics** *0//0/0/{n | n+3 | m}* **speed** *2x100*
				1x100G	**controller optics** *0//0/0/{n | n+3 | m}* **speed** *1x100*

Table 56: Other Platform Combinations: Supported Ports and Commands for Configuring Muxponder Mode

Platforms with NC57-MPA-2D4H-S in 800G mode, (0,1) and (2,3) sharing 400G	**MPA Slots**	**ZR/ZRP**	**Bright ZRP**	**Mode**	**Command**
NCS-57C3-MOD-(S/SE-S)	m = 2,3	7.8.1	7.9.1	400G	**hw-module port-range** *{0 1 | 2 3}* **instance** *m* **location** *0/x/CPU0* **mode** *400*
NC57-MOD-S	m = 1,2	7.8.1	7.10.1	4x100G	**hw-module port-range** *{0 1 | 2 3}* **instance** *m* **location** *0/x/CPU0* **mode** *4x100*
				3x100G	**hw-module port-range** *{0 1 | 2 3}* **instance** *m* **location** *0/x/CPU0* **mode** *3x100*
				2x100G	**controller optics** *0/x/m/{0 | 1 | 2 | 3}* **breakout** *2x100*
				1x100G	**controller optics** *0/x/m/{0 | 1 | 2 | 3}* **breakout** *1x100*
Platforms with NC57-MPA-2D4H-S in 400G mode, (0,1,2,3) sharing 400G	**MPA Slots**	**ZR/ZRP**	**Bright ZRP**	**Mode**	**Command**
NCS-57C3-MOD-(S/SE-S)	m = 1	7.8.1	7.9.1	4x100G	**hw-module port-range** *0 3* **instance** *m* **location** *0/x/CPU0* **mode** *4x100*
NCS-55A2-MOD-(S/SE-S/SE-H-S/HD-S/HX-S)	m = 1,2	7.5.1	7.10.1	3x100G	**hw-module port-range** *0 2* **instance** *m* **location** *0/x/CPU0* **mode** *3x100*
NC55-MOD-A-(S/SE-S)	m = 1,2	7.9.1	7.10.1	2x100G	**hw-module port-range** *{0 1 | 2 3}* **instance** *m* **location** *0/x/CPU0* **mode** *2x100-pam4*
				1x100G	**controller optics** *0/x/m/{0 | 1 | 2 | 3}* **breakout** *1x100*

Note The following line cards do not support CVR-QSFP-SFP10G and any 1Gbps optics:

- NCS-57B1-6D24-SYS
- NCS-57B1-5DSE-SYS
- NC57-24DD
- NC57-18DD-SE
- NC57-36H-SE
- NC57-36H6D
- NC57-MOD-S

Muxponder mode options available for QDD-400G-ZR-S are:

- 4x100

Muxponder mode options available for QDD-400G-ZRP-S and DP04QSDD-HE0 are:

- 4x100
- 3x100
- 2x100 (or 2x100-PAM4)
- 1x100

See the following tables for the modulation values, based on the muxponder mode:

- Table 49: QDD-400G-ZR-S Transponder and Muxponder Configuration Values, on page 345
- Table 51: QDD-400G-ZRP-S Transponder and Muxponder Configuration Values, on page 346
- Table 52: DP04QSDD-HE0 Transponder and Muxponder Configuration Values, on page 347
- DP04QSDD-ER1 Transponder and Muxponder Configuration Values, on page 346

Using the **no breakout** *muxponder mode* command, you can switch from the muxponder mode to the transponder mode, on optics controllers.

Muxponder Mode Configuration Example

The following example shows how to configure muxponder mode on the optics controller:

```
Router#config
Router(config)#controller optics 0/0/0/13
Router(config-Optics)#breakout 4x100
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Note In the above example, the Cisco IOS XR software creates four Ethernet clients with 100GE speed, which can be verified using the **show interfaces brief | include** *R/S/I/P* command.

Running Configuration

This example shows the running configuration for the optics controller:

```
Router#show run controller optics 0/0/0/13
Thu May 13 12:24:42.353 UTC
controller Optics0/0/0/13
 cd-min -4000
 cd-max 4000
 breakout 4x100
 !
```

Verification

This example shows how to verify the muxponder mode configuration:

```
Router#show interfaces brief | include 0/0/0/13
 Hu0/0/0/13/0          up          up               ARPA  1514  100000000
 Hu0/0/0/13/1          up          up               ARPA  1514  100000000
 Hu0/0/0/13/2          up          up               ARPA  1514  100000000
 Hu0/0/0/13/3          up          up               ARPA  1514  100000000
```

Transponder Mode Configuration Example

The following example shows how to switch to the transponder mode, on the optics controller:

```
Router#config
Router(config)#controller optics 0/0/0/13
Router(config-Optics)#no breakout 4x100
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Note The Cisco IOS XR software creates a single 400GE interface, which can be verified using the **show interfaces brief | include** *R/S/I/P* command.

Running Configuration

This example shows the running configuration for the optics controller. The breakout configuration is absent in the running configuration.

```
Router#show run controller optics 0/0/0/13
Thu May 13 13:51:20.330 UTC
controller Optics0/0/0/13
 cd-min -4000
 cd-max 4000
 transmit-power -100
 !
```

Verification

This example shows how to verify the transponder mode configuration:

```
Router#show interfaces brief | include 0/0/0/13
FH0/0/0/13          up          up               ARPA  1514  400000000
```

Configuring Modulation

You can configure modulation on optics controllers. Based on the muxponder mode, you can choose the modulation.

Note The system accepts any modulation value that is entered. However, if the modulation value is outside the supported range, it is not configured on the optical module. Instead, the optical module is auto-configured with a valid modulation value. To view this value, use the **show controller optics** *R/S/I/P* command.

See the following tables for the supported modulation values:

- Table 49: QDD-400G-ZR-S Transponder and Muxponder Configuration Values, on page 345
- Table 51: QDD-400G-ZRP-S Transponder and Muxponder Configuration Values, on page 346
- Table 52: DP04QSDD-HE0 Transponder and Muxponder Configuration Values, on page 347

Modulation Configuration Example

The following example shows how to configure modulation on the optics controller:

```
Router#config
Router(config)#controller optics 0/0/0/1
Router(config-Optics)#modulation 16Qam
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration:

```
Router#show run controller optics 0/0/0/1
controller Optics0/0/0/1
 cd-min -4000
 cd-max 4000
 transmit-power -100
 modulation 16Qam
!
```

Note Use the **show controller optics** *R/S/I/P* command to verify the modulation value of the optical module.

Verification

This example shows how to verify the configured modulation value for the optics controller:

```
Router#show controller optics 0/0/0/1
 Controller State: Up
 Transport Admin State: In Service
 Laser State: On
 LED State: Green
 FEC State: FEC ENABLED
 Optics Status
         Optics Type:  QSFPDD 400G ZR
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
```

```
        Wavelength=1552.524nm
        Alarm Status:
        -------------
        Detected Alarms: None
        LOS/LOL/Fault Status:
        Alarm Statistics:
        -------------
        HIGH-RX-PWR = 0            LOW-RX-PWR = 0
        HIGH-TX-PWR = 0            LOW-TX-PWR = 0
        HIGH-LBC = 0               HIGH-DGD = 0
        OOR-CD = 0                 OSNR = 35
        WVL-OOL = 0                MEA  = 0
        IMPROPER-REM = 0
        TX-POWER-PROV-MISMATCH = 0
        Laser Bias Current = 0.0 %
        Actual TX Power = -7.87 dBm
        RX Power = -8.27 dBm
        RX Signal Power = -8.43 dBm
        Frequency Offset = 130 MHz
        Performance Monitoring: Enable
        THRESHOLD VALUES
        ----------------
        Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
        ------------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)          1.9      -28.2           0.0        -25.0
        Tx Power Threshold(dBm)          0.0      -15.0          -2.0        -16.0
        LBC Threshold(mA)               0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)       80.00      -5.00         75.00        15.00
        Voltage Threshold(volt)         3.46       3.13          3.43         3.16
        LBC High Threshold = 98 %
        Configured Tx Power = -6.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 80.00 ps
        Baud Rate =  59.8437500000 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 0 ps/nm
        Configured CD-MIN -4000 ps/nm  CD-MAX 4000 ps/nm
        Second Order Polarization Mode Dispersion = 5.00 ps^2
        Optical Signal to Noise Ratio = 36.30 dB
        Polarization Dependent Loss = 0.40 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 4.00 ps
        Temperature = 54.00 Celsius
        Voltage = 3.37 V
Transceiver Vendor Details
        Form Factor            : QSFP-DD
        Optics type            : QSFPDD 400G ZR
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E20-19E
        Rev Number             : 10
        Serial Number          : ACA2447003L
        PID                    : QDD-400G-ZR-S
        VID                    : ES03
        Firmware Version       : 61.12
        Date Code(yy/mm/dd)    : 20/12/02
```

Configuring DAC Rate

You can set the DAC (digital to analog conversion) sampling rate on optics controllers. You can modify the DAC sampling rate only on the QDD-400G-ZRP-S and DP04QSDD-HE0 optical modules.

Note QDD-400G-ZR-S supports 1x1 dac-rate in cFEC mode. QDD-400G-ZRP-S optical modules support 1x1 dac-rate in cFEC mode and 1x1.25 dac-rate in oFEC mode. DP04QSDD-HE0 optical modules support 1x1.5 dac-rate in cFEC mode and 1x1.25 dac-rate in oFEC mode

DAC Rate Configuration Example

The following example shows how to set the DAC rate on the optics controller:

```
Router#config
Router(config)#controller optics 0/0/0/1
Router(config-Optics)#dac-rate 1x1
```

Verification

This example shows the running configuration:

```
Router#show run controller optics 0/0/0/1
Thu May 13 12:52:35.020 UTC
controller Optics0/0/0/1
 cd-min -4000
 cd-max 4000
 transmit-power -100
 modulation 16Qam
 DAC-Rate 1x1
!
!
```

Verification

This example shows how to verify the configured DAC rate for the optics controller:

```
Router#show controller optics 0/0/0/1
 Controller State: Up
 Transport Admin State: In Service
 Laser State: On
 LED State: Green
 FEC State: FEC ENABLED
 Optics Status
         Optics Type:  QSFPDD 400G ZR
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm
         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
         Alarm Statistics:
         -------------
         HIGH-RX-PWR = 0            LOW-RX-PWR = 0
         HIGH-TX-PWR = 0            LOW-TX-PWR = 0
         HIGH-LBC = 0               HIGH-DGD = 0
         OOR-CD = 0                 OSNR = 35
         WVL-OOL = 0                MEA  = 0
         IMPROPER-REM = 0
         TX-POWER-PROV-MISMATCH = 0
```

```
        Laser Bias Current = 0.0 %
        Actual TX Power = -7.87 dBm
        RX Power = -8.27 dBm
        RX Signal Power = -8.43 dBm
        Frequency Offset = 130 MHz
        DAC Rate = 1x1
        Performance Monitoring: Enable
        THRESHOLD VALUES
        ----------------
        Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
        ------------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)          1.9      -28.2           0.0        -25.0
        Tx Power Threshold(dBm)          0.0      -15.0          -2.0        -16.0
        LBC Threshold(mA)               0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)       80.00      -5.00         75.00        15.00
        Voltage Threshold(volt)         3.46       3.13          3.43         3.16
        LBC High Threshold = 98 %
        Configured Tx Power = -6.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 80.00 ps
        Baud Rate =  59.8437500000 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 0 ps/nm
        Configured CD-MIN -4000 ps/nm  CD-MAX 4000 ps/nm
        Second Order Polarization Mode Dispersion = 5.00 ps^2
        Optical Signal to Noise Ratio = 36.30 dB
        Polarization Dependent Loss = 0.40 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 4.00 ps
        Temperature = 54.00 Celsius
        Voltage = 3.37 V
Transceiver Vendor Details
        Form Factor            : QSFP-DD
        Optics type            : QSFPDD 400G ZR
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E20-19E
        Rev Number             : 10
        Serial Number          : ACA2447003L
        PID                    : QDD-400G-ZR-S
        VID                    : ES03
        Firmware Version       : 61.12
        Date Code(yy/mm/dd)    : 20/12/02
```

Configuring FEC

You can configure forward error correction (FEC) only on optics controllers. You can modify FEC only on the QDD-400G-ZRP-S and DP04QSDD-HE0 optical modules. FEC is a feature that is used for controlling errors during data transmission. This feature works by adding data redundancy to the transmitted message using an algorithm. This redundancy allows the receiver to detect and correct a limited number of errors occurring anywhere in the message, instead of having to ask the transmitter to resend the message.

Note QDD-400G-ZR-S supports cFEC (concatenated forward error correction). QDD-400G-ZRP-S and DP04QSDD-HE0 support cFEC and oFEC (open forward error correction).

FEC Configuration Example

The following sample shows how to configure FEC on the optics controller:

```
Router#configure
Router(config)#controller optics 0/0/0/13
Router(config-Optics)#fec CFEC
Router(config-Optics)#commit
Router(config-Optics)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration:

```
Router#show controllers optics 0/0/0/13
controller Optics0/0/0/1
 cd-min -4000
 cd-max 4000
 transmit-power -100
 fec CFEC
 modulation 16Qam
 DAC-Rate 1x1.25
!
```

Verification

This example shows how to verify the FEC configuration for the optics controller:

```
Router#show controller coherentdsp 0/0/0/13
Thu May 27 17:28:51.960 UTC
Port                                          : CoherentDSP 0/0/0/13
Controller State                              : Down
Inherited Secondary State                     : Normal
Configured Secondary State                    : Maintenance
Derived State                                 : Maintenance
Loopback mode                                 : Internal
BER Thresholds                                : SF = 1.0E-5  SD = 1.0E-7
Performance Monitoring                        : Enable
Bandwidth                                     : 400.0Gb/s

Alarm Information:
LOS = 6 LOF = 0 LOM = 0
OOF = 0 OOM = 0 AIS = 0
IAE = 0 BIAE = 0        SF_BER = 0
SD_BER = 0      BDI = 0 TIM = 0
FECMISMATCH = 0 FEC-UNC = 0     FLEXO_GIDM = 0
FLEXO-MM = 0    FLEXO-LOM = 0   FLEXO-RDI = 0
FLEXO-LOF = 5
Detected Alarms                               : LOS
Bit Error Rate Information
PREFEC  BER                                   : 5.0E-01
POSTFEC BER                                   : 0.0E+00
Q-Factor                                      : 0.00 dB
Q-Margin                                      : -7.20dB
OTU TTI Received

FEC mode                                      : C_FEC
```

Configuring Loopback

You can configure internal or line loopback on coherent DSP controllers. Loopback can be performed only in the maintenance mode.

Loopback Configuration Example

This example shows how to enable internal loopback configuration on coherent DSP controllers:

```
Router#config
Router(config)#controller coherentDSP 0/0/0/4
Router(config-CoDSP)#secondary-admin-state maintenance
Router(config-CoDSP)#loopback internal
Router(config-CoDSP)#commit
```

Running Configuration

This example shows the running configuration on coherent DSP controllers:

```
Router#show run controller coherentdsp 0/0/0/4
Thu May 13 19:51:08.175 UTC
controller CoherentDSP0/0/0/4
 secondary-admin-state maintenance
 loopback internal
!
```

Verification

This example shows how to verify the loopback configuration on coherent DSP controllers:

```
Router#show controller coherentdsp 0/0/0/4
Thu May 27 17:28:51.960 UTC
Port                                          : CoherentDSP 0/0/0/4
Controller State                              : Down
Inherited Secondary State                     : Normal
Configured Secondary State                  : Maintenance
Derived State                                 : Maintenance
Loopback mode                               : Internal
BER Thresholds                                : SF = 1.0E-5  SD = 1.0E-7
Performance Monitoring                        : Enable
Bandwidth                                     : 400.0Gb/s
Alarm Information:
LOS = 6 LOF = 0 LOM = 0
OOF = 0 OOM = 0 AIS = 0
IAE = 0 BIAE = 0        SF_BER = 0
SD_BER = 0      BDI = 0 TIM = 0
FECMISMATCH = 0 FEC-UNC = 0     FLEXO_GIDM = 0
FLEXO-MM = 0    FLEXO-LOM = 0   FLEXO-RDI = 0
FLEXO-LOF = 5
Detected Alarms                               : LOS
Bit Error Rate Information
PREFEC  BER                                   : 5.0E-01
POSTFEC BER                                   : 0.0E+00
Q-Factor                                      : 0.00 dB
Q-Margin                                      : -7.20dB
OTU TTI Received
FEC mode                                      : C_FEC
```

Disable Auto-Squelching

Table 57: Feature History Table

Feature Name	Release Information	Description
Disable Auto-Squelching	Release 7.11.1	Introduced in this release on: NCS 5500 modular routers; NCS 5700 fixed port routers This release introduces support to disable Auto squelching. This helps to detect weak signals that are hidden within the laser source noise. By disabling Auto squelch, you can reduce the processing overhead in systems that have stable laser sources and minimal noise, helping you optimize the performance of your system. When the Auto squelch function is enabled, the optical module will generate a local fault signal on the host side if it detects a fault on the media side. By default, Auto squelch is enabled. The feature introduces these changes: **CLI:**The following keyword has been introduced. • **host auto-squelch disable** **YANG DATA models:** • New XPaths for `Cisco-IOS-XR-controller-optics-cfg` (see Github, YANG Data Models Navigator)

This release introduces the support to disable auto-squelch functionality on the module on the host side. When enabled, the squelch function is activated on the module when no suitable media-side input signal from the remote end is available to be forwarded to the host-side output (example: Rx LOS is asserted). Auto squelching is commonly used to suppress unwanted noise from laser sources in communication systems. When disabled and no valid signal is detected on the module from the remote end, the module will generate a local fault towards the NPU. However, disabling auto-squelching provides you with expanded signal detection. This enables you to detect extremely weak signals that are embedded within the laser source noise. Also, by eliminating the need to continuously monitor and suppress unwanted noise, system resources can be allocated more efficiently, leading to improved performance.

In this feature, we introduced the **host auto-squelch disable** command to disable the auto-squelch functionality when there is an invalid input signal from the remote end. This feature provides you with the flexibility to customize the system's behavior according to your requirements.

Disabling Laser Squelching Configuration Example

This example shows how to disable laser squelching for a host on controller optics:

```
router#config
router(config)#controller 0/0/0/0
router(config-Optics)#host auto-squelch disable
router(config-Optics)#commit
```

Verification

This example shows how to verify the laser squelching disabled configuration:

```
router#show controllers optics 0/0/0/0
    Host Squelch Status: disable
```

Configuring Performance Monitoring

Performance monitoring (PM) parameters are used by service providers to gather, store, set thresholds for, and report performance data for early detection of problems. The user can retrieve both current and historical PM counters for the various controllers in 30-second, 15-minute, and 24-hour intervals.

Performance monitoring can be configured on optics controllers and coherent DSP controllers.

To stop performance monitoring on optics or coherent DSP controllers, use the **perf-mon disable** keyword.

Configuring PM Parameters

The performance monitorning (PM) threshold and the threshold crossing alert (TCA) reporting status can be configured for optics controllers and coherent DSP controllers:

Table 58: PM Thresholds and TCA Report Status for Optics Controllers

PM Parameters	Description
CD	Sets the CD (chromatic dispersion) threshold or TCA reporting status.
DGD	Sets the DGD (differential group delay) threshold or TCA reporting status.
LBC	Sets the LBC (laser bias current) threshold or TCA reporting status in mA.
FREQ-OFF	Sets the FREQ-OFF (low signal frequency offset) threshold or TCA reporting status in Mhz.
OPR	Sets the OPR (optical power RX) threshold or TCA reporting status in uW or dbm.

PM Parameters	Description
OPT	Sets the OPT (optical power TX) threshold or TCA reporting status in uW or dbm.
OSNR	Sets the OSNR (optical signal-to-noise ratio) threshold or TCA reporting status.
PCR	Sets the PCR (polarization change rate) threshold or TCA reporting status.
PDL	Sets the PDL (polarization dependent loss) threshold or TCA reporting status.
RX-SIG	Sets the RX-SIG (receiving signal power) threshold or TCA reporting status in uW or dbm.
SNR	Sets the SNR (signal-to-noise ratio) threshold or TCA reporting status.
SOPMD	Sets the SOPMD (second order polarization mode dispersion) threshold or TCA reporting status.

Table 59: PM Thresholds TCA Report Status for Coherent DSP Controllers

PM Parameters	Description
Q	Sets the Q threshold or TCA reporting status.
Q-margin	Sets the Q margin threshold or TCA reporting status.
EC-BITS	Sets the EC-BITS (error corrected bits) threshold or TCA reporting status.
PostFEC BER	Sets the post-FEC BER threshold or TCA reporting status.
PreFEC BER	Sets the pre-FEC BER threshold or TCA reporting status.
UC-WORDS	Sets the UC-WORDS (uncorrected words) threshold or TCA reporting status.

Performance Monitoring Configuration Example

This example shows how to enable performance monitoring and set PM thresholds on the optics controller:

```
Router#config
Router(config)#controller optics 0/2/0/16
Router(config-Optics)#perf-mon enable
Router(config-Optics)#pm 30-sec optics threshold cd max 100
Router(config-Optics)#pm 30-sec optics threshold cd min -100
Router(config-Optics)#commit
```

Running Configuration

This example shows the running configuration on optics controllers:

```
Router#show run controller optics 0/2/0/16
Thu May 13 20:18:55.957 UTC
controller Optics0/2/0/16
pm 30-sec optics threshold cd max 100
pm 30-sec optics threshold cd min -100
 perf-mon enable
!
```

Verification

This example shows how to verify the PM parameters on optics controllers. Verify the configuration changes in the Configured Threshold fields:

```
Router#show controller optics 0/2/0/16 pm current 30-sec optics 1
  Thu May 27 17:58:49.889 UTC
Optics in the current interval [17:58:30 - 17:58:49 Thu May 27 2021]
Optics current bucket type : Valid
            MIN       AVG       MAX      Operational      Configured      TCA   Operational
      Configured     TCA
                                          Threshold(min)   Threshold(min) (min) Threshold(max)
   Threshold(max) (max)
LBC[mA ]      : 0.0       0.0       0.0      0.0               NA              NO   100.0
          NA               NO
OPT[dBm]      : -9.98     -9.98     -9.98    -15.09            NA              NO   0.00
          NA               NO
OPR[dBm]      : -40.00    -40.00    -40.00   -30.00            NA              NO   8.00
          NA               NO
CD[ps/nm]     : 0         0         0        -80000          -100          NO   100
    100          NO
DGD[ps ]      : 0.00      0.00      0.00     0.00              NA              NO   80.00
          NA               NO
SOPMD[ps^2]   : 0.00      0.00      0.00     0.00              NA              NO   2000.00
          NA               NO
OSNR[dB]      : 0.00      0.00      0.00     0.00              NA              NO   40.00
          NA               NO
PDL[dB]       : 0.00      0.00      0.00     0.00              NA              NO   7.00
          NA               NO
PCR[rad/s]    : 0.00      0.00      0.00     0.00             NA              NO   2500000.00
       NA              NO
RX_SIG[dBm]   : -40.00    -40.00    -40.00   -30.00            NA              NO   1.00
          NA               NO
FREQ_OFF[Mhz]: 0          0         0        -3600             NA              NO   3600
          NA               NO
SNR[dB]       : 0.00      0.00      0.00     7.00              NA              NO   100.00
          NA               NO

Last clearing of "show controllers OPTICS" counters never
!
```

Performance Monitoring Configuration Example

This example shows how to enable performance monitoring and set PM thresholds and TCA reporting status on the coherent DSP controller:

```
Router#config
Router(config)#controller CoherentDSP0/2/0/16
Router(config-CoDSP)#perf-mon enable
Router(config-CoDSP)#pm 30-sec fec report Q max-tca enable
Router(config-CoDSP)#pm 30-sec fec report Q-margin max-tca enable
Router(config-CoDSP)#pm 30-sec fec report Q min-tca enable
Router(config-CoDSP)#pm 30-sec fec report Q-margin min-tca enable
Router(config-CoDSP)#pm 30-sec fec threshold Q max 1200
Router(config-CoDSP)#pm 30-sec fec threshold Q-margin max 500
Router(config-CoDSP)#pm 30-sec fec threshold Q min 900
```

```
Router(config-CoDSP)#pm 30-sec fec threshold Q-margin min 280
Router(config-CoDSP)#commit
```

Running Configuration

This example shows the running configuration on coherent DSP controllers:

```
Router#show run controller coherentdsp 0/2/0/16
Thu May 13 19:56:09.136 UTC
controller CoherentDSP0/2/0/16
 pm 30-sec fec report Q max-tca enable
 pm 30-sec fec report Q-margin max-tca enable
 pm 30-sec fec report Q min-tca enable
 pm 30-sec fec report Q-margin min-tca enable
 pm 30-sec fec threshold Q max 1200
 pm 30-sec fec threshold Q-margin max 500
 pm 30-sec fec threshold Q min 900
 pm 30-sec fec threshold Q-margin min 280
 perf-mon enable
 !
```

Verification

This example shows how to verify the PM parameters on coherent DSP controllers. Verify the configuration changes in the highlighted fields:

```
Router#show controllers coherentdsp 0/2/0/16 pm current 30-sec fec
Thu May 27 23:04:54.167 UTC
g709 FEC in the current interval [23:04:30 - 23:04:54 Thu May 27 2021]
FEC current bucket type : Valid
    EC-BITS   : 0                       Threshold : 111484000000           TCA(enable)  :
YES
    UC-WORDS  : 0                       Threshold : 5                      TCA(enable)  :
YES
                                      MIN       AVG        MAX      Threshold      TCA
 Threshold     TCA
                                                                        (min)     (enable)
   (max)     (enable)
PreFEC BER                    :     0E-15     0E-15     0E-15      0E-15        NO
0E-15        NO
PostFEC BER                   :     0E-15     0E-15     0E-15      0E-15        NO
0E-15        NO
Q[dB]                         :      0.00      0.00      0.00      9.00  YES 120.00  YES
Q_Margin[dB]                  :      0.00      0.00      0.00      2.80  YES  5.00   YES
 !
```

Configuring Alarms Threshold

The alarms threshold can be configured for monitoring alarms on optics controllers:

Table 60: Alarms Threshold Parameters for Optics Controllers

Alarm Threshold Parameters	Description
CD	Sets the CD (chromatic dispersion) alarm threshold (cd-low-threshold and cd-high-threshold).
DGD	Sets the DGD (differential group delay) alarm threshold.

Alarm Threshold Parameters	Description
LBC	Sets the LBC (laser bias current) threshold in mA.
OSNR	Sets the OSNR (optical signal-to-noise ratio) alarm threshold.

Alarm Threshold Configuration Example

This example shows how to configure alarm threshold on the optics controller:

```
Router#config
Router(config)#controller optics 0/2/0/16
Router(config-Optics)#cd-low-threshold -2000
Router(config-Optics)#cd-high-threshold 2000
Router(config-Optics)#commit
```

Running Configuration

This example shows the running configuration on the optics controller:

```
Router#show run controller optics 0/2/0/16
Thu May 13 20:18:55.957 UTC
controller Optics0/2/0/16
 cd-low-threshold 2000
 cd-high-threshold 2000
!
```

Verification

This example shows how to verify the alarm threshold on optics controllers:

```
Router#show controller optics 0/2/0/16
Fri May 28 01:04:33.604 UTC
 Controller State: Up
 Transport Admin State: In Service
 Laser State: Off
 LED State: Off
 FEC State: FEC ENABLED
 Optics Status
         Optics Type:  QSFPDD 400G ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm
         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
         Alarm Statistics:
         -------------
         HIGH-RX-PWR = 0            LOW-RX-PWR = 0
         HIGH-TX-PWR = 0            LOW-TX-PWR = 0
         HIGH-LBC = 0               HIGH-DGD = 0
         OOR-CD = 0                 OSNR = 0
         WVL-OOL = 0                MEA  = 0
         IMPROPER-REM = 0
         TX-POWER-PROV-MISMATCH = 0
         Laser Bias Current = 0.0 mA
         Actual TX Power = -40.00 dBm
         RX Power = -40.00 dBm
         RX Signal Power = -40.00 dBm
         Frequency Offset = 0 MHz
         Laser Temperature = 0.00 Celsius
         Laser Age = 0 %
         DAC Rate = 1x1.25
```

```
        Performance Monitoring: Enable
        THRESHOLD VALUES
        ----------------
        Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
        ------------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         13.0      -24.0          10.0        -22.0
        Tx Power Threshold(dBm)          0.0      -16.0          -2.0        -14.0
        LBC Threshold(mA)               0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)       80.00      -5.00         75.00         0.00
        Voltage Threshold(volt)         3.46       3.13          3.43         3.16
        LBC High Threshold = 98 %
        Configured Tx Power = -10.00 dBm
        Configured CD High Threshold = -5000 ps/nm
        Configured CD lower Threshold = -5000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 80.00 ps
        Baud Rate =  60.1385459900 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 0 ps/nm
        Configured CD-MIN -26000 ps/nm  CD-MAX 26000 ps/nm
        Second Order Polarization Mode Dispersion = 0.00 ps^2
        Optical Signal to Noise Ratio = 0.00 dB
        Polarization Dependent Loss = 0.00 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 0.00 ps
        Temperature = 21.00 Celsius
        Voltage = 3.42 V
Transceiver Vendor Details
        Form Factor            : QSFP-DD
        Optics type            : QSFPDD 400G ZRP
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E30-19E
        Rev Number             : 10
        Serial Number          : ACA244900GN
        PID                    : QDD-400G-ZRP-S
        VID                    : ES03
        Firmware Version       : 161.06
        Date Code(yy/mm/dd)    : 20/12/08
!
```

Configuring FEC Alarm Threshold

Table 61: Feature History Table

Feature Name	Release Information	Description
Configurable FDD and FED Alarm Threshold Values	Release 24.3.1	

Feature Name	Release Information	Description
		Introduced in this release on: NCS 5700 Fixed Port Routers. We now ensure that you have accurate data to initiate proactive maintenance for non-critical FEC errors or take prompt action to prevent potential optical link data loss in your network. This is made possible because we've enabled the configuration of FEC (Forward Error Correction) Detected Degrade (FDD) alarm threshold values for non-critical FEC errors and FEC Excessive Degrade (FED) alarm threshold values for critical FEC errors. You can configure or clear these values for QDD-400G-ZR, QDD-400G-ZRP, and DP04QSDD-HE0 optical modules. Prior to this release, the router would automatically generate FEC alarms based on default threshold values. The feature introduces these changes: **CLI:** Modified the **controller optics** command by adding the following keywords: • **host fec-threshold excess-degrade raise** • **media fec-threshold excess-degrade raise** • **host fec-threshold excess-degrade clear** • **media fec-threshold excess-degrade clear** • **host fec-threshold detected-degrade raise** • **media fec-threshold detected-degrade raise** • **host fec-threshold detected-degrade clear**

Feature Name	Release Information	Description
		• **media fec-threshold detected-degrade clear** The **fec-thresholds** keyword is added to the **show controllers optics** command. **YANG Data Model:** • New XPaths for Cisco-IOS-XR-controller-optics-oper.yang • ~~Cisco-IOS-XR-um-cont-optics-fec-threshold-cfg.yang~~

Forward Error Correction (FEC) is used to control errors during data transmission. FEC works by adding data redundancy to the transmitted message. This redundancy allows the receiver to detect and correct a limited number of errors occurring anywhere in the message, instead of the transmitter resending the entire message. For additional information on FEC, see Understanding FEC and Its Implementation.

There are two types of FEC alarms:

- FEC Detected Degrade (FDD) alarm: The FDD alarm is raised when the link degradation is within the permissible limit and does not cause traffic disruption. This alarm indicates the system is working harder than usual to maintain data transmission. Link degradation could be due to issues in the cable, network congestion, or other hardware failure.
- FEC Excessive Degrade (FED) alarm: The FED alarm is raised when the link degradation exceeds beyond the permissible limit and causes traffic disruption. This alarm indicates the system is working harder than usual to maintain data transmission. Without corrective measures, network performance deteriorates further and eventually results in traffic loss. Link degradation could be due to issues in the cable, network congestion, or other hardware failure.

The FEC alarms threshold values can now be configured to control alarms (raise and clear FEC alarms) on both media and host side of the optical tranceiver. The optical transceiver is divided into two sides, the host side, which is positioned towards the router, and the media side, which is positioned towards the wire or cable media.

When the average bit error rate (BER) exceeds the **raise threshold value**, the FEC alarm is raised (or asserted). Similarly, when the BER drops below the **clear threshold value**, then the alarm is cleared (or de-asserted).

Guidelines and Restrictions for Setting the FEC Alarm Thresholds

- The **raise threshold value** must always be greater than the **clear threshold value** for both FDD and FED alarms.
- The **raise** or **clear threshold value** of FED alarm must always be greater than the **raise or clear threshold value** of the FDD alarm.
- While the router configuration permits a range of 1 to 18446744073709551615, the router only supports a range of 1 to 2046000000000000000. The threshold value provided by users is converted from a 64 bit number to a 16 bit number. As a result, there is minor variation between the user provided value

(configured value) and the programmed value. The user input (threshold value) is appended with exponents relative to E-18.

Table 62:

Configured Value	Programmed Value (Displayed using the Show CLI command)	Pattern	
1, 2, 3, ….,10	0, 1, 2,….,9	1<ConfiguredValue< 10, show command value = ConfiguredValue - 1	1->>>0.9999, displayed as 0 and so on
11,12,13,….,99	1.0, 1.1, 1.2,…9.8	10<ConfiguredValue<99, show command value = ConfiguredValue - 0.1	
111,222,333…999	1.10, 2.21, 3.32	100<ConfiguredValue<999, show command value = ConfiguredValue - 0.01	
1111,1112,1113 upto 2047	1.110, 1.111, 1.112…	1000<ConfiguredValue< 2047 show command value = ConfiguredValue - 0.001	
2050, 12345, 23456,65432,…	2.0500, 1.2300, 2.3400,6.5400…	2047<ConfiguredValue<maximum-range show command value = first 3 digits appended by 0s	

Configuration Examples to Set FEC Alarm Threshold

Examples to configure FEC alarm threshold:

Configuring FDD Alarm Thresholds

FDD Configuration Example

This example shows how to set FDD clear and raise alarm thresholds on the optics controller:

```
Router#config
Router(config)#controller optics 0/0/0/10
Router(config-Optics)#host fec-threshold detected-degrade clear 12000
Router(config-Optics)#host fec-threshold detected-degrade raise 22000
Router(config-Optics)#commit
Router(config-Optics)#end
```

Running Configuration

This example shows the running configuration on the optics controller:

```
Router#show running-config controller optics 0/0/0/10
Sat Feb  3 06:01:56.354 UTC
```

```
controller Optics0/0/0/10
host fec-threshold detected-degrade raise 22000
host fec-threshold detected-degrade clear 12000
!
!
```

Verification

This example shows how to verify the alarm threshold values on optics controllers:

```
Router#show controller optics 0/0/0/10 fec-thresholds
FEC Threshold Information

                                Raise                    Clear
 Media FEC excess degrade   :   1.2600E-02               1.2100E-02
 Media FEC detected degrade :   1.1700E-02               1.1300E-02
 Host FEC excess degrade    :   2.4000E-02               2.4000E-03
 Host FEC detected degrade  :   2.2000E-14               1.1989E-14
```

Configuring FED Alarm Thresholds

FED Configuration Example

This example shows how to set FED raise and clear alarm thresholds on the optics controller:

```
Router#config
Router(config)#controller optics 0/0/0/12
Router(config-Optics)#host fec-threshold excess-degrade clear 14000
Router(config-Optics)#host fec-threshold excess-degrade raise 24000
Router(config-Optics)#commit
Router(config-Optics)#end
```

Running Configuration

This example shows the running configuration on the optics controller:

```
Router#show running-config controller optics 0/0/0/12
Sat Feb  3 06:02:00.153 UTC
controller Optics0/0/0/12
host fec-threshold excess-degrade raise 24000
host fec-threshold excess-degrade clear 14000
!
```

Verification

This example shows how to verify the alarm threshold values on optics controllers:

```
Router#show controller optics 0/0/0/12 fec-thresholds
FEC Threshold Information

                               Raise                    Clear
 Media FEC excess degrade   :   1.2600E-02               1.2100E-02
 Media FEC detected degrade :   1.1700E-02               1.1300E-02
 Host FEC excess degrade    :   2.3900E-14               1.3999E-14
 Host FEC detected degrade  :   9.0000E-03               9.0000E-04
```

Media Link-down PreFEC Degrade Enablement

Table 63: Feature History Table

Feature Name	Release Information	Description
Media Link-down PreFEC Degrade Enablement	Release 24.3.1	Introduced in this release on: NCS 5700 Fixed Port Routers. The Media Link-down PreFEC Degrade functionality can be used to protect the media side of the optical transceiver during transmission errors. By using this feature, you can proactively switch the traffic to standby path when the BER counter crosses the threshold value. This feature helps to avoid further traffic impact when the optical network reaches more noise or error. The feature introduces these changes: **CLI:** Modified the **controller optics** command by adding the **media link-down prefec-degrade** keyword. **YANG Data Model:** • New XPaths for `Cisco-IOS-XR-controller-optics-oper.yang` • New XPaths for `Cisco-IOS-XR-um-cont-optics-fec-threshold-cfg.yang` (see GitHub, YANG Data Models Navigator)

The Media Link-down PreFEC Degrade functionality can be used to protect the media side of the optical transceiver during transmission errors, such as errors due to noise, or data transmission errors. This feature is disabled by default. You can enable this feature by using the **media link-down prefec-degrade** command.

Prerequisites for using Media Link-down PreFEC Degrade Functionality

To use the Media Link-down PreFEC Degrade functionality, you must configure the FEC Alarm Threshold. For information on configuring FEC alarms threshold, see Configuring FEC Alarm Threshold.

About Media Link-down PreFEC Degrade Functionality

Prior to this release, the FEC Alarm Threshold functionality enabled you to configure the FEC alarms threshold values to control alarms (raise and clear FEC alarms) on media and host side of the optical transceiver. Using the FEC Alarm Threshold functionality, you can configure the FDD and FED alarm threshold values and set the **raise threshold value** and **clear threshold value** values to control alarms.

After you configure FEC Alarm Threshold and enable Media Link-down PreFEC Degrade functionality, you get the alarm notification when the average bit error rate (BER) exceeds the threshold value. This triggers

link-down and enables switchover functionality automatically. The traffic is switched to standby path, and remains in the standby path until the alarm is cleared or based on the settings done by the network operator.

Note In Cisco IOS XR Release 24.3.1, the Link-down PreFEC Degrade feature is supported only on the media side of the optical transceiver.

Configure Media Link-down PreFEC Degrade

The purpose of this task is to enable the media link-down preFEC degrade functionality to proactively switch the traffic to standby path.

Procedure

Step 1 Execute the **media link-down prefec-degrade** command to configure link-down preFEC degrade on the media side of the optics controller.

Example:

```
Router#config
Router(config)#controller optics 0/2/0/16
Router(config-Optics)#media link-down prefec-degrade
Router(config-Optics)#commit
```

Step 2 Execute the **show running-config controller optics** *R/S/I/P* command to view the running configuration on the optics controller.

Example:

```
Router#show running-config controller optics 0/2/0/16
Thu May 13 20:18:55.957 UTC
controller Optics0/2/0/16
 media link-down prefec-degrade
!
```

Step 3 Execute the **show controller optics** *R/S/I/P* command to verify link-down preFEC degrade feature on optics controllers.

Example:

```
Router#show controller optics 0/2/0/16
Fri May 28 01:04:33.604 UTC
 Controller State: Up
 Transport Admin State: In Service
 Laser State: On
 Media linkdown prefec degrade : Enabled
 LED State: Green
 FEC State: FEC ENABLED
 Optics Status
         Optics Type:  QSFPDD 400G ZRP
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm
         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
         Alarm Statistics:
         -------------
```

```
        HIGH-RX-PWR = 0            LOW-RX-PWR = 0
        HIGH-TX-PWR = 0            LOW-TX-PWR = 0
        HIGH-LBC = 0               HIGH-DGD = 0
        OOR-CD = 0                 OSNR = 0
        WVL-OOL = 0                MEA  = 0
        IMPROPER-REM = 0
        TX-POWER-PROV-MISMATCH = 0
        Laser Bias Current = 0.0 mA
        Actual TX Power = -40.00 dBm
        RX Power = -40.00 dBm
        RX Signal Power = -40.00 dBm
        Frequency Offset = 0 MHz
        Laser Temperature = 0.00 Celsius
        Laser Age = 0 %
        DAC Rate = 1x1.25
        Performance Monitoring: Enable
        THRESHOLD VALUES
        ----------------
        Parameter                 High Alarm  Low Alarm  High Warning  Low Warning
        ------------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         13.0      -24.0          10.0        -22.0
        Tx Power Threshold(dBm)          0.0      -16.0          -2.0        -14.0
        LBC Threshold(mA)               0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)       80.00      -5.00         75.00         0.00
        Voltage Threshold(volt)         3.46       3.13          3.43         3.16
        LBC High Threshold = 98 %
        Configured Tx Power = -10.00 dBm
        Configured CD High Threshold = -5000 ps/nm
        Configured CD lower Threshold = -5000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 80.00 ps
        Baud Rate =  60.1385459900 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 0 ps/nm
        Configured CD-MIN -26000 ps/nm  CD-MAX 26000 ps/nm
        Second Order Polarization Mode Dispersion = 0.00 ps^2
        Optical Signal to Noise Ratio = 0.00 dB
        Polarization Dependent Loss = 0.00 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 0.00 ps
        Temperature = 21.00 Celsius
        Voltage = 3.42 V
 Transceiver Vendor Details
        Form Factor             : QSFP-DD
        Optics type             : QSFPDD 400G ZRP
        Name                    : CISCO-ACACIA
        OUI Number              : 7c.b2.5c
        Part Number             : DP04QSDD-E30-19E
        Rev Number              : 10
        Serial Number           : ACA244900GN
        PID                     : QDD-400G-ZRP-S
        VID                     : ES03
        Firmware Version        : 161.06
        Date Code(yy/mm/dd)     : 20/12/08
!
```

Alarms Troubleshooting

Table 64: Feature History Table

Feature Name	Release	Description
Enhanced Alarm Prioritization, Monitoring, and Management	Release 7.10.1	Introduced in this release on: NCS 5500 fixed port routers NCS 5500 modular routers (NCS 5500 line cards) In this release, we introduce enhanced alarm management that offers improved alarm prioritization, monitoring and management, as listed below: • Suppression of LOL (Loss of Line) alarm when the LOS-P (Loss of Signal-Payload) alarm is generated. This prioritizes the detection and handling of the LOS-P alarm. • Ability to clear alarm static counters using the command **clear counters controller coherentDSP location**. Clearing static counters enables you to monitor alarms generated for a definitive time period. • Suppression of warnings when the respective alarm is triggered. This prevents redundant or repetitive alerts.

This section contains the procedures for troubleshooting alarms.

CD Alarm

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The Chromatic Dispersion (CD) alarm is raised when the detected chromatic dispersion value is above or below the configured threshold values.

Clear the CD Alarm

Procedure

Configure threshold value within range if CD value is not within the threshold range.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

DGD Alarm

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The Differential Group Delay (DGD) alarm is raised when the value of the differential group delay read by the pluggable port module exceeds the configured threshold value.

Clear the DGD Alarm

Procedure

Configure the threshold value within range if DGD value is not within the threshold range.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

FLEXO_LOF

Default Severity: Critical

Logical Object: OTN

Flexo LOF alarm is raised when loss of alignment is detected on the Flexo frame for more than 3ms.

Clear the FLEXO_LOF Alarm

Procedure

Identify and correct the underlying cause of mis-alignment. The Flexo LOF (Loss of Frame) alarm is cleared when good alignment is detected on the Flexo frame for more than 3ms.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

FLEXO_LOM

Default Severity: Critical

Logical Object: OTN

Flexo LOM (Loss of Multi-Frame) is raised when loss of multi-frame alignment is detected on the Flexo multi-frame for more than 10ms

Clear the FLEXO_LOM Alarm

Procedure

Identify and correct the underlying cause of mis-alignment. The Flexo LOM alarm is cleared when good multi-frame alignment is detected on the Flexo multi-frame.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

HI-LASERBIAS Alarm

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The HI-LASERBIAS alarm is raised when the physical pluggable port laser detects a laser bias value beyond the configured high threshold.

Clear the HI-LASERBIAS Alarm

Procedure

Configure the threshold value within range if high laser bias threshold value is not within the threshold range.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

HI-RXPOWER Alarm

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The HI-RXPOWER alarm occurs on the client optics controller when the measured individual lane optical signal power of the received signal exceeds the default threshold. The HI-RXPOWER alarm occurs on the trunk optics controller when the total optical signal power of the received signal exceeds the default threshold.

Clear the HI-RXPOWER Alarm

Procedure

Physically verify by using a standard power meter that the optical input power is overcoming the expected power threshold. Connect an attenuator accordingly.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

HI-RXPOWER Warn

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Software

The HI-RXPOWER warning occurs on the client optics controller when the measured individual lane optical signal power of the received signal exceeds the default threshold. The HI-RXPOWER warning occurs on the trunk optics controller when the total optical signal power of the received signal exceeds the default threshold.

Clear the HI-RXPOWER Warn Alarm

Procedure

Physically verify by using a standard power meter that the optical input power is overcoming the expected power threshold. Connect an attenuator accordingly.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

HI-TEMP Alarm

Default Severity: Critical

Logical Object: Software

The HI-TEMP alarm occurs when the optical module temperature exceeds the default threshold.

Clear the HI-TEMP Alarm

Procedure

Verify the fan is intact and empty slots are blocked for cooling.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

HI-TEMP Warn

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Software

The HI-TEMP warning occurs when the optical module temperature exceeds the default threshold.

Clear the HI-TEMP Warn Alarm

Procedure

Verify the fan is intact and empty slots are blocked for cooling

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

HI-TXPOWER Alarm

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The HI-TXPOWER alarm occurs on the client optics controller when the measured individual lane optical signal power of the transmitted signal exceeds the default threshold. The HI-TXPOWER alarm occurs on the trunk optics controller when the total optical signal power of the transmitted signal exceeds the default threshold.

Clear the HI-TXPOWER Alarm

Procedure

Physically verify by using a standard power meter that the optical output power is overcoming the expected power threshold.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

HI-TXPOWER Warn

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Software

The HI-TXPOWER warning occurs on the client optics controller when the measured individual lane optical signal power of the transmitted signal exceeds the default threshold. The HI-TXPOWER warning occurs on the trunk optics controller when the total optical signal power of the transmitted signal exceeds the default threshold.

Clear the HI-TXPOWER Warn Alarm

Procedure

Physically verify by using a standard power meter that the optical output power is overcoming the expected power threshold.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

IMPROPER-REM

Default Severity: Critical

Logical Object: Software

The Improper Removal alarm is raised when a physical pluggable is not present on a service-provisioned port.

Clear the IMPROPER-REM Alarm

Procedure

Insert the appropriate QSFP.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LOF

Default Severity: Critical

Logical Object: OTN

Flexo LOF alarm is raised when loss of alignment is detected on the Flexo frame for more than 3ms.

Clear the LOF Alarm

Procedure

Identify and correct the underlying cause of mis-alignment. The Flexo LOF (Loss of Frame) alarm is cleared when good alignment is detected on the Flexo frame for more than 3ms.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LOL

Default Severity: Major

Logical Object: Software

LOL alarm is raised when loss of lock is detected on the receive side of the CDR (Clock and Data Recovery)

Clear the LOL Alarm

Procedure

Verify the fiber and power levels.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LOM

Default Severity: Critical

Logical Object: OTN

Flexo LOM (Loss of Multi-Frame) is raised when loss of multi-frame alignment is detected on the Flexo multi-frame for more than 10ms

Clear the LOM Alarm

Procedure

Identify and correct the underlying cause of mis-alignment. The Flexo LOM alarm is cleared when good multi-frame alignment is detected on the Flexo multi-frame.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LO-RXPOWER Alarm

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The LO-RXPOWER alarm is raised on the client or trunk optics controller when the measured individual lane optical signal power of the received signal falls below the default threshold.

Clear the LO-RXPOWER Alarm

Procedure

Verify that the trunk-rx port is cabled correctly and clean the fiber connecting the faulty TXP/MXP card to the drop port of the DWDM card.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LO-RXPOWER Warn

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Software

The LO-RXPOWER warning is raised on the client or trunk optics controller when the measured individual lane optical signal power of the received signal falls below the default threshold.

Clear the LO-RXPOWER Warn Alarm

Procedure

Verify that the trunk-rx port is cabled correctly and clean the fiber connecting the faulty TXP/MXP card to the drop port of the DWDM card.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LOS

Default Severity: Major

Logical Object: Software

This alarm occurs when there is a loss of signal

Clear the LOS Alarm

Procedure

Identify and correct the underlying cause of signal LOS. The alarm is cleared when signal is improved.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LOS-P

Default Severity: Minor

Logical Object: OTN

This alarm occurs when there is a loss of signal.

Clear the LOS-P Alarm

Procedure

Identify and correct the underlying cause of signal LOS. The alarm is cleared when signal is improved.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LO-TXPOWER Alarm

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The LO-TXPOWER alarm is raised on the client or trunk optics controller when the measured individual lane optical signal power of the transmitted signal falls below the default threshold.

Clear the LO-TXPOWER Alarm

Procedure

Verify the optics detection and any failures.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

LO-TXPOWER Warn

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Software

The LO-TXPOWER warning is raised on the client or trunk optics controller when the measured individual lane optical signal power of the transmitted signal falls below the default threshold.

Clear the LO-TXPOWER Warn Alarm

Procedure

Verify the optics detection and any failures.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

OOR_CD

Default Severity: Minor

Logical Object: Controller

This alarm occurs when the Chromatic Dispersion is out of range

Clear the OOR_CD Alarm

Procedure

Configure threshold value within range if CD value is not within the threshold range.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

OSNR Alarm

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The Optical Signal Noise Ratio (OSNR) alarm occurs when the measured OSNR falls below the threshold.

Clear the OSNR Alarm

Procedure

Step 1 Verify the value of the minimum acceptable OSNR value of NCS 5500 using the show controller optics R/S/I/P command.

Step 2 If the value is not within the OSNR threshold range, configure the minimum acceptable OSNR value using the controller optics R/S/I/P osnr-low-threshold command in the config mode. The range is 0–4000 (in units of 01db).

Step 3 If the value is within the range of the minimum acceptable OSNR, contact TAC.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

UNC-WORD Alarm

Default Severity: Not Reported (NR), Not-Alarmed, Non-Service-Affecting (NSA)

Logical Object: OTN

The Uncorrected FEC Word (UNC-WORD) condition is raised when the FEC is unable to correct the frame.

Clear the UNC-WORD Alarm

Procedure

Step 1 Ensure that the fiber connector for the card is completely plugged in.

Step 2 Ensure that the ports on the far end and near end nodes have the same port rates and FEC settings.

Step 3 If the BER threshold is correct and at the expected level, use an optical test set to measure the power level of the line to ensure it is within guidelines. For specific procedures to use the test set equipment, consult the manufacturer.

Step 4 If the optical power level is good, verify that the optical receive levels are within the acceptable range.

Step 5 If receive levels are good, clean the fibers at both ends.

Step 6 If the condition does not clear, verify that a single-mode fiber is used.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

WVL-OOL

Default Severity: Major

Logical Object: Controller

The Wavelength Out of Lock alarm is raised when the port detects the optical input frequency to be out of range.

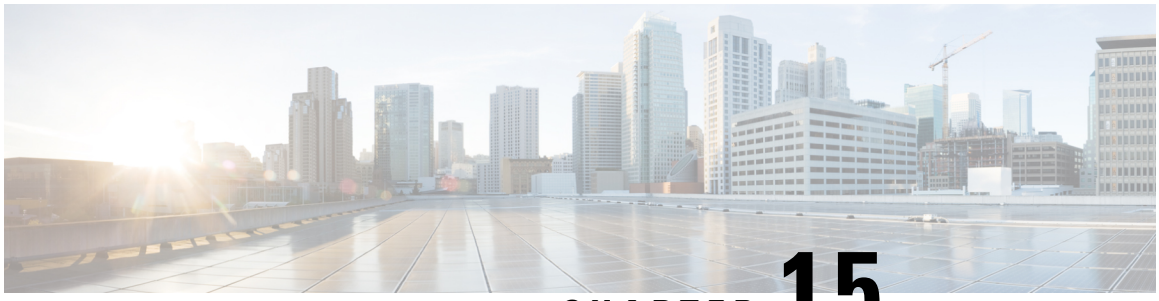
Clear the WVL-OOL Alarm

Procedure

Step 1 Verify the wavelength configuration.

Step 2 Verify whether the pluggable is inserted properly.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).



CHAPTER 15

Configuring Controllers

This chapter describes the Optics Controller and Coherent DSP Controller for the 6-port Coherent Line Card (NC55-6X200-DWDM-S). This chapter also describes the procedures used to configure the controllers.

Note When you plan to replace a configured optical module with a different type of optical module, you must clear the configurations of the old module before installing the new optical module.

Note When two MACsec enabled Cisco NCS 5500 routers with Coherent Line Cards are connected, there is no compatibility between Coherent Line Cards of IOS XR Release version 6.5.x (or lower) and 6.6.1 (or higher).

Optics Controllers

Controllers are represented in the *rack*/*slot*/*instance*/*port* format (*r*/*s*/*i*/*p*); for example, 0/3/0/1. Each port has an optics controller that is created on startup.

Note You must shut down the optics controller before you perform any of the following tasks:

- Configure the controller
- Restore a saved configuration
- Upgrade the DSP processor or CFP2 optics module Field Programmable Device (FPD)

Note When there are dualrate optics on NCS-57C3-MOD-S/-SE-S + NC57-MPA-12L-S, and while configuring lower speed, you may see a few initial link flaps, after that the link stabilizes and no further flaps will be seen.

CFP2 DCO Optics Support

There are two hardware versions of the CFP DCO optics (A0 and B0). You can identify the version A0 and B0 using a show coherent driver internal location 0/0/CPU0 command and looking at "VID".

A0 = V01

B0 = V02

The CFP2 DCO version A0 optics support the following traffic types:

Traffic Type Index	Speed	Modulation	Forward Error Correction	Differential
1	100G	qpsk	15sdfec	disable
2	100G	qpsk	15sdfecde	enable
3	200G	16qam	15sdfec	disable
4	200G	8qam	15sdfec	disable

The CFP2 DCO version B0 optics support the following traffic-types:

Traffic Type Index	Speed	Modulation	Forward Error Correction	Differential
1	100G	qpsk	15sdfec	disable
2	100G	qpsk	15sdfecde	enable
3	100G	qpsk	otu7staircase	enable
4	200G	16qam	15sdfec	disable
5	200G	8qam	15sdfec	disable

The 100G/Staircase FEC traffic-type is supported with CFP2 DCO version B0 optics.

Port Mode Speed Support for NC57 Line Cards

Table 65: Feature History Table

Feature Name	Release Information	Feature Description
50G Optics Support for Quad Port Mode on NC57 Line Cards	Release 24.2.1	*Introduced in this release on: NCS 5500 modular routers; NCS 5700 line cards [Mode: Compatibility; Native]* This feature provides higher bandwidth on the following NC57 line cards with the support for 50G optics on the 8-port quads of these line cards: • NC-57-48Q2D-S • NC-57-48Q2D-SE **CLI:** This feature modifies the **hw-module quad** command.

Bidirectional CFP2 DCO Optics Support

Table 66: Feature History Table

Feature Name	Release	Description
Support for DP04CFP2-D15 Bidirectional CFP2-DCO Optical Module	Release 7.8.1	In this release, support for DP04CFP2-D15 bidirectional CFP2-DCO optical module is added for NC55-MOD-A-S and NCS-55A2-MOD-S routers with the following MPAs: • NC55-MPA-2TH-S • NC55-MPA-1TH2H-S The bidirectional CFP2-DCO optical module allows for data transmission and reception in both directions over a single fiber of a network, offering a cost and operationally effective method for expanding the network capacity in fiber-restricted networks.

The bidirectional CFP2-DCO optical module provides an effective way to increase the network capacity in situations where only single fiber is available. The bidirectional CFP2-DCO optical module enables data transmission and reception in both directions over single fiber of a network. Using dense wavelength division multiplexing (DWDM), the bidirectional CFP2-DCO optics can operate at 100G and 200G speeds through NC55-MPA-2TH-S and NC55-MPA-1TH2H-S MPAs operating in NC55-MOD-A-S and NCS-55A2-MOD-S routers.

The bidirectional CFP2 DCO optics support the following traffic configurations:

Speed	Modulation	Forward Error Correction	Differential
100G	qpsk	ofec	disable
200G	qpsk	ofec	disable

The bidirectional CFP2 DCO optics support the following Tx-Rx channel mapping:

Table 67: Tx-Rx Channel Map

Tx channel	Rx channel
1	3
5	7
9	11
13	15
17	19
21	23
25	27
29	31
33	35
37	39
41	43
45	47
49	51
53	55
57	59
61	63
65	67
69	71
73	75
77	79
81	83
85	87

Tx channel	Rx channel
89	91
93	95

Configuring Bidirectional CFP2 DCO Optical Module

This example shows steps to configure a 200G bidirectional CFP2 DCO optical module with Tx channel 1 and Rx channel 3:

```
RP/0/RP0/CPU0:router(config)#controller optics 0/0/1/0
RP/0/RP0/CPU0:router(config-optics)#port-mode 200G qpsk ofec diff disable
RP/0/RP0/CPU0:router(config-optics)#commit
RP/0/RP0/CPU0:router(config-optics)#dwdm-carrier 50Ghz-grid itu-ch 1
RP/0/RP0/CPU0:router(config-optics)#commit
RP/0/RP0/CPU0:router(config-optics)#exit
RP/0/RP0/CPU0:router(config)#controller optics 0/0/1/1
RP/0/RP0/CPU0:router(config-optics)#port-mode 200G qpsk ofec diff disable
RP/0/RP0/CPU0:router(config-optics)#commit
RP/0/RP0/CPU0:router(config-optics)#dwdm-carrier 50Ghz-grid itu-ch 3
RP/0/RP0/CPU0:router(config-optics)#commit
RP/0/RP0/CPU0:router(config-optics)#exit
```

Verification

This example displays the verification of bidirectional CFP2 DCO optical module communication between 0/0/1/0 and 0/0/1/1:

```
RP/0/RP0/CPU0:router#show coherent driver summary location 0/0/CPU0
Thu Sep 29 03:23:58.778 UTC
=============================================================================================
PORT       ADMIN-STATE    PLUGGABLE   TRAFFIC TYPE               FREQUENCY(100Mhz)
LASER STATE
=============================================================================================
0/0/1/0    UP             CFP2        200G_QPSK_0-FEC_NODIFF     1961000
OFF
0/0/1/1    UP             CFP2        200G_QPSK_0-FEC_NODIFF     1960000
OFF
```

Maintenance Mode

Coherent DSP controllers can be placed in maintenance mode. Use the **controller coherentDSP secondary-admin-state maintenance** command to place controllers in maintenance mode.

Use the **show controllers optics** *r*/*s*/*i*/*p* command to view optics parameter values, laser state, controller state, admin state, and trunk alarms on the card, and threshold values for the different optics parameters.

Use the **show controllers coherentDSP** *r*/*s*/*i*/*p* command to view the DSP controller state and alarm status and statistics.

Note In maintenance mode, all alarms are suppressed and the **show alarms** command does not display alarm details. However, traffic is not affected in maintenance mode.

Note The FEC is disabled for 25G and 50G optics in NC57-MPA-12L-S MPA when connected on 55A2-MOD-SE-S/-SE-H-S router, and in Line card NC57-MOD-S while verifying the FEC status using **show controllers** { **TwentyfiveGigE** | **FiftyGigE**}

Performance Monitoring

Performance monitoring (PM) parameters are used by service providers to gather, store, set thresholds for, and report performance data for early detection of problems. The user can retrieve both current and historical PM counters for the various controllers in 30-second, 15-minute, and 24-hour intervals.

PM for optical parameters include input signal power and transmit power, optical signal-to-noise ratio, chromatic dispersion, polarization dependent loss, second order polarization mode dispersion, differential group delay, and transmitter laser bias current.

PM for DSP parameters include:

- FEC: error corrected bits, uncorrectable blocks, pre-FEC BER (block errors ratio)
- OTN: errored seconds, severely effected seconds, unavailable seconds, failed counts

These parameters simplify troubleshooting operations and enhance data that can be collected directly from the equipment.

Fibre Channel over PLE Transmission Using TTS Auto-Negotiation

Table 68: Feature History Table

Feature Name	Release Information	Feature Description
Fibre Channel over PLE Transmission Using TTS Auto-Negotiation	Release 7.10.1	Introduced in this release on: NCS 5700 fixed port routers; NCS 5500 modular routers (NCS 5700 line cards [Mode: Compatibility; Native]) You can now enhance transmission speed and connectivity between ports with Fibre Channel (FC) over Private Line Emulation (PLE) using Transmitter Training Signal (TTS) with auto-negotiation function. FC over PLE technology facilitates fast and efficient connections and data storage replication between multiple data centers in a Storage Area Network (SAN) spanning different geographical locations. TTS is a feature introduced for the 32G FC ports. The feature introduces these changes: • **CLI:** The **tts** keyword is added to the **controller** command for FC. • **YANG Data Model:** New XPaths for `Cisco-IOS-XR-mpls-te-cfg.yang` (see GitHub, YANG Data Models Navigator)

SAN replication, or Storage Area Network replication, is a technology used in data storage and disaster recovery strategies to create redundant copies of data between storage systems located in different geographical locations. The primary goal of SAN replication is to ensure data availability, business continuity, and data protection in case of hardware failures, data corruption, or site-level disasters. SAN replication typically involves two or more storage arrays connected through a high-speed network, such as Fibre Channel.

SAN extension technologies enable the connection of remote storage systems, facilitating the replication of data between them. Together, SAN extension and replication form an integrated solution that provides both data replication and data accessibility between geographically dispersed data centers.

Private Line Emulation (PLE) using Transmitter Training Signal (TTS) with auto-negotiation function emulates the switching capabilities of FC ports without requiring dedicated equipment, enabling seamless interconnection between optical networks and Ethernet networks. FC over PLE involves extending FC connections using dedicated leased lines or private circuits. It's used for scenarios where the FC traffic needs to travel over a controlled and secure network, such as for SAN disaster recovery purposes.

The following illustration shows the example of an FC over PLE transmission between two SAN sites connected to two PE routers* using 32G FC ports through an MPLS core network.

Figure 24: FC over PLE Transmission between two SANs Through MPLS Core Network

* NCS 5700 fixed port routers; NCS 5500 modular routers (NCS 5700 line cards [Mode: Compatibility; Native]

When transporting Private Line Emulation (PLE) FC client traffic over an MPLS core network, TTS facilitates communication between sender and receiver FC ports. It allows both ends of the FC link to adjust their equalization settings based on the actual characteristics of the link, considering factors like distance, cable quality, and signal attenuation. As a result, the FC receiver uses this information to optimize the signal reception and compensate for any signal impairments that might occur during data transmission.

Restrictions and Usage Guidelines for FC over PLE transmission using TTS Auto-Negotiation

The following restrictions and guidelines are applicable for FC over PLE transmission using TTS:

- You must enable the FC ThirtyTwoGigFibreChanCtrlr controller interface (32G FC) on the NCS 5500 or NCS 5700 devices that are connected to the SAN devices.
- You must configure this feature only on the PLE MPA1 even ports, that is, 0, 2, 4, 6, and so on.

Configure FC over PLE transmission using TTS Auto-Negotiation

Perform the following tasks to configure the FC over PLE transmission using TTS auto-negotiation:

1. Enable the FC controller interface.

```
Router(config)# controller Optics0/0/1/6
Router(config-Optics)# port-mode FC framing cem-packetize rate FC32
Router(config-Optics)# commit
Router(config-Optics)# exit
```

2. Configure TTS

```
outer(config)# controller ThirtyTwoGigFibreChanCtrlr 0/1/1/0
Router(config-ThirtyTwoGigFibreChanCtrlr)# tts
Router(config-ThirtyTwoGigFibreChanCtrlr)# commit
```

Running Configuration

```
Router# show running-config controller ThirtyTwoGigFibreChanCtrlr 0/1/1/0
controller ThirtyTwoGigFibreChanCtrlr 0/1/1/0
tts
!
```

Verification

The following example shows the operational speed value of the 32G FC port used for PLE transmission:

```
Router# show controllers ThirtyTwoGigFibreChanCtrlr 0/1/1/0
Operational data for Fibre Channel controller ThirtyTwoGigFibreChanCtrlr 0/1/1/0
State:
 Admin State : Up
 Operational state : Down
 LED state : Red On
 Secondary admin state : Normal
 Laser Squelch : Disabled
Performance Monitoring is enabled
Operational values:
 Speed : 32 Gbps
 Loopback : None
 BER monitoring:
 Signal Degrade : 1e-0
 Signal Fail : 1e-0
 Hold-off Time : 0 ms
 Forward Error Correction : Not Configured
```

How to Configure Controllers

This section contains the following procedures:

Configuring Optics Controller

You can configure parameters such as performance monitoring, high power threshold, and wavelength for Optics controller.

To configure the Optics controller, use the following commands:

Before you begin

You must shut down the optics controller before you perform any of the following tasks:

- Configure the controller
- Restore a saved configuration
- Upgrade the DSP processor or CFP2 optics module Field Programmable Device (FPD)

SUMMARY STEPS

1. **configure**
2. **controller optics** *r*/*s*/*i*/*p*
3. **shutdown**
4. **commit**

5. **rx-high-threshold** *rx-high*
6. **tx-high-threshold** *tx-high*
7. **no shutdown**
8. **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure terminal`	Enters global configuration mode.
Step 2	**controller optics** *r*/*s*/*i*/*p* **Example:** `RP/0/RP0/CPU0:router(config)# controller optics 0/3/0/1`	Enters optics controller configuration mode.
Step 3	**shutdown** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# shutdown`	Shuts down the optics controller.
Step 4	**commit** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 5	**rx-high-threshold** *rx-high* **Example:** `RP/0/RP0/CPU0:router(config-Optics)# rx-high-threshold 200`	Configures the high receive power threshold. The range is -400 to 300 (in the units of 0.1 dBm).
Step 6	**tx-high-threshold** *tx-high* **Example:** `RP/0/RP0/CPU0:router(config-Optics)# tx-high-threshold 300`	Configures the high transmit power threshold. The range is -400 to 300 dBm (in the units of 0.1 dBm).
Step 7	**no shutdown** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# no shutdown`	Removes the shutdown configuration on the optics controller.

	Command or Action	Purpose
Step 8	**commit** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.

Note When you bring up the local optics controller, you might briefly see transient loss of signal (LOS) alarms on the console. This behavior might be observed during the initial tuning of the channel.

```
PKT_INFRA-FM-2-FAULT_CRITICAL : ALARM_CRITICAL :LOS-P :DECLARE :CoherentDSP0/3/0/1:
PKT_INFRA-FM-2-FAULT_CRITICAL : ALARM_CRITICAL :LOS-P :CLEAR :CoherentDSP0/3/0/1:
```

During the laser-on process, you might briefly see transient loss of line (LOL) alarms on the console. This alarm is cleared when the laser-on process is complete.

```
PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :CTP2 RX LOL :DECLARE ::
PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :CTP2 RX LOL :CLEAR ::
```

The laser-on process can take up to 120 seconds to complete.

Restrictions and Usage Guidelines for Port Modes

This section provides the restrictions and usage guidelines for the supported port modes.

Table 69: Restrictions and Usage Guidelines for Port Modes

Port Mode	Usage Guidelines	Restrictions
25Gbps	• The 25Gbps mode is supported on the following line cards: • NCS-55A2-MOD-S • NCS-55A2-MOD-HD-S • NCS-55A2-MOD-SE-S • NC55A2-MOD-SE-H-S • NCS-55A2-MOD-HX-S • NCS-55A1-48Q6H • NCS-55A1-24Q6H-S • NC55-MOD-A-SE-S • NC55-MOD-A-S • NC55-32T16Q4H-A • N540-24Z8Q2C-M • N540X-ACC-SYS • N540-ACC-SYS • N540-28Z4C-SYS • The 25Gbps mode is divided into four quads (0-3). Each quad consists of the following ports: • Quad 0 - Ports 24-27 • Quad 1 - Ports 28-31 • Quad 2 - Ports 32-35 • Quad 3 - Ports 36-39 • 10Gbps mode supports both 1Gpbs and 10Gbps port speed.	• 25Gbps mode is the default mode set on the quad. • Port speeds of 1Gbps and 10Gbps are incompatible with a 25Gbps port speed within the same quad. They cannot be configured to operate simultaneously.

Port Mode	Usage Guidelines	Restrictions

50Gbps	• The 50Gbps mode is supported only on the NC-57-48Q2D-S and NC-57-48Q2D-SE-S Line Cards.
	• The 50Gpbs mode is divided into two quads (0 and 1). Each quad consists of the following ports:
	  • Quad 0 - Ports 32-39
	  • Quad 1 - Ports 40-47
	• 25Gbps mode supports 1Gbps, 10Gbps, and 25Gbps port speed.
		• 25Gbps mode is the default mode set on the quad.
		• Port speeds of 1Gbps, 10Gbps, and 25Gbps are incompatible with a 50Gbps port speed within the same quad. They cannot be configured to operate simultaneously.

Note Starting from IOS-XR Release 25.1.x, FEC is disabled by default for CU1M/CU2M 25G copper optics. Use the `show controller twentyFiveGigE interface` command to verify the FEC status.

Configure Port Mode Speed

Each port on the 6-port Coherent Line Card can support 100 Gbps (DWDM QPSK), 150Gbps (DWDM 8 QAM), or 200Gbps (DWDM 16 QAM) WDM signals.

Note You might rarely see up to five syslog messages mentioning that the recovery mechanism got triggered to recover the port. These messages are about a port in down state due to auto-negotiation mismatch with the peer port and other port-down scenarios. You can ignore such syslog messages as they will not affect the functionality of the ports.

Note The line card has three Digital Signal Processors (DSPs), one for each pair of ports:

- Ports 0 and 1 – DSP0
- Ports 2 and 3 – DSP1
- Ports 4 and 5 – DSP2

When you configure the port-mode speed for 150Gbps (8 QAM), the port pairs belonging to a DSP are coupled. Ensure that you configure the port-mode speed on each port of the port pair that belongs to the same DSP.

To configure the port mode speed, use the following commands:

Before you begin

Ensure that you shut down the controller before you configure the controller or restore a saved configuration.

SUMMARY STEPS

1. **configure**
2. **controller optics** *r*/*s*/*i*/*p*
3. **shutdown**
4. **commit**
5. **port-mode speed** { **100G** | **150G** | **200G** } **mod** { **16qam** | **8qam** |**qpsk** } **fec** { **15sdfec** | **15sdfecde** | **25sdfec** | **otu7staircase** } **diff** { **enable** | **disable** }
6. **no shutdown**
7. **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**controller optics** *r*/*s*/*i*/*p* **Example:** `RP/0/RP0/CPU0:router(config)# controller optics 0/3/0/0`	Enters optics controller configuration mode
Step 3	**shutdown** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# shutdown`	Shuts down the optics controller.
Step 4	**commit** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 5	**port-mode speed** { **100G**	**150G**	**200G** } **mod** { **16qam**	**8qam** |**qpsk** } **fec** { **15sdfec**	**15sdfecde**	**25sdfec**	**otu7staircase** } **diff** { **enable**	**disable** } **Example:**	Configures the port mode speed.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config-Optics)# port-mode speed 100G mod qpsk fec 15sdfec diff`	
Step 6	**no shutdown** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# no shutdown`	Removes the shutdown configuration on the optics controller.
Step 7	**commit** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# commit`	Saves the configuration changes to the running configuration file.

Note When you bring up the local optics controller, you might briefly see transient loss of signal (LOS) alarms on the console. This behavior might be observed during the initial tuning of the channel.

```
PKT_INFRA-FM-2-FAULT_CRITICAL : ALARM_CRITICAL :LOS-P :DECLARE :CoherentDSP0/3/0/1:
PKT_INFRA-FM-2-FAULT_CRITICAL : ALARM_CRITICAL :LOS-P :CLEAR :CoherentDSP0/3/0/1:
```

During the laser-on process, you might briefly see transient loss of line (LOL) alarms on the console. This alarm clears when the laser-on process is complete.

```
PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :CTP2 RX LOL :DECLARE ::
PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :CTP2 RX LOL :CLEAR ::
```

Note On NCS-55A2-MOD-S and NC55-MOD-A-S with CFP2-DCO optics:

- During the laser-on process, you might briefly see Optical Transport Network (OTN) alarms on the console. This alarm clears when the laser-on process is complete.

  ```
  PKT_INFRA-FM-6-FAULT_INFO : OTUK-BDI :DECLARE :CoherentDSP0/0/2/2:
  PKT_INFRA-FM-6-FAULT_INFO : OTUK-BDI :CLEAR :CoherentDSP0/0/2/2:
  ```

- During the laser-on process, you might briefly see transient transmit power and receive power alarms on the console. These alarms are cleared when the laser-on process is complete.

  ```
  PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR :LO-RXPOWER :DECLARE :Optics0/0/2/0:
  PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR :LO-TXPOWER :DECLARE :Optics0/0/2/0:
  PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR :HI-RXPOWER :DECLARE :Optics0/0/2/0:

  PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR :LO-RXPOWER :CLEAR :Optics0/0/2/0:
  PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR :HI-RXPOWER :CLEAR :Optics0/0/2/0:
  PKT_INFRA-FM-4-FAULT_MINOR : ALARM_MINOR :LO-TXPOWER :CLEAR :Optics0/0/2/0:
  ```

- When you bring up the local optics controller, you might see repeated remote faults on the console.

  ```
  PLATFORM-DPA-2-RX_FAULT : Interface HundredGigE0/0/2/2/0, Detected Remote Fault
  PLATFORM-DPA-2-RX_FAULT : Interface HundredGigE0/0/2/2/1, Detected Remote Fault
  PLATFORM-DPA-2-RX_FAULT : Interface HundredGigE0/0/2/2/0, Detected Local Fault
  PLATFORM-DPA-2-RX_FAULT : Interface HundredGigE0/0/2/2/1, Detected Local Fault
  PLATFORM-DPA-2-RX_FAULT : Interface HundredGigE0/0/2/2/0, Detected Remote Fault
  PLATFORM-DPA-2-RX_FAULT : Interface HundredGigE0/0/2/2/1, Detected Remote Fault
  ```

If you need to change the port-mode speed, ensure that you remove the existing port mode speed configuration by entering the **no port-mode** command. You can then change the port mode speed.

The following example shows how to change the port mode speed to 100Gbps.

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# controller optics 0/3/0/0
RP/0/RP0/CPU0:router(config-Optics)# shutdown
RP/0/RP0/CPU0:router(config-Optics)# commit
RP/0/RP0/CPU0:router(config-Optics)# no port-mode
RP/0/RP0/CPU0:router(config-Optics)# commit
RP/0/RP0/CPU0:router(config-Optics)# port-mode speed 100G mod qpsk fec 15sdfec diff enable
RP/0/RP0/CPU0:router(config-Optics)# commit
RP/0/RP0/CPU0:router(config-Optics)# no shutdown
RP/0/RP0/CPU0:router(config-Optics)# commit
RP/0/RP0/CPU0:router(config-Optics)# exit
RP/0/RP0/CPU0:router(config)#
```

To modify the default 25Gpbs mode into 10Gbps mode, perform the below configuration:

Before Cisco IOS XR Release 7.5.1:

```
RP/0/RP0/CPU0:router(config)# hw-module quad 0 location 0/0/CPU0

RP/0/RP0/CPU0:router(config-quad-0x0)# mode 10g
```

From Cisco IOS XR Release 7.5.1:

```
RP/0/RP0/CPU0:router(config)# hw-module quad 0 location 0/0/CPU0 instance 1 mode 10g

RP/0/RP0/CPU0:router(config-quad-0x0)# mode 10g
```

Note A quad number always starts from 0 to the maximum supported number. The number of quads supported varies from platform to platform and the CLI validates it. For example, the NCS 540 Series Router supports two quads (0 and 1). If you enter X=3, the CLI returns an error.

Here, `instance` indicates the MPA card instance. It can range from 0-5. For Cisco NCS 540 Series Routers, it is always 0. Whereas, for Cisco NCS 5500 Series Routers, the instance can be between 0-5, adding 1 for every MPA instance. The default value is 0.

To modify the default 25Gbps into 50Gbps mode, perform the following configuration:

Starting with Cisco IOS XR Release 24.2.1, you can configure 50Gpbs mode only on NC-57-48Q2D-S and NC-57-48Q2D-SE-S line cards.

```
RP/0/RP0/CPU0:router(config)# hw-module quad 0 location 0/0/CPU0 instance 0 mode 50g

RP/0/RP0/CPU0:router(config-quad-0x0)# mode 50g
```

Note A quad number always starts from 0 to the maximum supported number. The number of quads supported varies from platform to platform and the CLI validates it. For example, the NCS 540 Series Router supports two quads (0 and 1). If you enter X=3, the CLI returns an error.

Here, `instance` indicates the MPA card instance. It can range from 0-5. For Cisco NCS 540 Series Routers, it is always 0. Whereas, for Cisco NCS 5500 Series Routers, the instance can be between 0-5, adding 1 for every MPA instance. The default value is 0.

Note To revert to the default 25Gbps mode, use the `no` form of the `hw-module quad` command.

After you configure the port-mode speed, you can configure the following interfaces:

- 100G – Each optics controller configuration creates a single 100GE port:
  - **interface HundredGigE** *r*/*s*/*i*/*p*/**0** (where*p* = CTP2 port 0-5)

    0/3/0/0/0

    0/3/0/1/0

    0/3/0/2/0

    0/3/0/3/0

    0/3/0/4/0

    0/3/0/5/0

- 200G – Each optics controller configuration creates two 100GE ports:
  - **interface HundredGigE** *r*/*s*/*i*/*p*/**0,** *r*/*s*/*i*/*p*/**1** (where*p* = CTP2 port 0-5

    0/3/0/0/0, 0/3/0/0/1

    0/3/0/1/0, 0/3/0/1/1

    0/3/0/2/0, 0/3/0/2/1

    0/3/0/3/0, 0/3/0/3/1

    0/3/0/4/0, 0/3/0/4/1

    0/3/0/5/0, 0/3/0/5/1

- 150G (coupled) – Coupled optics controller configuration creates three 100GE port:
  - **interface HundredGigE** *r*/*s*/*i*/*p*/**0,** *r*/*s*/*i*/*p*/**1,** *r*/*s*/*i*/*p*+1/**0** (where*p* = CTP2 port: 0, 2, 4 [port *p* and *p* +1 are coupled])

    0/3/0/0/0, 0/3/0/0/1, 0/3/0/1/0

    0/3/0/2/0, 0/3/0/2/1, 0/3/0/3/0

    0/3/0/4/0, 0/3/0/4/1, 0/3/0/5/0

For more information, see the *Configuring Ethernet Interfaces* chapter.

Configure Lower Port Speeds for Dual-Mode Optical Modules

Table 70: Feature History Table

Feature Name	Release	Description
Configure lower port speeds for dual-mode optical modules	Release 7.9.1	You can now configure the lower port speed using simple CLI keyword: **speed** or **quad** and switch between the higher and lower speeds without changing the optical module. Earlier, by default, only the higher port speed was available. The feature introduces new XPaths for YANG Data Model: **Cisco-IOS-XR-optics-speed-cfg.yang** (see GitHub, YANG Data Models Navigator.)

A dual-mode optic operates in two port speeds, a higher or a lower speed. For more information on how to configure the Port Mode Speed, refer Configure Port Mode Speed, on page 405.

From Cisco IOS XR Software Release 7.9.1 onwards, you can configure the following dual-mode optical modules to operate on their lower port speeds:

- SFP-10/25G-CSR-S
- SFP-10/25G-LR-S
- SFP-10/25G-LR-I
- SFP-10/25G-BXD-I
- SFP-10/25G-BXU-I
- QSFP-40/100-SRBD

Configuration

To configure a lower port speed use the following command:

hw-module quad*number* **location** *node-id* **[instance** *mpa-instance* **] mode** *mode-type*

A **quad** number always starts from 0 to the maximum supported number (0,1,2,3...n). Each quad houses a group of 2 or 4 ports. The number of quads supported varies from platform to platform and the CLI validates it.

Based on the platform support, configure the optical module to operate at lower port speed by using the CLI keywords: **speed** or **quad**.

For more information on the platforms supported, refer Optics Compatibility Matrix.

Examples

In the following example, **quad** keyword is used in the command to change the speed from 25G to 10G:

```
Router (config)#hw-module quad 2 location 0/0/CPU0 instance 2 mode 10g
Router (config)#commit
```

Verification

Use the `show controller` command to verify the configuration:

```
Router #show controller tengige 0/2/2/0 internal
Mon Mar  6 11:43:02.036 UTC

Internal data for interface: TenGigE0/2/2/0
Subport Number      : 255
Port Number         : 0 *
Bay Number          : 2 *
Board Type          : 0x000069bc *
Port Type           : 10GE *
Bandwidth(Kbps)     : 10000000 *
Transport mode      : LAN *
BIA MAC addr        : 008a:96f5:2d60
Oper. MAC addr      : 008a:96f5:2d60
Egress MAC addr     : 008a:96f5:2d60
Port Available      : true *
Status polling is   : disabled *
Status events are   : disabled
I/F Handle          : 0x04000210 *
Cfg Link Enabled    : enabled
H/W Tx Enable       : yes
MTU                 : 1514 *
H/W Speed           : 10 Gbps *
H/W Duplex          : Full *
H/W Loopback Type   : None *
FEC                 : Not Configured *
H/W FlowCtrl Type   : Disabled *
H/W AutoNeg Enable  : Off *
H/W Link Defects    : Link Local Fault *
Link Up             : no *
Link Led Status     : Yellow On *
Pluggable Present   : Yes *
Pluggable Type      :
Pluggable PID       :  *
Pluggable Compl.    : Third Party Optics
```

In the following example, **speed** keyword is used in the command to change the speed from 100G to 40G:

```
Router (config)#controller optics 0/0/1/1
Router (config)#speed 40g
Router (config)#commit
```

Verification

Use the `show controller` command to verify the configuration:

```
Router #show controller fortyGigE 0/1/0/34 internal
Mon Mar  6 11:39:22.635 UTC

Internal data for interface: FortyGigE0/1/0/34
Subport Number      : 255
Port Number         : 34 *
Bay Number          : 0 *
Board Type          : 0x0000698f *
Port Type           : 40GE *
Bandwidth(Kbps)     : 40000000 *
```

```
Transport mode      : LAN *
BIA MAC addr        : 008a:96f5:2d18
Oper. MAC addr      : 008a:96f5:2d18
Egress MAC addr     : 008a:96f5:2d18
Port Available      : true *
Status polling is   : disabled *
Status events are   : disabled
I/F Handle          : 0x02001a08 *
Cfg Link Enabled    : enabled
H/W Tx Enable       : yes
MTU                 : 1514 *
H/W Speed           : 40 Gbps *
H/W Duplex          : Full *
H/W Loopback Type   : None *
FEC                 : Not Configured *
H/W FlowCtrl Type   : Disabled *
H/W AutoNeg Enable  : Off *
H/W Link Defects    : No Fault *
Link Up             : yes *
Link Led Status     : Green ON *
Pluggable Present   : Yes *
Pluggable Type      : QSFP28 100G SR BD
Pluggable PID       : QSFP-40/100-SRBD *
Pluggable Compl.    : Compliant
```

Note You can configure the port in 10G or revert to 25G using **no** form of the command:

Use the following command to revert the speed to 25G.

```
Router (config)#no hw-module quad 2 location 0/0/CPU0 instance 2 mode 10g
Router (config)#commit
```

Use the following command to revert the speed to 100G.

```
Router (config)#no controller optics 0/0/1/1 speed 40g
Router (config)#commit
```

Configuring Wavelength

To configure wavelength, use the following commands:

Before you begin

- Before configuring the wavelength, use the **show controllers optics***r*/s/*i*/*p* **dwdm-carrrier-map** command to display the wavelength and channel mapping for optics controllers.
- You must shut down the controller before you configure the controller or restore a saved configuration.

SUMMARY STEPS

1. **configure**
2. **controller optics** *r*/s/*i*/*p*
3. **shutdown**
4. **commit**
5. **dwdm-carrier** {**100MHz-grid frequency** *frequency* } | {**50GHz-grid** [**frequency** *frequency* | *channel-number*] }

6. **no shutdown**
7. **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**controller optics** *r/s/i/p* **Example:** `RP/0/RP0/CPU0:router(config)# controller optics 0/3/0/1`	Enters optics controller configuration mode.
Step 3	**shutdown** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# shutdown`	Shuts down the optics controller.
Step 4	**commit** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.
Step 5	**dwdm-carrier** {**100MHz-grid frequency** *frequency* } | {**50GHz-grid** [**frequency** *frequency* | *channel-number*] } **Example:** `RP/0/RP0/CPU0:router(config-Optics)# dwdm-carrier 100MHz-grid frequency 1960875`	Configures the frequency on the trunk port.
Step 6	**no shutdown** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# no shutdown`	Removes the shutdown configuration on the optics controller.
Step 7	**commit** **Example:** `RP/0/RP0/CPU0:router(config-Optics)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.

To configure a DWDM carrier with the required frequency:

```
RP/0/RP0/CPU0:router#config
RP/0/RP0/CPU0:router(config)#controller Optics0/3/0/0
RP/0/RP0/CPU0:router(config-Optics)#dwdm-carrier
RP/0/RP0/CPU0:router(config-Optics)#dwdm-carrier 100MHz-grid
RP/0/RP0/CPU0:router(config-Optics)#dwdm-carrier 100MHz-grid frequency
RP/0/RP0/CPU0:router(config-Optics)#dwdm-carrier 100MHz-grid frequency 1960625
```

The output of `show run controller optics 0/3/0/0` command is:

```
RP/0/RP0/CPU0:router#show run controller optics 0/3/0/0
Wed Nov  6 13:47:33.178 UTC
controller Optics0/3/0/0
transmit-power -7
port-mode speed 100G mod qpsk fec 25sdfec diff disable
dwdm-carrier 100MHz-grid frequency 1960625
```

Note When you bring up the local optics controller, you might briefly see transient loss of signal (LOS) alarms on the console. This behavior might be observed during the initial tuning of the channel.

```
PKT_INFRA-FM-2-FAULT_CRITICAL : ALARM_CRITICAL :LOS-P :DECLARE :CoherentDSP0/3/0/1:
PKT_INFRA-FM-2-FAULT_CRITICAL : ALARM_CRITICAL :LOS-P :CLEAR :CoherentDSP0/3/0/1:
```

During the laser-on process, you might briefly see transient loss of line (LOL) alarms on the console. This alarm is cleared when the laser-on process is complete.

```
PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :CTP2 RX LOL :DECLARE ::
PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :CTP2 RX LOL :CLEAR ::
```

Configuring Coherent DSP Controller

You can configure the administrative state for the Coherent DSP controller. To configure the Coherent DSP controller, use the following commands.

Note The coherent DSP controller doesn't support Q factor, Q margin, and post FEC BER reporting. Therefore, no threshold crossing alert (TCA) is raised for these parameters.

SUMMARY STEPS

1. **configure**
2. **controller coherentDSP** *r*/*s*/*i*/*p*
3. **secondary-admin-state** *admin-state*
4. **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.
Step 2	**controller coherentDSP** *r/s/i/p* **Example:** `RP/0/RP0/CPU0:router(config)# controller coherentDSP 0/3/0/1`	Enters Coherent DSP optics controller configuration mode.
Step 3	**secondary-admin-state** *admin-state* **Example:** `RP/0/RP0/CPU0:router(config-CoDSP)# secondary-admin-state maintenance`	Configures the administrative state of the controller indicating that the controller is under maintenance.
Step 4	**commit** **Example:** `RP/0/RP0/CPU0:router(config-CoDSP)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.

Configuring Performance Monitoring

You can configure the performance monitoring parameters for the optics and Coherent DSP controllers. To configure PM parameters, use the following commands.

SUMMARY STEPS

1. **configure**
2. **controller** { **optics** | **coherentDSP** } *r/s/i/p*
3. **pm** { **30-sec** | **15-min** | **24-hour** } { **optics** | **fec** | **otn** } [**report** | **threshold** *value*]
4. **commit**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router# configure`	
Step 2	**controller** { **optics** | **coherentDSP** } *r*/*s*/*i*/*p* **Example:** `RP/0/RP0/CPU0:router(config)# controller coherentDSP 0/3/0/1`	Enters optics or Coherent DSP controller configuration mode.
Step 3	**pm** { **30-sec** | **15-min** | **24-hour** } { **optics** | **fec** | **otn** } [**report** | **threshold** *value*] **Example:** `RP/0/RP0/CPU0:router(config-CoDSP)# pm 15-min otn threshold es-ne`	Configures the performance monitoring parameters.
Step 4	**commit** **Example:** `RP/0/RP0/CPU0:router(config-CoDSP)# commit`	Saves the configuration changes to the running configuration file and remains within the configuration session.

Verify Controller Details

Execute the **show controllers** *controller-type* command to display and verify the controller details of the Optical Transport Network (OTN).

Note Due to a hardware limitation, this command cannot display the Forward Error Correction (FEC) Correctable and FEC Uncorrectable alarms on the NCS 5500 12 port 10G Modular Port Adaptor (MPA) with PID NC55-MPA-12T-S.

```
Router# show controllers otu20/0/2/1
Thu Jul 14 10:41:57.642 UTC

Port                                               : OTU2 0/0/2/1
Controller State                                   : Down
LED state                                          : Red Flashing
Inherited Secondary State                          : Normal
Configured Secondary State                         : Normal
Derived State                                      : In Service
Loopback mode                                      : None
BER Thresholds                                     : SF = 1.0E-6  SD = 1.0E-7
Performance Monitoring                             : Enable

Alarm Information:
LOS = 0 LOF = 1 LOM = 0
OOF = 1 OOM = 1 AIS = 0
IAE = 0 BIAE = 0        SF_BER = 0
SD_BER = 0      BDI = 0 TIM = 0
FECMISMATCH = 0 FEC-UNC = 0     FLEXO_GIDM = 0
```

```
FLEXO-MM = 0    FLEXO-LOM = 0   FLEXO-RDI = 0
FLEXO-LOF = 0
Detected Alarms                                  : LOF OOF OOM

OTU TTI Received

FEC mode                                         : STANDARD

AINS Soak                                        : None
AINS Timer                                       : 0h, 0m
AINS remaining time                              : 0 seconds
```

Execute the **show controllers coherentDSP** command to display status and configuration information for interfaces configured as coherent DSP controllers.

```
Router#show controllers coherentDSP 0/0/0/13
Thu May 27 06:56:37.505 UTC

Port                                             : CoherentDSP 0/0/0/13
Controller State                                 : Up
Inherited Secondary State                        : Normal
Configured Secondary State                       : Normal
Derived State                                    : In Service
Loopback mode                                    : None
BER Thresholds                                   : SF = 1.0E-5  SD = 1.0E-7
Performance Monitoring                           : Enable
Bandwidth                                        : 400.0Gb/s

Alarm Information:
LOS = 32        LOF = 0 LOM = 0
OOF = 0 OOM = 0 AIS = 0
IAE = 0 BIAE = 0        SF_BER = 0
SD_BER = 0      BDI = 0 TIM = 0
FECMISMATCH = 0 FEC-UNC = 0     FLEXO_GIDM = 0
FLEXO-MM = 0    FLEXO-LOM = 0   FLEXO-RDI = 0
FLEXO-LOF = 43
Detected Alarms                                  : None

Bit Error Rate Information
PREFEC  BER                                      : 8.5E-04
POSTFEC BER                                      : 0.0E+00
Q-Factor                                         : 9.90 dB

Q-Margin                                         : 2.70dB

OTU TTI Received
```

Execute the **show controllers optics** command to display status and configuration information about the interfaces configured as optics controller.

```
Router#show controllers optics 0/0/0/7
 Controller State: Up
 Transport Admin State: In Service
 Laser State: On
 LED State: Green
 FEC State: FEC ENABLED
 Optics Status
         Optics Type:  QSFPDD 400G ZR
         DWDM carrier Info: C BAND, MSA ITU Channel=61, Frequency=193.10THz,
         Wavelength=1552.524nm
         Alarm Status:
         -------------
         Detected Alarms: None
         LOS/LOL/Fault Status:
```

```
        Alarm Statistics:
        -------------
        HIGH-RX-PWR = 0            LOW-RX-PWR = 0
        HIGH-TX-PWR = 0            LOW-TX-PWR = 0
        HIGH-LBC = 0               HIGH-DGD = 0
        OOR-CD = 0                 OSNR = 55
        WVL-OOL = 0                MEA  = 0
        IMPROPER-REM = 0
        TX-POWER-PROV-MISMATCH = 0
        Laser Bias Current = 0.0
        Actual TX Power = -8.16 dBm
        RX Power = -7.85 dBm
        RX Signal Power = -7.55 dBm
        Frequency Offset = 5 MHz
        Performance Monitoring: Enable
        THRESHOLD VALUES
        ----------------
        Parameter                High Alarm  Low Alarm  High Warning  Low Warning
        -----------------------  ----------  ---------  ------------  -----------
        Rx Power Threshold(dBm)         1.9      -28.2           0.0        -25.0
        Tx Power Threshold(dBm)         0.0      -15.0          -2.0        -16.0
        LBC Threshold(mA)              0.00       0.00          0.00         0.00
        Temp. Threshold(celsius)      80.00      -5.00         75.00        15.00
        Voltage Threshold(volt)        3.46       3.13          3.43         3.16
        LBC High Threshold = 98 %
        Configured Tx Power = -6.00 dBm
        Configured CD High Threshold = 80000 ps/nm
        Configured CD lower Threshold = -80000 ps/nm
        Configured OSNR lower Threshold = 9.00 dB
        Configured DGD Higher Threshold = 80.00 ps
        Baud Rate =  59.8437500000 GBd
        Modulation Type: 16QAM
        Chromatic Dispersion 2 ps/nm
        Configured CD-MIN -2400 ps/nm  CD-MAX 2400 ps/nm
        Second Order Polarization Mode Dispersion = 87.00 ps^2
        Optical Signal to Noise Ratio = 36.30 dB
        Polarization Dependent Loss = 0.40 dB
        Polarization Change Rate = 0.00 rad/s
        Differential Group Delay = 2.00 ps
        Temperature = 51.00 Celsius
        Voltage = 3.36 V
Transceiver Vendor Details
        Form Factor            : QSFP-DD
        Optics type            : QSFPDD 400G ZR
        Name                   : CISCO-ACACIA
        OUI Number             : 7c.b2.5c
        Part Number            : DP04QSDD-E20-19E
        Rev Number             : 10
        Serial Number          : ACA2449003P
        PID                    : QDD-400G-ZR-S
        VID                    : ES03
        Firmware Version       : 61.12
        Date Code(yy/mm/dd)    : 20/12/03
```

Replace Optical Module

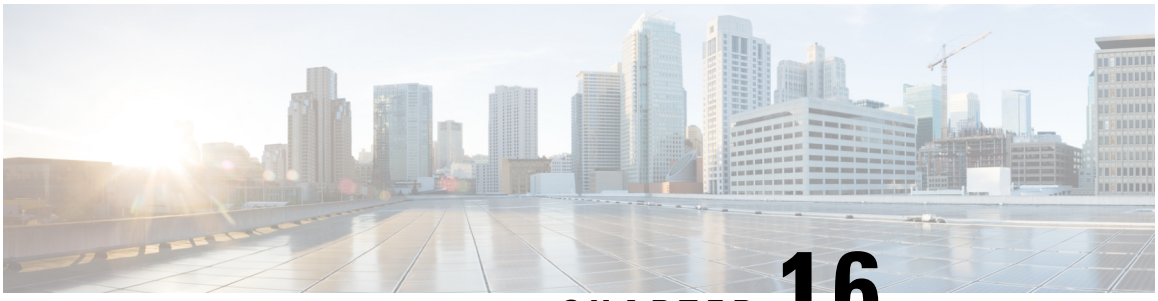
In this example, we are replacing QSFP-100G-SR4-S QSFP optics configured for 4x25 breakout with QSFP-40G-SR4 optics and configure it for 4x10 breakout.

1. Delete the optical module configuration using the **no breakout** command.

```
Router# configure
Router(config)# controller optics 0/2/0/35
Router(config-Optics)# no breakout 4x25
Router(config-Optics)# commit
```

2. Replace the QSFP-100G-SR4-S QSFP optical module with QSFP-40G-SR4 optical module.
3. Configure 4x10 breakout for QSFP-40G-SR4 optical module.

```
Router# configure
Router(config)# controller optics 0/2/0/35
Router(config-Optics)# breakout 4x10
Router(config-Optics)# commit
```



CHAPTER 16

Configuring QDD Optical Line System

This chapter describes the QDD Optical Line System (OLS) and its supported configurations.

Configuring QDD Optical Line System

Table 71: Feature History Table

Feature Name	Release Information	Description
QDD Optical Line System	Release 7.10.1	

Feature Name	Release Information	Description
		Introduced in this release on: NCS 5500 fixed port routers (select variants only*); NCS 5700 fixed port routers (select variants only*) The QDD Optical Line System (OLS) is a new pluggable optical amplifier that interconnects two routers or switches for transmitting traffic on a limited number of coherent optical channels over a single span point-to-point link. With the QDD OLS pluggable, it's now possible to obtain the functionality of amplification into a QSFP-DD module that can be plugged into a port of the router or switch. The benefits of this pluggable are: • Provides compact solution for amplification. • Provides extended reach. • Increases fiber bandwidth. • Lowers power dissipation. This feature introduces the following: • **CLI**: • **controller ots (QDD OLS)** • **rx-low-threshold** • **tx-low-threshold** • **ampli-control-mode** • **egress-ampli-gain** • **egress-ampli-power** • **egress-ampli-safety-control-mode** • **egress-ampli-osri** • **show controllers ots (QDD OLS)** • **YANG Data Model**: • `Cisco-IOS-XR-controller-ots-oper.yang` • `Cisco-IOS-XR-controller-ots-cfg.yang` • `Cisco-IOS-XR-pmengine-oper.yang` • `Cisco-IOS-XR-pmengine-cfg.yang` • `Cisco-IOS-XR-pmengine-clear-act.yang`

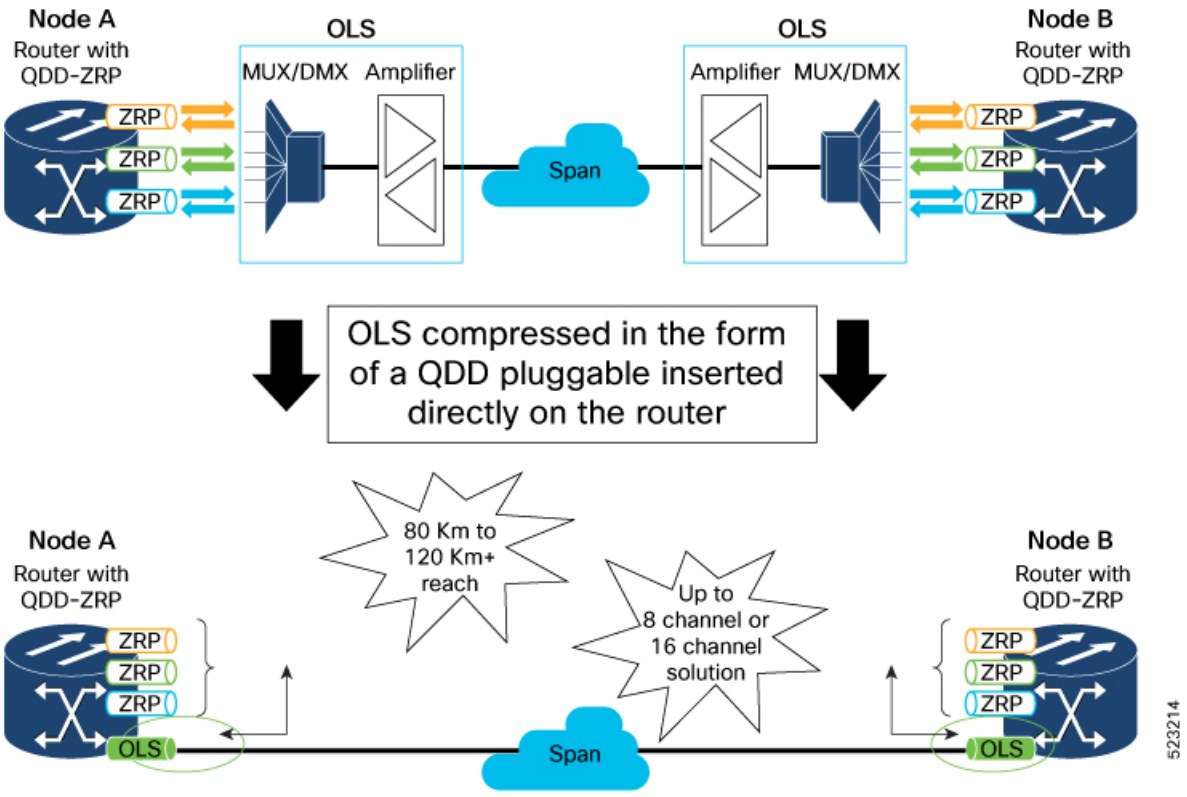
Feature Name	Release Information	Description
		* The QDD Optical Line System is now supported on the following hardware: • NCS-57B1-6D24-SYS and NCS-57B1-5DSE-SYS routers. • On NCS-57C3-MOD and NCS-55A2-MOD routers, the QDD OLS pluggable can be used only through the NC57-MPA-2D4H-S modular port adapter.

The QDD OLS is a pluggable optical amplifier that interconnects two routers or switches for transporting a limited number of coherent optical channels over a single span point-to-point link.

Currently, an optical line system (OLS) requires a separate Cisco Network Convergence System 1000 Series or Cisco Network Convergence System 2000 Series optical system with dedicated 48 or 64 channels MUX/DMX units and amplifiers. The new QDD OLS module provides amplification functionality in a QSFP module, while the passive cables provide MUX/DMX functionality. With this solution, you can compress a point-to-point DWDM system directly into the routing or switching platform.

The new optical line system can now transport 8 or 16 optical channels without any additional optical hardware unit. With the use of external passive MUX/DMX units (examples for these) along with this setup, it's also possible to obtain up to 32 optical channels.

Figure 25: QDD Optical Line System



Supported Routers and MPAs

The support of the QDD OLS pluggable on the routers and MPA is explained as follows:

- The QDD OLS pluggable can be directly inserted into the NCS-57B1-6D24-SYS and NCS-57B1-5DSE-SYS routers.
- On NCS-57C3-MOD and NCS-55A2-MOD routers, the QDD OLS pluggable can be used only through the NC57-MPA-2D4H-S modular port adapter.

Supported Wavelength or Frequency Configuration

For each channel supported through ONS-BRK-CS-8LC or ONS-BRK-CS-16LC passive/mux cable, the wavelength or the frequency must be configured according to the table below.

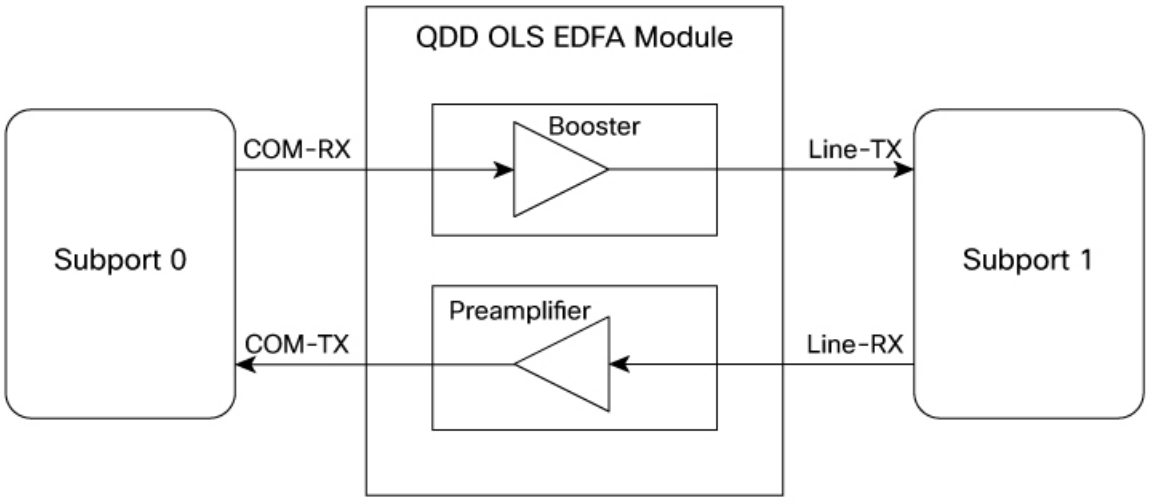
Table 72: QDD OLS Operating Signal Wavelength Range

Channel Spacing	Total Bandwidth	Wavelength		Frequency	
		Start	End	Start	End
8 channels - 200 GHz spaced 16 channels - 100 GHz spaced	19.2 nm 2.4 THz	1539.1 nm	1558.4 nm	192.375 THz	194.775 THz

Functional Description of QDD OLS

The QDD OLS pluggable contains the COM side and the Line side as shown in the figure below:

Figure 26: Functional Description of QDD OLS



Each physical port of the QDD OLS pluggable is represented as two ots controllers (subport 0 and subport 1). COM port is subport 0 and Line port is subport 1.

The Gain of the Booster is associated to subport 1 while the gain of the Preamplifier is associated to subport 0.

Controller	Optical Ports
ots R/S/I/P/0	COM-RX (booster input)
	COM-TX (preamplifier output)
ots R/S/I/P/1	LINE-RX (preamplifier input)
	LINE-TX (booster output)

QDD OLS Configurations

The following section contains the QDD OLS configuration details.

Configuring the Operational Mode, Amplifier Gain, and Amplifier Output Power

You can configure the mode of operation of the OLS pluggable to either gain control or power control mode.

In the gain control mode, you can configure the desired gain value of the OLS pluggable.

In the power control mode, you can configure the desired output power (TX) of the OLS pluggable.

Gain Control Operational Mode and Amplifier Gain Configuration Example

The following example shows how to configure the gain control operational mode and the amplifier gain of the OLS pluggable:

```
Router#config
Router(config)#controller ots 0/0/2/1/0
Router(config-Ots)#ampli-control-mode manual
Router(config-Ots)#egress-ampli-gain 150
Router(config-Ots)#commit
Router(config-Ots)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration for the OLS pluggable:

```
Router#show run controller optics 0/0/2/1/0
controller Ots0/0/2/1/0
 ampli-control-mode manual
 egress-ampli-gain 150
!
!
```

Verification

This example shows how to verify the configured gain control operational mode and amplifier gain of the OLS pluggable:

```
Router#show controllers ots 0/0/2/1/0
Thu Mar 23 21:33:49.862 UTC
```

```
Controller State: Up

Transport Admin State: In Service

LED State: Green

               Alarm Status:
               -------------
               Detected Alarms: None

               Alarm Statistics:
               -----------------
               RX-LOS-P = 4
                RX-LOC = 0
                TX-POWER-FAIL-LOW = 1
                INGRESS-AUTO-LASER-SHUT = 0
                INGRESS-AUTO-POW-RED = 0
                INGRESS-AMPLI-GAIN-LOW = 0
                INGRESS-AMPLI-GAIN-HIGH = 0
                EGRESS-AUTO-LASER-SHUT = 0
                EGRESS-AUTO-POW-RED = 0
                EGRESS-AMPLI-GAIN-LOW = 4
                EGRESS-AMPLI-GAIN-HIGH = 1
                HIGH-TX-BR-PWR = 0
                HIGH-RX-BR-PWR = 0
                SPAN-TOO-SHORT-TX = 0
                SPAN-TOO-SHORT-RX = 0

               Parameter Statistics:
               ---------------------
               Total Tx Power = 16.72 dBm
                Rx Signal Power = -22.29 dBm
                Tx Signal Power = 16.53 dBm
                Egress Ampli Gain = 14.7 dB
               Egress Ampli OSRI = OFF

               Configured Parameters:
               -------------
               Egress Ampli Gain = 15.0 dB
                Egress Ampli Power = 4.0 dBm
               Egress Ampli OSRI = OFF
                Ampli Control mode = Manual
                Rx Low Threshold = -30.0 dBm
                Tx Low Threshold = -5.0 dBm


               Temperature = 27.92 Celsius
                Voltage = 3.33 V

Optical Module Details

               Optics type                : QDD DUAL EDFA
               Name                       : CISCO-II-VI
               OUI Number                 : 00.90.65
               Part Number                : 60P310001
               Rev Number                 : 01
               Serial Number              : IFB26520001
               PID                        : ONS-QDD-OLS
               VID                        : VES1
               Firmware Version           : 0.10
               Date Code(yy/mm/dd) : 23/02/22
               Fiber Connector Type    : CS
```

Power Control Operational Mode and Amplifier Output Power Configuration Example

The following example shows how to configure the power control operational mode and the amplifier output power of the OLS pluggable :

```
Router#config
Router(config)#controller ots 0/0/2/1/0
Router(config-Ots)#ampli-control-mode powermode
Router(config-Ots)#egress-ampli-power 50
Router(config-Ots)#commit
Router(config-Ots)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration for the OLS pluggable:

```
Router(controller-Ots)#show run controller ots 0/0/2/1/0
controller Ots0/0/2/1/0
 ampli-control-mode powermode
 egress-ampli-power 50
!
```

Verification

This example shows how to verify the configured power control operational mode and amplifier output power of the OLS pluggable:

```
Router#show controllers ots 0/0/2/1/0
Thu Jun  1 08:56:37.236 UTC

Controller State: Up

Transport Admin State: In Service

LED State: Green

               Alarm Status:
               -------------
               Detected Alarms: None

               Alarm Statistics:
               -----------------
               RX-LOS-P = 4
                RX-LOC = 0
                TX-POWER-FAIL-LOW = 1
                INGRESS-AUTO-LASER-SHUT = 0
                INGRESS-AUTO-POW-RED = 0
                INGRESS-AMPLI-GAIN-LOW = 0
                INGRESS-AMPLI-GAIN-HIGH = 0
                EGRESS-AUTO-LASER-SHUT = 0
                EGRESS-AUTO-POW-RED = 0
                EGRESS-AMPLI-GAIN-LOW = 4
                EGRESS-AMPLI-GAIN-HIGH = 1
                HIGH-TX-BR-PWR = 0
                HIGH-RX-BR-PWR = 0
                SPAN-TOO-SHORT-TX = 0
                SPAN-TOO-SHORT-RX = 0

               Parameter Statistics:
               ---------------------
               Total Tx Power = 5.00 dBm
                Rx Signal Power = -22.29 dBm
                Tx Signal Power = 4.99 dBm
                Egress Ampli Gain = 3.2 dB
```

```
                Egress Ampli OSRI = OFF

                 Configured Parameters:
                -------------
                Egress Ampli Gain = 15.0 dB
                 Egress Ampli Power = 5.0 dBm
                Egress Ampli OSRI = OFF
                 Ampli Control mode = Power
                 Rx Low Threshold = -30.0 dBm
                 Tx Low Threshold = -5.0 dBm

                Temperature = 29.33 Celsius
                 Voltage = 3.34 V

Optical Module Details

                Optics type                 : QDD DUAL EDFA
                Name                        : CISCO-II-VI
                OUI Number                  : 00.90.65
                Part Number                 : 60P310001
                Rev Number                  : 01
                Serial Number               : IFB26520001
                PID                         : ONS-QDD-OLS
                VID                         : VES1
                Firmware Version            : 0.10
                Date Code(yy/mm/dd)         : 23/02/22
                Fiber Connector Type        : CS
```

Configuring the Low-Threshold Power

You can set the low-threshold power of the optical signal (RX and TX) that can be received or transmitted from the OLS pluggable.

Low-Threshold Power Configuration Example

The following example shows how to configure the optical receive (RX) low-threshold power on the OLS pluggable:

```
Router#config
Router(config)#controller ots 0/0/2/1/0
Router(config-Ots)#rx-low-threshold -200
Router(config-Ots)#commit
Router(config-Ots)#exit
Router(config)#exit
```

Note To configure the optical transmit (TX) low-threshold power on the OLS pluggable, use the **tx-low-threshold** *tx-low* command.

Running Configuration

This example shows the running configuration for the OLS pluggable:

```
Router#show run controller ots 0/0/2/1/0
controller Ots0/0/2/1/0
 rx-low-threshold -200
!
!
```

Verification

This example shows how to verify the configured optical receive (RX) low-threshold power value for the OLS pluggable:

```
Router#show controllers ots 0/0/2/1/0

 Controller State: Up

 Transport Admin State: In Service

 LED State: Yellow

        Alarm Status:
        -------------
        Detected Alarms:
                RX-LOS-P

        Alarm Statistics:
        -----------------
        RX-LOS-P = 0
        RX-LOC = 0
        TX-POWER-FAIL-LOW = 0
        INGRESS-AUTO-LASER-SHUT = 0
        INGRESS-AUTO-POW-RED = 0
        INGRESS-AMPLI-GAIN-LOW = 0
        INGRESS-AMPLI-GAIN-HIGH = 0
        EGRESS-AUTO-LASER-SHUT = 0
        EGRESS-AUTO-POW-RED = 0
        EGRESS-AMPLI-GAIN-LOW = 0
        EGRESS-AMPLI-GAIN-HIGH = 0
        HIGH-TX-BR-PWR = 0
        HIGH-RX-BR-PWR = 0
        SPAN-TOO-SHORT-TX = 0
        SPAN-TOO-SHORT-RX = 0

        Parameter Statistics:
        ---------------------
        Total Tx Power = -50.00 dBm
        Rx Signal Power = -50.00 dBm
        Tx Signal Power = -50.00 dBm
        Egress Ampli Gain = 0.0 dB
        Egress Ampli OSRI = OFF


        Configured Parameters:
        -------------
        Egress Ampli Gain = 20.0 dB
        Egress Ampli Power = 8.0 dBm
        Egress Ampli OSRI = OFF
        Ampli Control mode = Manual
        Rx Low Threshold = -20.0 dBm
        Tx Low Threshold = -5.0 dBm


        Temperature = 14.29 Celsius
        Voltage = 3.37 V

 Optical Module Details

        Optics type            : QDD DUAL EDFA
        Name                   : CISCO-ACCELINK
        OUI Number             : 00.00.00
        Part Number            : EDFA-211917-QDD
        Rev Number             : 19
        Serial Number          : ACW2631Z00X
```

```
PID                    : ONS-QDD-OLS=
Firmware Version       : 1.09
Date Code(yy/mm/dd)    : 22/06/02
Fiber Connector Type   : CS
```

Configuring the Optical Safety Remote Interlock (OSRI)

To shut down the amplifier, use the Optical Safety Remote Interlock (OSRI) configuration. This configuration is used during the maintenance of the pluggable, debugging scenarios, and when the OLS pluggable isn't in use. With this configuration enabled, the output power can still be a maximum of -15dBm based on the input power.

OSRI Configuration Example

The following example shows how to configure the Optical Safety Remote Interlock (OSRI) on the OLS pluggable:

```
Router#config
Router(config)#controller ots 0/0/2/1/0
Router(config-Ots)#egress-ampli-osri on
Router(config-Ots)#commit
Router(config-Ots)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration for the OLS pluggable:

```
Router#show run controller optics 0/0/2/1/0
controller Ots0/0/2/1/0
 egress-ampli-osri on
 !
```

Verification

This example shows how to verify the configured OSRI for the OLS pluggable:

```
Router#show controllers ots 0/0/2/1/0

Thu Jun  1 09:04:10.335 UTC

Controller State: Up

Transport Admin State: In Service

LED State: Green

               Alarm Status:
               -------------
               Detected Alarms: None

               Alarm Statistics:
               -----------------
               RX-LOS-P = 4
                RX-LOC = 0
                TX-POWER-FAIL-LOW = 1
                INGRESS-AUTO-LASER-SHUT = 0
                INGRESS-AUTO-POW-RED = 0
                INGRESS-AMPLI-GAIN-LOW = 0
                INGRESS-AMPLI-GAIN-HIGH = 0
                EGRESS-AUTO-LASER-SHUT = 0
                EGRESS-AUTO-POW-RED = 0
                EGRESS-AMPLI-GAIN-LOW = 4
```

```
                 EGRESS-AMPLI-GAIN-HIGH = 1
                 HIGH-TX-BR-PWR = 0
                 HIGH-RX-BR-PWR = 0
                 SPAN-TOO-SHORT-TX = 0
                 SPAN-TOO-SHORT-RX = 0

                Parameter Statistics:
                ---------------------
                Total Tx Power = -50.00 dBm
                 Rx Signal Power = -22.36 dBm
                 Tx Signal Power = -50.00 dBm
                 Egress Ampli Gain = 0.0 dB
                Egress Ampli OSRI = ON

                Configured Parameters:
                -------------
                Egress Ampli Gain = 15.0 dB
                 Egress Ampli Power = 5.0 dBm
                Egress Ampli OSRI = ON
                 Ampli Control mode = Power
                 Rx Low Threshold = -30.0 dBm
                 Tx Low Threshold = -5.0 dBm

                Temperature = 27.90 Celsius
                 Voltage = 3.34 V

Optical Module Details

                Optics type                     : QDD DUAL EDFA
                Name                            : CISCO-II-VI
                OUI Number                      : 00.90.65
                Part Number                     : 60P310001
                Rev Number                      : 01
                Serial Number                   : IFB26520001
                PID                             : ONS-QDD-OLS
                VID                             : VES1
                Firmware Version                : 0.10
                Date Code(yy/mm/dd)             : 23/02/22
                Fiber Connector Type            : CS
```

Configuring Safety Control Mode

You can enable safety control mode only on subport 1.

With safety-control-mode set as **auto** and if LOS is detected on the line RX, the line TX normalizes the signal output power to 8 dBm and the ALS (automatic laser shutdown) and APR (automatic power reduction) alarms are raised.

Safety Control Configuration Example

The following example shows how to enable safety control mode on the OLS pluggable (on subport 1):

```
Router#config
Router(config)#controller ots 0/0/2/1/1
Router(config-Ots)#egress-ampli-safety-control-mode auto
Router(config-Ots)#commit
Router(config-Ots)#exit
Router(config)#exit
```

Running Configuration

This example shows the running configuration for the OLS pluggable:

```
Router#show run controller ots 0/0/2/1/1
controller Ots0/0/2/1/1
 ampli-control-mode manual
 egress-ampli-gain 230
 egress-ampli-safety-control-mode auto
!
```

Verification

This example shows how to verify the configured safety control mode:

```
Router#show controllers ots 0/0/2/1/1

 Thu Jun  1 09:04:17.550 UTC

Controller State: Down

Transport Admin State: In Service

LED State: Yellow

               Alarm Status:
               -------------
               Detected Alarms:
                               RX-LOS-P
                               EGRESS-AUTO-LASER-SHUT
                               EGRESS-AUTO-POW-RED
                               EGRESS-AMPLI-GAIN-HIGH

               Alarm Statistics:
               -----------------
               RX-LOS-P = 12
                RX-LOC = 0
                TX-POWER-FAIL-LOW = 1
                INGRESS-AUTO-LASER-SHUT = 0
                INGRESS-AUTO-POW-RED = 0
                INGRESS-AMPLI-GAIN-LOW = 0
                INGRESS-AMPLI-GAIN-HIGH = 0
                EGRESS-AUTO-LASER-SHUT = 13
                EGRESS-AUTO-POW-RED = 13
                EGRESS-AMPLI-GAIN-LOW = 2
                EGRESS-AMPLI-GAIN-HIGH = 12
                HIGH-TX-BR-PWR = 0
                HIGH-RX-BR-PWR = 0
                SPAN-TOO-SHORT-TX = 0
                SPAN-TOO-SHORT-RX = 0

               Parameter Statistics:
               ---------------------
               Total Tx Power = 8.08 dBm
                Rx Signal Power = -50.00 dBm
                Tx Signal Power = 5.61 dBm
                Egress Ampli Gain = 28.9 dB
               Egress Ampli Safety Control mode = auto
                Egress Ampli OSRI = OFF



               Configured Parameters:
               -------------
               Egress Ampli Gain = 23.0 dB
                Egress Ampli Power = 3.0 dBm
               Egress Ampli Safety Control mode = auto
                Egress Ampli OSRI = OFF
                Ampli Control mode = Manual
```

```
                 Rx Low Threshold = -30.0 dBm
                 Tx Low Threshold = -5.0 dBm


                Temperature = 23.00 Celsius
                 Voltage = 3.36 V

Optical Module Details

                Optics type                     : QDD DUAL EDFA
                Name                            : CISCO-ACCELINK
                OUI Number                      : 00.00.00
                Part Number                     : EDFA-211917-QDD
                Rev Number                      : 24
                Serial Number                   : ACW2651Z001
                PID                             : ONS-QDD-OLS
                VID                             : VES1
                Firmware Version                : 2.04
                Date Code(yy/mm/dd)             : 22/12/27
                Fiber Connector Type            : CS
```

Use Case for QDD OLS pluggable

The QDD OLS pluggable can transport 8 or 16 coherent optical channels from the DWDM optical modules that are plugged into the router.

The optical modules are interconnected with the QDD OLS amplifiers using the following cables:

- ONS-BRK-CS-8LC: dual fanout 1x8 cable-assembly with embedded passive splitter and coupler
- ONS-BRK-CS-16LC: dual fanout 1x16 cable-assembly with embedded passive splitter and coupler
- ONS-CAB-CS-LC-5: dual adapter patch-cord CS-connector to LC-connector

The following section explains the 8-channel Optical Line System (OLS) that is achieved by using the QDD OLS pluggable and QDD-400G-ZRP-S modules. With this 8-channel Optical Line System (OLS) set-up it's now possible to obtain 28 dB/112 kilometer span reach. Also, the fiber bandwidth is increased by 8 times.

8-Channel Optical Line System

The following section explains the 8-channel Optical Line System (OLS) that is achieved by using the QDD OLS pluggable and QDD-400G-ZRP-S modules. With this 8-channel Optical Line System (OLS) set up it's now possible to obtain 28 dB/112 kilometer span reach. Also, the fiber bandwidth is increased by 8 times.

This section explains the 8-channel optical line system (OLS) that is achieved by using the following:

- Four NCS-57C3-MOD or NCS-57C3-MODS-SYS routers (represented as Node A, Node B, Node C, and Node D)
- Four NC57-MPA-2D4H-S MPAs
- Sixteen QDD-400G-ZRP-S modules
- Two QDD OLS (ONS-QDD-OLS) pluggables
- Two ONS-BRK-CS-8LC breakout cables

- Two ONS-CAB-CS-LC-5 fiber optic cable

Connections on Node A

Two NC57-MPA-2D4H-S MPAs are inserted in MPA slot 2 and MPA slot 3 of the NCS-57C3-MOD or NCS-57C3-MODS-SYS router. Four QDD-400G-ZRP-S modules are inserted into port 0 and port 2 of both the NC57-MPA-2D4H-S MPAs. The QDD OLS (ONS-QDD-OLS) pluggable is inserted into port 3 of the NC57-MPA-2D4H-S MPA that is installed MPA slot 3 of the NCS-57C3-MOD or NCS-57C3-MODS-SYS router.

Connections on Node B

Two NC57-MPA-2D4H-S MPAs are inserted in MPA slot 2 and MPA slot 3 of the NCS-57C3-MOD or NCS-57C3-MODS-SYS router. Four QDD-400G-ZRP-S modules are inserted into port 0 and port 2 of both the NC57-MPA-2D4H-S MPAs.

Connections between Node A and Node B

Using the ONS-BRK-CS-8LC breakout cable connect eight QDD-400G-ZRP-S modules (four each on Node A and Node B) and the QDD OLS (ONS-QDD-OLS) pluggable (port 3 of the NC57-MPA-2D4H-S MPA that is installed in MPA slot 3 of Node A).

Connections on Node C

Two NC57-MPA-2D4H-S MPAs are inserted in MPA slot 2 and MPA slot 3 of the NCS-57C3-MOD or NCS-57C3-MODS-SYS router. Four QDD-400G-ZRP-S modules are inserted into port 0 and port 2 of both the NC57-MPA-2D4H-S MPAs.

Connections on Node D

Two NC57-MPA-2D4H-S MPAs are inserted in MPA slot 2 and MPA slot 3 of the NCS-57C3-MOD or NCS-57C3-MODS-SYS router. Four QDD-400G-ZRP-S modules are inserted into port 0 and port 2 of both the NC57-MPA-2D4H-S MPAs. The QDD OLS (ONS-QDD-OLS) pluggable is inserted into port 3 of the NC57-MPA-2D4H-S MPA that is installed MPA slot 2 of the NCS-57C3-MOD or NCS-57C3-MODS-SYS router.

Connections between Node C and Node D

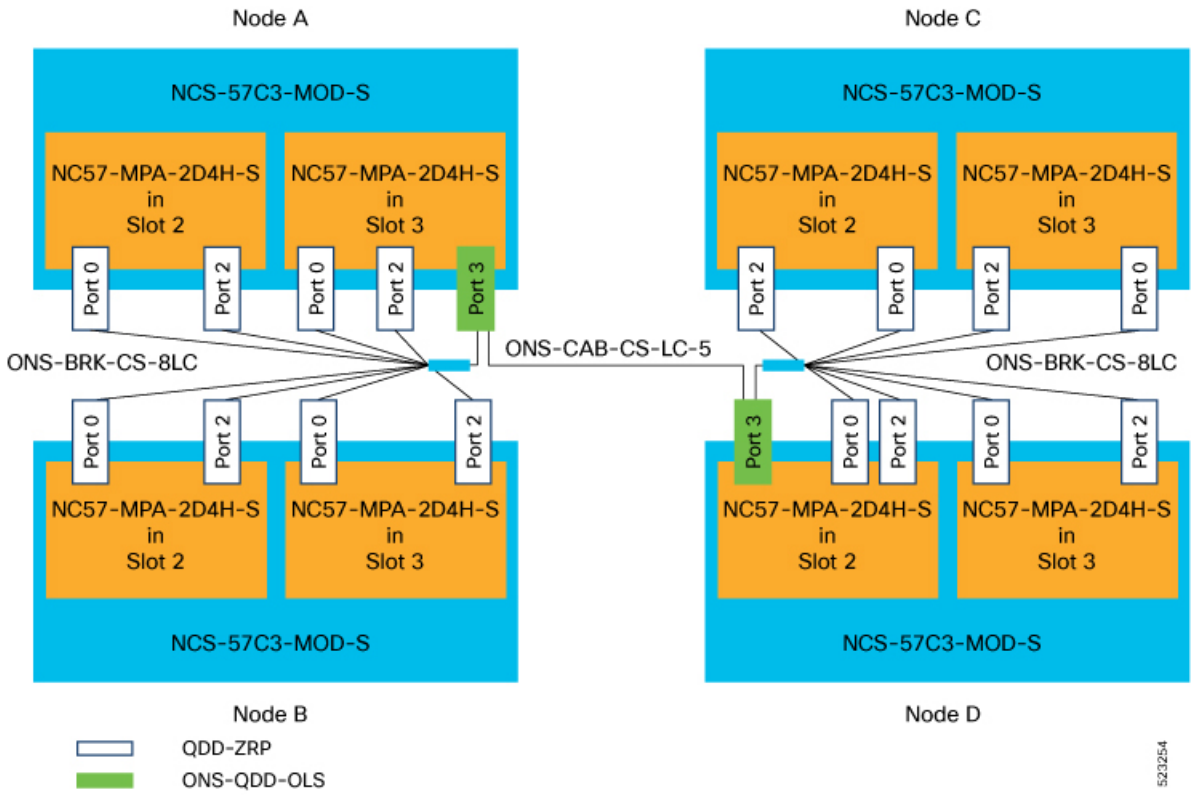
Using the ONS-BRK-CS-8LC breakout cable connect eight QDD-400G-ZRP-S modules (four each on Node C and Node D) and the QDD OLS (ONS-QDD-OLS) pluggable (port 3 of the NC57-MPA-2D4H-S MPA that is installed in MPA slot 2 of Node D).

Connections between Node A and Node D

Using the ONS-CAB-CS-LC-5 fiber optic cable connect both the QDD OLS (ONS-QDD-OLS) pluggables that are present in Node A and Node D.

The representation of these interconnections between Node A/Node B and Node C/Node D are depicted in the block diagram below:

Figure 27: 8-Channel Optical Line System



OLS Alarms Troubleshooting

This section contains the procedures for troubleshooting alarms.

RX-LOS-P

Default Severity: Critical

Logical Object: Controller

The RX-LOS-P alarm is raised when there is loss of signal.

Clear the RX-LOS-P Alarm

1. Verify the transmission (TX) at the peer end.
2. Check the fiber connections.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

RX-POWER-FAIL-LOW

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The RX-POWER-FAIL-LOW alarm is raised when the RX power is below the configured low threshold values.

Clear the RX-POWER-FAIL-LOW Alarm

1. Verify the transmission (TX) at the peer end.
2. Check the fiber connections.
3. Increase the peer end gain or transmit-power value to obtain the RX power above the threshold.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

TX-POWER-FAIL-LOW

Default Severity: Critical

Logical Object: Controller

The TX-POWER-FAIL-LOW alarm is raised when the TX power is below the configured low threshold values.

Clear the TX-POWER-FAIL-LOW Alarm

1. Increase the gain or power configuration value to obtain the TX power above the threshold.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

EGRESS-AMPLI-GAIN-LOW

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The EGRESS-AMPLI-GAIN-LOW alarm is raised when the actual gain of the OLS pluggable is lower than the configured gain value.

Clear the EGRESS-AMPLI-GAIN-LOW Alarm

1. Configure the gain value within the optimum range.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

EGRESS-AMPLI-GAIN-HIGH

Default Severity: Minor (MN), Non-Service-Affecting (NSA)

Logical Object: Controller

The EGRESS-AMPLI-GAIN-HIGH alarm is raised when the actual gain of the OLS pluggable is higher than the configured gain value.

Clear the EGRESS-AMPLI-GAIN-HIGH Alarm

1. Verify the RX and TX values and adjust the gain within the optimum working range.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

EGRESS-AUTO-LASER-SHUT

Default Severity: Not-Alarmed

Logical Object: Controller

The EGRESS-AUTO-LASER-SHUT alarm is raised when there is loss of signal (LOS) on the OTS line side (subport 1)

Clear the EGRESS-AUTO-LASER-SHUT Alarm

1. Verify the fiber connections on the line side of the OLS pluggable.
2. Verify the gain or power on the line side of the peer end.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).

EGRESS-AUTO-POW-RED

Default Severity: Not-Alarmed

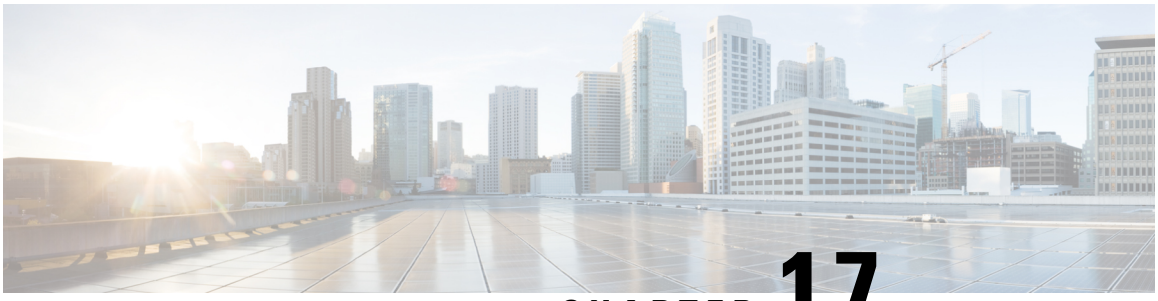
Logical Object: Controller

The EGRESS-AUTO-POW-RED alarm is raised when there is loss of signal (LOS) on the OTS line side (subport 1)

Clear the EGRESS-AUTO-POW-RED Alarm

1. Verify the fiber connections on the line side of the OLS pluggable.
2. Verify the gain or power on the line side of the peer end.

If the alarm does not clear, log into the Technical Support Website at http://www.cisco.com/c/en/us/support/index.html for more information or call Cisco TAC (1 800 553-2447).



CHAPTER 17

Global Navigation Satellite System

This chapter describes the Global Navigation Satellite System (GNSS) NCS-55A2-MOD-SE-S Line Card. This chapter also describes the procedures used to configure the GNSS port.

This chapter describes the Global Navigation Satellite System (GNSS) and the procedures used to configure the GNSS port for fixed-port routers.

Configuring the Global Navigation Satellite System

Table 73: Feature History Table

Feature Name	Release	Description
Extending GNSS Functionality to Cisco Network Convergence System 5700 Series variants	Release 7.5.1	A Global Navigation Satellite System (GNSS) receiver receives radio signals from GNSS satellites and decodes the information from multiple satellites to determine its distance from each satellite. Based on this data, the GNSS receiver identifies the location of each satellite. This feature is supported on the following variants of Cisco Network Convergence System 5700 Series fixed chassis: • NCS-57B1-6D24-SYS • NCS-57B1-5DSE-SYS For more information about the Cisco NCS 5700 series fixed chassis, see the Cisco NCS-57B1 Fixed Chassis Data Sheet.

In typical telecom networks, synchronization works in a hierarchal manner where the core network is connected to a stratum-1 clock. The stratum-1 clock is then distributed along the network in a tree-like structure. However, with a GNSS receiver, clocking is changed to a flat architecture, where access networks can directly take clock from satellites in sky by using an on-board GPS chip.

To optimize the GNSS system, it requires all the systems to share a common time scale and coordinated system. If all the systems do not have a common time, the receiver sees a time offset and then the receiver will have to select only one constellation having common time scale. Then there will be a requirement to add more satellites to increase the coverage of the constellation itself.

This capability simplifies network synchronization planning, provides flexibility and resilience in resolving network synchronization issues in the hierarchical network.

These Cisco IOS XR routers now support on board GNSS receiver to recover time.

Information About GNSS

Overview of GNSS

The following routers support the GNSS receiver:

- NCS-55A2-MOD-S
- NCS-55A2-MOD-HD-S
- NCS-55A2-MOD-HX-S
- NCS-55A2-MOD-SE-S

Starting from Cisco IOS XR Release 7.5.1, the following 57B1 variants of NCS 5700 fixed chassis support GNSS receiver:

- NCS-57B1-6D24-SYS
- NCS-57B1-5DSE-SYS

No license is required to enable the GNSS module. The GNSS LED on the front panel indicates the status of the module. The following table describes the different status of GNSS LED:

LED Status	Description
Green	GNSS NormalState.Selfsurvey is complete.
Amber	All other states

The following table describes the different status of GNSS LED for 5700 Series variants:

LED Status	Description
Green	GNSS is Locked to an RF input (Satellites)
Amber	GNSS Receiver not Locked RF input(Satellites)
OFF	GNSS not configured

NCS-57B1-6D24-SYS and NCS-57B1-5DSE-SYS can also receive 1PPS, 10 MHz, and ToD signals from an external clocking and timing source. However, the timing signals from the GNSS module (when enabled) take precedence over those of the external source. For more information, see the Cisco NCS 5700 series: NCS-57B1 Fixed Chassis Data Sheet.

Note NCS-55A2-MOD-SE-S can also receive 1PPS, 10 MHz, and ToD signals from an external clocking and timing source. However, the timing signals from the GNSS module (when enabled) take precedence over those of the external source.

Note We do not recommend that you configure both the front panel (10M, 1PPS and ToD) input configuration and the GNSS input configuration.

By default, anti-jamming is enabled on the GNSS module.

Operation of GNSS Module

The GNSS module has the following stages of acquiring and providing timing signals to the Cisco router:

- Self-survey mode - When the router is reset, the GNSS module comes up in self-survey mode. It tries to lock on to a minimum of four different satellites and computes approximately 2000 different positions of the satellites to obtain a 3-D location (Latitude, Longitude, and Height) of it current position. This operation takes about 35 to 40 minutes. During this stage also, the module is able to generate accurate timing signals and achieve a Normal or Phase-locked state.
- Over determined clock mode - The router switches to over determined (OD) mode when the self-survey mode is complete and the position information is stored in non-volatile memory on the router. In this mode, the module only processes the timing information based on satellite positions captured in self-survey mode.

The router saves the tracking data, which is retained even when the router is reloaded.

The GNSS module stays in the OD mode unless one of the following conditions occur:

- A position relocation of the antenna of more than 100 meters is detected. This detection causes an automatic restart of the self-survey mode.
- A manual restart of the self-survey mode or when the stored reference position is deleted.
- A worst-case recovery option after a jamming-detection condition that cannot be resolved with other methods.

You can configure the GNSS module to automatically track any satellite or configure it to explicitly use a specific constellation. However, the module uses configured satellites only in the OD mode.

Note GLONASS and BeiDou satellites cannot be enabled simultaneously.

When the router is reloaded, it always comes up in the OD mode unless:

- The router is reloaded when the self-survey mode is in progress.
- The physical location of the router is changed to more than 100 m from its pre-reloaded condition.

When the system restarts GNSS self-survey by using the default gnss slot R0/R1 command in config mode, the 10MHz, 1PPS, and ToD signals are not changed and remain up.

Prerequisites for GNSS

To use GNSS, the antenna must see as much as possible from the sky. For proper timing, a minimum of four satellites must be locked. For more information, see the *Cisco NCS 5500 Series Router Hardware Installation Guide or Cisco NCS 5700 Series Router Hardware Installation Guide*.

Restrictions for GNSS

- The GNSS module is not supported through SNMP; all configurations are performed through commands.
- The GNSS holdover performance is one microsecond in two hours of holdover after twelve hours of GNSS lock time.
- TDEV fails marginally on NCS-55A2-MOD-SE-S with GNSS input.

Configure GNSS

Configuration Example

You can configure any of the following constellation options for a router:

- GPS
- Galileo
- GLONASS
- BeiDou
- QZSS

Based on your configuration, the output displays the status of the GNSS receiver on the router models.

This section describes how you can configure GNSS for a router.

```
/* Enable the GNSS receiver and enter the gnss-receiver submode */

Router(config)# gnss-receiver 0 location 0/0/CPU0
Router(config-gnss)# frequency synchronization
Router(config-gnss-freqsync)# selection input
```

Optional Configuration Example

```
Router(config)# gnss-receiver 0 location 0/0/CPU0
Router(config-gnss)# anti-jam disable
Router(config-gnss)# constellation GPS
Router(config-gnss)# snr threshold 10
Router(config-gnss)# frequency synchronization
Router(config-gnss-freqsync)# selection input
Router(config-gnss-freqsync)# priority 5  >>>Values can range from 1 (highest priority) to
 254 (lowest priority). The default value is 100.
Router(config-gnss-freqsync)# wait-to-restore 0
```

Running Configuration

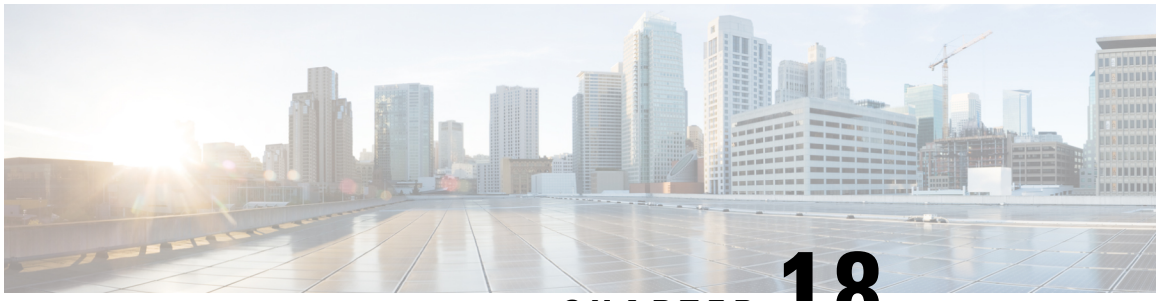
```
gnss-receiver 0 location 0/RP0/CPU0
frequency synchronization
  selection input
  priority 1
  wait-to-restore 0
  quality receive exact itu-t option 1 PRC
 !
!
```

Verification

The following is the output of the **show gnss-receiver** command on the router models.

```
# show gnss-receiver
GNSS-receiver 0 location 0/RP0/CPU0
    Status: Available, Up
```

```
    Position: 741:12.12 N 4451:39.60 E 0.827km
    Time: 2019:01:17 14:43:08 (UTC offset: 18s)
    Firmware version: 1.4
    Lock Status: Phase Locked, Receiver Mode: 3D-fix
    Survey Progress: 100, Holdover Duration: 0
    Major Alarm: Not used
    Minor Alarm: Not used
    Anti-jam: Enabled, Cable-delay compensation: 0
    1PPS polarity: Positive
    PDOP: 6.000, HDOP: 0.000, VDOP: 0.000, TDOP: 1.000
    Constellation: GPS, Satellite Count: 10

Router# show gnss-receiver
Fri Jan 17 07:27:34.804 UTC
GNSS-receiver 0 location 0/RP0/CPU0
    Status: Available, Up
    Position: 12:56.18 N 77:41.77 E 0.823km
    Time: 2020:01:17 07:31:41 (UTC offset: 0s)
    Locked at: 2020:01:15 17:15:28
    Firmware version: TIM 1.10
    Lock Status: Phase Locked, Receiver Mode: Time fix only
    Survey Progress: 100, Holdover Duration: Unknown
    Major Alarms: Unknown
    Minor Alarms: Unknown
    Anti-jam: Enabled, Cable-delay compensation: 0
    1PPS polarity: Positive
    PDOP: 99.990, HDOP: 99.990, VDOP: 99.990, TDOP: 0.240
    Constellation: GPS, Satellite Count: 17
    Satellite Thresholds:
        SNR - 0 dB-Hz, Elevation - 0 degrees, PDOP - 0, TRAIM - 0 us
    Satellite Info:
        CHN: Channel, AQUN: Aquisition, EPH: Ephemeris
        PRN   CHN   AQUN   EPH    SV            Signal
        No.   No.   Flag   Flag   Type          Strength   Elevat'n   Azimuth
        ---   ---   ----   ----   -----------   --------   --------   --------
          1   n/a   On     On     GPS             44.000     19.000    220.000
          3   n/a   On     On     GPS             48.000     62.000    299.000
          4   n/a   On     On     GPS             46.000     30.000    338.000
          7   n/a   On     On     GPS             47.000      9.000    261.000
          8   n/a   On     On     GPS             41.000     17.000    172.000
          9   n/a   On     On     GPS             44.000      7.000    317.000
         11   n/a   On     On     GPS             42.000     10.000    202.000
         14   n/a   On     On     GPS             42.000     22.000     90.000
         16   n/a   On     On     GPS             46.000     66.000     59.000
         22   n/a   On     On     GPS             47.000     71.000    238.000
         23   n/a   On     On     GPS             46.000     27.000    332.000
         26   n/a   On     On     GPS             48.000     40.000     40.000
```



CHAPTER 18

Configuring WAN-PHY Controllers

This module describes the configuration of WAN-PHY controllers on the Cisco NCS 5500 Series Routers.

Table 74: Feature History for Configuring WAN-PHY Controllers

Release	Modification
Release 7.2.1	This feature was introduced.

WAN-PHY Controller

Table 75: Feature History Table

Feature Name	Release Information	Feature Description
WAN-PHY SONET Controller	Release 7.2.1	WAN-PHY renders 10 Gigabit Ethernet frames compatible with the SONET OC-192 or SDH STM-64 container format as defined by ANSI. In this release WAN-PHY supports only SONET OC-192 format.
Support for SDH mode under WAN-PHY Controller	Release 7.2.2	In this release, support of SDH STM-64 format is added for WAN-PHY Controllers. Support of SONET OC-192 formats existed in earlier releases.

WAN-PHY renders 10 Gigabit Ethernet compatible with the SONET STS-192c and SDH STM-64 container format as defined by ANSI. WAN-PHY effectively bridges the asynchronous world of Ethernet data with synchronous SONET/SDH transport allowing 10 Gigabit Ethernet to be transparently carried over current DWDM networks without having to directly map the Ethernet frames into SONET/SDH.

To achieve this compatibility, a WAN Interface Sublayer (WIS) is inserted between the 10 Gigabit Ethernet Physical Coding Sublayer (PCS) and the serial Physical Medium Attachment sublayer/Physical Medium Dependent sublayer (PMA/PMD).

When the controller is in SONET mode the WIS sublayer transports 10 Gigabit Ethernet frames in an OC-192c SONET payload which can interoperate with SONET section or line level repeaters.

When the controller is in SDH mode the WIS sublayer transports 10 Gigabit Ethernet frames in an STM-64 payload which can interoperate with SDH section or line level repeaters.

WAN-PHY is supported on NC55-MPA-12T-S card and 10G pluggables.

This table lists modular line cards and 2-RU systems that support NC55-MPA-12T-S card:

Table 76: Supported MOD Line Cards and 2-RU Systems:

Modular Line Card	2-RU Systems
• NC55-MOD-A-S • NC55-MOD-A-SE-S	• NCS-55A2-MOD-S • NCS-55A2-MOD-SE-S • NCS-55A2-MOD-HX-S • NCS-55A2-MOD-SE-H-S • NCS-55A2-MOD-HD-S

Restrictions

Consider these limitations before configuring WAN-PHY mode:

- WAN-PHY feature works on these 10G pluggables:
  - SFP-10G-SR-X
  - SFP-10G-LR-X
  - SFP-10G-ZR
- SONET or SDH configurations are rejected if the port has 1G optics.
- SONET or SDH configurations are rejected if MACsec is already configured on that port.

Configuring SONET Mode on an Interface

This task describes how to configure WAN-PHY in the SONET mode on the NC55-MPA-12T-S.

To enable WAN-PHY in SONET mode on an interface, configure **port-mode sonet framing WIS** command in the controller optics mode:

```
controller Optics 0/0/1/10
 port-mode sonet framing WIS
!
```

Verification

To verify the WHY-PHY SONET configuration, run these show coomands:

- **show portmode all**
- **show controllers OC192 0/0/1/10**
- **show controllers STS192c 0/0/1/10**

```
RP/0/RP0/CPU0:ios#show portmode all
Tue Apr 28 11:45:55.671 UTC

Portmode Information
------------------------------------------------
Port Name       Portmode Type   Framing                 Mapping                 PT type
                                      Rate
None
Optics0_0_1_10  Sonet           WIS framing type      None mapping type            NA
                                          None
```

In above show command, the Framing column confirms that the framing type is WIS (WAN Interface Sublayer). When the controller is in WAN-PHY mode the WIS sublayer transports 10 Gigabit Ethernet frames in an OC-192c SONET payload.

When the online help funtion (?) on the router is used against the **show controllers oc192** or **show controllers STS192c** command, the list of WAN-PHY enabled card locations are displayed. This is a simple way to verify if WAN-PHY is enabled on the router.

For example:

```
RP/0/RP0/CPU0:ios # show controllers oc192 ?
0/0/1/10  OC192 Interface Instance
R/S/I/P  Forward interface in Rack/Slot/Instance/Port format


RP/0/RP0/CPU0:ios#show controllers OC192 0/0/1/10
Port OC1920/0/1/10:


 Status:
 Primary State: Up
 Configured Sec admin State: Normal
 Inherited Sec admin State: Normal
 Derived State: In Service
 performace_monitoring enabled

Loopback: None

SECTION
  LOF = 0          LOS    = 0          TIM-S = 0          BIP(B1) = 0
Overhead
J0 Transmit:    (0)
J0 Receive:     (0)
```

```
J0 Expected:    (0)

LINE
  AIS = 0          RDI    = 0          FEBE = 0          BIP(B2) = 0

Last clearing of "show controllers SONET" counters never

Detected Alarms: None
Masked Alarms: None
Detected Alerts: None
Masked Alerts: None

Framing: SONET
BER thresholds:  SF = 1.0E-3  SD = 1.0E-6
TCA thresholds:  B1 = 1.0E-6  B2 = 1.0E-6
  Clock source: internal (actual) line (configured)
```

Finally, the **show controllers STS192c 0/0/1/10** command is used to check SONET STS-192c format and data rate:

```
RP/0/RP0/CPU0:ios#show controllers STS192c 0/0/1/10

 Primary State: Up

 Sec Admin State: Normal

 Derived State: In Service

PATH
  FEBE   = 0          BIP(B3) = 0
  NEWPTR = 0          PSE    = 0          NSE  = 0
Detected Alarms:       None

Mask for Detected->Asserted:      None

Detected Alerts: None
Mask for Detected->Reported: None
Payload Scrambling: Disabled
C2 State: Stable   C2_rx = 0x0 (0)   C2_tx = 0x0 (0) / Scrambling Derived
B3 = 10e-6
Overhead J1
Transmit        : (0)
Received        : (0)
Expected        : (0)

 performace_monitoring enabled
```

The purpose of WAN-PHY is to render 10 Gigabit Ethernet compatible with the SONET STS-192c format and data rate, as defined by ANSI.

Configuring SDH Mode on an Interface

This task describes how to configure SDH mode on the NC55-MPA-12T-S:

```
controller Optics 0/0/2/1
 port-mode sdh framing WIS
!
```

Verification

To verify the SDH configuration, run these show coomands:

- show portmode all
- show controllers STM64 0/0/2/1
- show controllers vc4-64c 0/0/2/1

```
RP/0/RP0/CPU0:ios#show portmode all

Portmode Information
-------------------------------------------------
Port Name       Portmode Type   Framing                 Mapping                 PT type
   Rate
Optics0_0_2_1   SDH        WIS framing type        None mapping type         NA
None
```

The show command confirms that the Portmode type is SDH. When the controller is in SDH mode, WIS transports 10GE frames in an STM-64 payload.

The **show controllers STM64** command is used to check STM64 format and data rate:

```
RP/0/RP0/CPU0:ios#show controllers STM64 0/0/2/1
Mon Dec  7 11:13:31.697 UTC


Port STM640/0/2/1:

Status:
 Primary State: Down

 Configured Sec admin State: Normal

 Inherited Sec admin State: Normal

 Derived State: In Service

 performace_monitoring enabled

Loopback: None

REGENERATOR SECTION
  LOF = 1          LOS    = 0          RS-TIM = 0     RS-BIP = 0
Overhead
J0 Transmit:    (0)
J0 Receive:     (0)
J0 Expected:    (0)

MULTIPLEX SECTION
  AIS = 0          RDI    = 0          FEBE = 0          MS-BIP  = 0

Last clearing of "show controllers SDH" counters never

Detected Alarms: LOF
Masked Alarms: None
Detected Alerts: None
Masked Alerts: None

Framing: SDH
BER thresholds:  SF = 1.0E-3  SD = 1.0E-6
TCA thresholds:  B1 = 1.0E-6  B2 = 1.0E-6
  Clock source: internal (actual) line (configured)
```

```
RP/0/RP0/CPU0:ios#show controllers vc4-64c 0/0/2/1
Mon Dec  7 11:15:26.535 UTC

 Primary State: Down

 Sec Admin State: Normal

 Derived State: In Service

PATH
  FEBE   = 0          BIP(B3) = 0
  NEWPTR = 0          PSE    = 0          NSE  = 0
Detected Alarms: AU-LOP

Mask for Detected->Asserted:      None

Detected Alerts: None
Mask for Detected->Reported: None
Payload Scrambling: Disabled
C2 State: Stable   C2_rx = 0x0 (0)   C2_tx = 0x0 (0) / Scrambling Derived
B3 = 10e-6
Overhead J1
Transmit        : (0)
Received        : (0)
Expected        : (0)

 performace_monitoring enabled
```

TSoP Smart SFP for SDH and SONET Encapsulation

Table 77: Feature History Table

Feature Name	Release	Description
TSoP Smart SFP for SDH and SONET Encapsulation	Release 7.11.1	Introduced in this release on NCS 5500 fixed port routers This release introduces support for the Clear Channel Synchronous Transport Module Level-1 (STM1) Smart SFP (SFP-TS-OC3STM1-I) for the Transparent SONET or SDH over Packet (TSoP) protocol. This allows you to leverage your existing packet-switched network to transport traditional time-division multiplexing (TDM) traffic. TSoP Smart SFPs offer the following advantages: • Encapsulation of SDH or SONET bit streams into packet-switched network format • Improved suitability for pseudowire transport over an Ethernet network

The TSoP Smart SFP (SFP-TS-OC3STM1-I) is a special type of optical transceiver that allows for the transparent encapsulation of SDH or SONET bit streams into a packet format. This format is suitable for transporting pseudowires over an Ethernet network. The TSoP pseudowires can be manually configured or set up using the PWE3 control protocol [RFC4447].

TSoP provides packetization, de-packetization, and clock recovery. It translates the TDM bit stream into fixed-size data blocks (810 octets) and vice versa.

TSoP follows the SAToP method described in [RFC4553] for transporting E1/DS1 pseudowires over a packet-switched network. With TSoP, the entire OC-3 or STM-1 is encapsulated in a single circuit emulating pseudowire traffic. This traffic is then transported to a single destination across the Ethernet network.

.

Note The TSoP Smart SFP is used on any of the front panel ports of the 8-port Gigabit Ethernet SFP Interface Module (8x1GE).

- The Smart SFP transceivers are compatible with the Small Form Factor Pluggable 20-pin Multi-Source Agreement (MSA).
- TSoP Smart SFP (SFP-TS-OC3STM1-I) transports up to 155 Mbps on a L1.1 (40km) optical data link.

Prerequisites for TSoP

This section provides information about the prerequisites that apply to TSoP.

- Single mode optical fiber must be used to connect TSoP Smart SFP with the OC-3 port.
- The TSoP smart SFP pseudowire endpoints must use the same configuration parameters.

Restrictions for TSoP

This section provides information about the restrictions that apply to TSoP.

- TSoP is not supported on the 25GE ports, but it’s supported only on 1GE and 10GE ports.
- The RTP clock source value is Ethernet, by default. The **Clock source internal/line** under the **controller STM1** *r/s/i/p*, is not applicable.
- Ensure that there is at least 2 minutes time-delay between the swaps, during a quick OIR of TSoP smart SFP with other SFPs on the same port.
- Before you insert TSoP, always ensure that the Ethernet interface is in a **shutdown** state. If TSoP doesn't come up when the Ethernet interface is accidentally present in **no shut**, then remove TSoP and insert Gigabit Ethernet SFP to move it to the shutdown state, and then reinsert TSoP as a workaround.
- TSoP only supports Differential Clock Recovery (DCR) by default and doesn’t support any other clock configuration.
- Both sides of PE only support TSoP. Currently, interoperability with other devices is not supported.

Guidelines for TSoP Smart SFP

The TSoP is compatible with the following SFPs supported on the OC-3 interface module. We recommend using the specified attenuator:

- ONS-SI-155-I1 - For a cable length of 15km, use a 2 dB attenuator. Use an 8 dB attenuator for short distances to avoid receiver overload.
- ONS-SI-155-L1 - For a cable length of 40km, no attenuator is needed. Use a 10 dB attenuator for short distances to avoid receiver overload.

- ONS-SI-155-L2 - For a cable length of 40km, use a 2 dB attenuator. Use a 10 dB attenuator for short distances to avoid receiver overload.

Note Multimode SFP is not supported with TSoP.

De-jitter Buffer

A de-jitter buffer is a component in a packet-based network that helps mitigate the effects of jitter. Jitter refers to the variation in the arrival time of packets, which can lead to inconsistent delays and packet loss in real-time applications like voice or video.

The de-jitter buffer works by temporarily storing incoming packets and then releasing them at a regulated pace. It smooths out the variations in packet arrival times and ensures a more consistent and reliable stream of packets for playback.

The primary purpose of the de-jitter buffer is to ensure a steady and continuous playback of real-time data, such as voice packets in a voice-over-IP (VoIP) call. By absorbing and compensating for the variable delay, it helps maintain a stable voice quality without noticeable gaps or interruptions in the audio stream.

The size of the de-jitter buffer is a critical parameter to consider in network design. It should be large enough to handle the maximum expected delay variation (jitter) while still providing an acceptable level of delay. However, the buffer cannot be too large, as excessive buffering can introduce additional delay and affect the real-time nature of the application.

The de-jitter buffer for the TSoP can be configured to the following values:

- 292
- 627
- 810
- 1296
- 2633

Example configuration

This example shows how to configure De-jitter buffer.

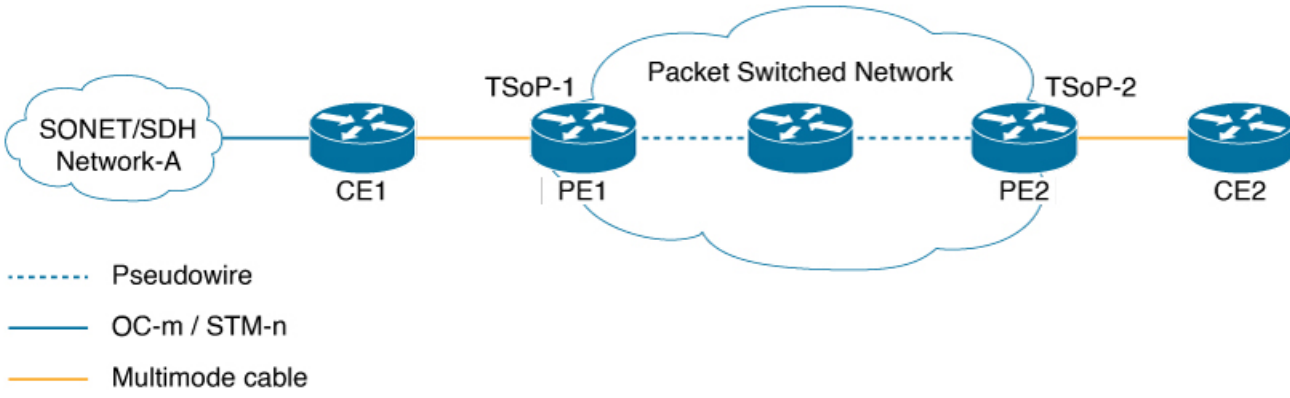
```
sh controll cem 0/0/0/10 payload-dejitter-mapping
Thu Jan 19 12:40:16.206 UTC
Client type : STM1
Client rate (in kbps) : 155000
Client default payload (in bytes) : 810
Client default dejitter (in usec) : 1296

Payload (in bytes) Possible dejitter values (in microseconds)
-----------------------------------------------------------
810 2633, 1296, 627, 292

For configuring out of range, we will get the below error:
Int CEM <>
```

```
cem payload 810 dejitter 696
!
```

Configuration for TSoP

Here is a sample configuration for TSoP:

Figure 28: TSoP in Packet Switched Network



Pre-requisites

These are the prerequisites for configuring PE routers and CE (SONET or SDH) routers for TSoP:

- The following are the pre-requisites on CE routers ASR 903:
  - The CE side routers must be ASR 903 operating on RSP4 or RSP3
  - SFP-OC3-SR must be plugged into ASR 903 for transmitting SONET or SDH packets
  - Supported Interface modules are:
    - NCS4200-1T8S-20CS
    - A900-IMA3G-1MSG
- The PE side routers must be NCS 5500.
- PE and CE routers must be connected using multimode cable
- Only static L2VPN tunnel configuration is supported
- Sync-E should be operational

Note Traffic switch over is not supported even when multiple links are available. Traffic flow occurs as per the adjacent labels or hops defined by the user during static L2VPN tunnel configuration

Configuration for

1. This example shows how to configure clock synchronization on the PE routers.

   - Configuring Smart SFP in PE1

   ```
   Router(config)# frequency synchronization quality itu-t option 1
   Router(config)# interface GigabitEthernet0/0/0/5
   Router(config)# no shut
   Router(config)# frequency synchronization
   Router(config)# quality transmit exact itu-t option 1 PRC
   ```

   - Configuring Smart SFP in PE2

   ```
   Router(config)# frequency synchronization quality itu-t option 1
   Router(config)# interface GigabitEthernet0/0/0/18
   Router(config)# frequency synchronization
   Router(config)# selection input
   Router(config)# priority 1
   Router(config)# wait-to-restore 0
   ```

2. This example shows how to configure PE and CE interfaces.

   - Configuration at CE1

   ```
   Router(config)# interface CEM0/0/0/10
   Router(config)# l2transport
   ```

   - Configuration at PE1

   ```
   Router(config)# interface GigabitEthernet0/0/0/5
   Router(config)# ipv4 address 10.1.1.1 255.255.255.0
   Router(config)# no shut
   ```

   - Configuration at CE2

   ```
   Router(config)# interface CEM0/0/0/17
   Router(config)# l2transport
   ```

   - Configuration at PE2

   ```
   Router(config)# interface GigabitEthernet0/0/0/18
   Router(config)# ipv4 address 10.1.1.2 255.255.255.0
   Router(config)# no shut
   ```

3. This example shows how to configure loopback interface.

   - Configuration at PE1

   ```
   Router(config)# interface Loopback0
   Router(config)# ipv4 address 1.1.1.1 255.255.255.255
   ```

   - Configuration at PE2

   ```
   Router(config)# interface Loopback0
   Router(config)# ipv4 address 1.1.1.4 255.255.255.255
   ```

4. This example shows how to configure the ISIS IGP and advertise loopback and core interfaces.

   - Configuration at PE1

   ```
   Router(config)# router isis core
   Router(config)#is-type level-2-only
   Router(config)#net 49.0000.0000.0000.0001.00
   Router(config)#nsr
   ```

```
Router(config)#nsf cisco
Router(config)#log adjacency changes
Router(config)#address-family ipv4 unicast
Router(config)#metric-style wide
Router(config)#segment-routing mpls sr-prefer
Router(config)#segment-routing bundle-member-adj-sid
Router(config)#address-family ipv6 unicast
Router(config)#metric-style wide
Router(config)#segment-routing mpls sr-prefer
Router(config)#segment-routing bundle-member-adj-sid
Router(config)#interface Loopback0
Router(config)#point-to-point
Router(config)#address-family ipv4 unicast
Router(config)#prefix-sid index 1
Router(config)#address-family ipv6 unicast
Router(config)#interface GigabitEthernet0/0/0/5
Router(config)#point-to-point
Router(config)#address-family ipv4 unicast
Router(config)#adjacency-sid absolute 28121
Router(config)#address-family ipv6 unicast
```

- Configuration at PE2

```
Router(config)#router isis core
Router(config)#is-type level-2-only
Router(config)#net 49.0000.0000.0000.0004.00
Router(config)#nsr
Router(config)#nsf cisco
Router(config)#log adjacency changes
Router(config)#address-family ipv4 unicast
Router(config)#metric-style wide
Router(config)#segment-routing mpls sr-prefer
Router(config)#segment-routing bundle-member-adj-sid
Router(config)#address-family ipv6 unicast
Router(config)#metric-style wide
Router(config)#segment-routing mpls sr-prefer
Router(config)#segment-routing bundle-member-adj-sid
Router(config)#interface Loopback0
Router(config)#point-to-point
Router(config)#address-family ipv4 unicast
Router(config)#prefix-sid index 4
Router(config)#address-family ipv6 unicast
Router(config)#interface GigabitEthernet0/0/0/18
Router(config)#point-to-point
Router(config)#address-family ipv4 unicast
Router(config)#adjacency-sid absolute 28211
Router(config)#address-family ipv6 unicast
```

5. This example shows how to configure Circuit-styled Segment routing traffic engineering tunnels.

- Configuration at PE1

```
Router(config)#segment-routing
Router(config)#global-block 80000 111999
Router(config)#local-block 25000 28999
Router(config)#traffic-eng
Router(config)#segment-list pe1-pe2-forward-path
Router(config)#index 1 mpls label 28121
Router(config)#segment-list pe1-pe2-reverse-path
Router(config)#index 1 mpls label 28211
Router(config)#policy pe1-pe2-circuit-styled-srte
Router(config)#color 10 end-point ipv4 1.1.1.4
```

```
Router(config)#path-protection
Router(config)#candidate-paths
Router(config)#preference 10
Router(config)#explicit segment-list pe1-pe2-forward-path
Router(config)#reverse-path segment-list pe1-pe2-reverse-path
```

- Configuration at PE2

```
Router(config)#segment-routing
Router(config)#global-block 80000 111999
Router(config)#local-block 25000 28999
Router(config)#traffic-eng
Router(config)#segment-list pe1-pe2-forward-path
Router(config)#index 1 mpls label 28121
Router(config)#segment-list pe1-pe2-reverse-path
Router(config)#index 1 mpls label 28211
Router(config)#policy pe1-pe2-circuit-styled-srte
Router(config)#color 10 end-point ipv4 1.1.1.4
Router(config)#path-protection
Router(config)#candidate-paths
Router(config)#preference 10
Router(config)#explicit segment-list pe1-pe2-forward-path
Router(config)#reverse-path segment-list pe1-pe2-reverse-path
```

6. This example shows how to configure BGP EVPN neighbor session.

- Configuration at PE1

```
Router(config)#router bgp 100
Router(config)#bgp router-id 1.1.1.1
Router(config)#bgp graceful-restart
Router(config)#address-family ipv4 unicast
Router(config)#address-family l2vpn evpn
Router(config)#neighbor 1.1.1.4
Router(config)#remote-as 100
Router(config)#update-source Loopback0
Router(config)#graceful-restart
Router(config)#address-family l2vpn evpn
```

- Configuration at PE2

```
Router(config)#bgp router-id 1.1.1.4
Router(config)#bgp graceful-restart
Router(config)#address-family ipv4 unicast
Router(config)#address-family l2vpn evpn
Router(config)#neighbor 1.1.1.1
Router(config)#remote-as 100
Router(config)#update-source Loopback0
Router(config)#graceful-restart
Router(config)#address-family l2vpn evpn
```

7. This example shows how to configure EVPN xconnect.

- Configuration at PE1

```
Router(config)#l2vpn
Router(config)#pw-class pw-cs-srte
Router(config)#encapsulation mpls
Router(config)#preferred-path sr-te policy pe1-pe2-circuit-styled-srte
Router(config)#xconnect group evpn_vpws
Router(config)#p2p p1
Router(config)#interface CEM0/0/0/10
```

```
Router(config)#neighbor evpn evi 10 target 1 source 2
Router(config)#pw-class pw-cs-srte
```

- Configuration at PE2

```
Router(config)#l2vpn
Router(config)#pw-class pw-cs-srte
Router(config)#encapsulation mpls
Router(config)#preferred-path sr-te policy pe1-pe2-circuit-styled-srte
Router(config)#xconnect group evpn_vpws
Router(config)#p2p p1
Router(config)#interface CEM0/0/0/17
Router(config)#neighbor evpn evi 10 target 2 source 1
Router(config)#pw-class pw-cs-srte
```

8. This example shows how to configure Dejitter.

- Configuration at PE1

```
Router(config)#int cem0/0/0/10
Router(config)#cem payload 810 dejitter 696
```

- Configuration at PE2

```
Router(config)#int cem0/0/0/17
Router(config)#cem payload 810 dejitter 696
```

Verification

Use the **show inventory** command to display all TSoP Smart SFPs installed on the router.

```
Router#show inventory
NAME: "GigabitEthernet0/0/0/17", DESCR: "Cisco SFP TSOP STM1 Pluggable Optics Module"
PID: SFP-TS-OC3STM1-I , VID: V01, SN: OEA2536001J
```

Use the **show hw-module fpd** command to display TSoP Smart SFPs FPD version.

```
Router#show hw-module fpd
Auto-upgrade:Disabled
FPD Versions
==============
Location Card type HWver FPD device ATR Status Running Programd
--------------------------------------------------------------------------------------------
0/RP0 NCS-55A2-MOD-SE-S 1.0 MB-MIFPGA CURRENT 0.21 0.21
0/RP0 NCS-55A2-MOD-SE-S 1.0 SSFP_OC3_STM1_6 CURRENT 12.01 12.01
0/RP0 NCS-55A2-MOD-SE-S 1.0 SSFP_STM1_TSOP_17 CURRENT 13.00 13.00  <<<<
0/RP0 NCS-55A2-MOD-SE-S 1.0 Bootloader CURRENT 1.18 1.18
0/RP0 NCS-55A2-MOD-SE-S 1.0 CPU-IOFPGA CURRENT 1.27 1.27
0/RP0 NCS-55A2-MOD-SE-S 1.0 MB-IOFPGA NEED UPGD 0.18 0.18
0/RP0 NCS-55A2-MOD-SE-S 1.0 SATA-INTEL_240G NEED UPGD 1120.00 1120.00
0/PM0 NC55-1200W-ACFW 1.0 LIT-PriMCU-ACFW CURRENT 2.09 2.09
0/PM1 NC55-1200W-ACFW LIT-PriMCU-ACFW NOT READY
RP/0/RP0/CPU0:ios#
```

Use the **show ipv4 interface brief** command to display the interface status.

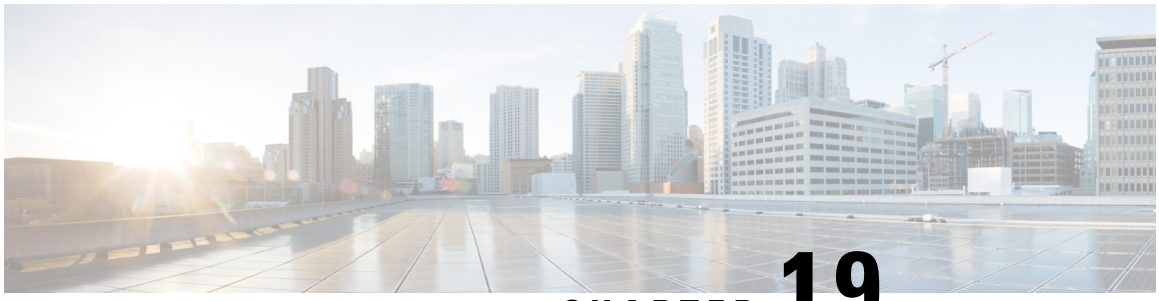
```
Router#show ipv4 interface brief
Interface IP-Address Status Protocol Vrf-Name
MgmtEth0/RP0/CPU0/0 unassigned Shutdown Down default
TenGigE0/0/0/0 unassigned Shutdown Down default
GigabitEthernet0/0/0/1 unassigned Shutdown Down default
GigabitEthernet0/0/0/2 unassigned Shutdown Down default
TenGigE0/0/0/3 unassigned Shutdown Down default
```

```
TenGigE0/0/0/4 unassigned Shutdown Down default
GigabitEthernet0/0/0/5 unassigned Shutdown Down default
GigabitEthernet0/0/0/6 unassigned Up Up default
GigabitEthernet0/0/0/7 unassigned Shutdown Down default
GigabitEthernet0/0/0/8 unassigned Shutdown Down default
GigabitEthernet0/0/0/9 unassigned Shutdown Down default
GigabitEthernet0/0/0/10 unassigned Shutdown Down default
TenGigE0/0/0/11 unassigned Shutdown Down default
TenGigE0/0/0/12 unassigned Shutdown Down default
TenGigE0/0/0/13 unassigned Shutdown Down default
TenGigE0/0/0/14 unassigned Shutdown Down default
TenGigE0/0/0/15 unassigned Shutdown Down default
GigabitEthernet0/0/0/16 unassigned Up Up default
CEM0/0/0/17 unassigned Up Up default   <<<
GigabitEthernet0/0/0/18 unassigned Shutdown Down default
TenGigE0/0/0/19 unassigned Shutdown Down default
```

Use the **show controller cem** verifying TSoP smart SFP stats and Dejitter configuration.

```
Router#show controller cem 0/0/0/17
Interface : CEM0/0/0/17
Admin state : Up
Oper state : Up
Port bandwidth : 155000 kbps
Dejitter buffer (oper/in-use) : 1296/180064 usec   <<<<<<
Payload size (oper) : 810 bytes
PDV (min/max/avg) : 51589/142643/97116 usec
Dummy mode : last-frame
Dummy pattern : 0x0
Idle pattern : 0x0
Signalling : No CAS
RTP : Not Enabled
Clock type : Differential
Detected Alarms : None

Statistics Info
---------------
Ingress packets : 0, Ingress packets drop : 0
Egress packets : 0, Egress packets drop : 0
Total error : 1145472000
Missing packets : 572736000, Malformed packets : 0
Jitter buffer underrun : 572736000, Jitter buffer overrun : 0
Misorder drops : 0
Reordered packets : 0, Frames fragmented : 0
Error seconds : 0, Severely error seconds : 0
Unavailable seconds : 0, Failure counts : 0

Generated L bits : 0, Received L bits : 0
Generated R bits : 0, Received R bits : 0

Endpoint Info
-------------
Passthrough : No

//Run the same command on CEm interface of PE1 router.

Router#show controll CEM0/0/0/10
Sat Mar 25 10:49:19.471 UTC
Interface                         : CEM0/0/0/6
Admin state                       : Up
Oper  state                       : Up
Port bandwidth                    : 155000 kbps
Dejitter buffer (oper/in-use)     : 1296/180645 usec
Payload size (oper)               : 810 bytes
PDV (min/max/avg)                 : 51589/142643/97116 usec
```

```
Dummy mode                          : last-frame
Dummy pattern                       : 0xab
Idle pattern                        : 0xff
Signalling                          : No CAS
RTP                                 : Enabled
Clock type                          : Differential
Detected Alarms                     : None

Statistics Info
---------------
Ingress packets          : 0, Ingress packets drop     : 0
Egress packets           : 0, Egress packets drop      : 0
Total error              : 385536000
        Missing packets          : 192768000, Malformed packets        : 0
        Jitter buffer underrun   : 192768000, Jitter buffer overrun    : 0
        Misorder drops           : 0
Reordered packets        : 0, Frames fragmented        : 0
Error seconds            : 0, Severely error seconds   : 0
Unavailable seconds      : 0, Failure counts           : 0

Generated L bits         : 0, Received  L bits         : 0
Generated R bits         : 0, Received  R bits         : 0

Endpoint Info
-------------
Passthrough     : No
RP/0/RP0/CPU0:Router#
```



CHAPTER 19

Managing Router Hardware

This chapter describes about clearing the memory and partitions of an RP or a line card before an RMA (Return Merchandise Authorization).

Clear the Memory and the Partitions of a Card

Users can clear the memory and the partitions of an RP or a line card before an RMA (Return Merchandise Authorization). Clearing the memory and partitions of the card is performed when the card is defective and has to be returned.

When a line card or an RP is identified for an RMA, the user might want to remove the card from the chassis. However, the service personnel may not be available onsite to remove the card immediately. By clearing the memory and partitions of the card, the users can clear the RP or the line card and power-off the card and also let it remain in the slot.

After clearing the memory, do not reload the card or the chassis until the card is removed from the slot. This is because reloading will reboot the card or the chassis resulting in restoring the data that was erased.

In a dual RP system, the reset of the standby RP must be executed from the active RP. Once the standby RP has been cleaned, the standby RP will be shut down to prevent resync with the active RP.

Prerequisites

XR VM and the System Admin VM must be operational.

Note Do not perform an admin process restart, card reload, or an FPD upgrade while clearing the memory and partitions of the card.

Commands

Run the following commands from the XR VM to clear the memory and the partitions of the card:

- **show zapdisk locations**- displays the locations where the memory and the partition can be cleared.
- **zapdisk start location** <*location-id*> - clears the memory and the partition from the specified location.

The following steps explain how to clear the memory or the partition of the card:

1. Display the Locations to Clear the Memory - Use the **show zapdisk locations** command to display the locations to be cleared.

   The following example shows how to display the location:

```
<! Display the Locations to Clear the Memory !>

Router# show zapdisk locations
0/RP1      Fully qualified location specification
0/2        Fully qualified location specification
0/6        Fully qualified location specification
all        all locations

Router#conf t
Router(config)#logging console disable
Router(config)#commit
Router(config)#end
```

2. Clear the Memory or Partition - Use the **zapdisk start location** command to clear the memory or partition.

   The following example shows how to clear the memory or partition:

```
<! Clear the Memory or Partition !>

Router#zapdisk start location 0/2
Action on designated location is in progress, please monitor admin syslog.
Action on designated location is in progress, please monitor admin syslog.

Router#zapdisk start location 0/6
Action on designated location is in progress, please monitor admin syslog.
Action on designated location is in progress, please monitor admin syslog.

Router#zapdisk start location 0/RP1
Action on designated location is in progress, please monitor admin syslog.
Action on designated location is in progress, please monitor admin syslog.
```

3. Verify that the memory and the partition is cleared - Use **show logging**, **show platform**, **show controller card**, and **show reboot-history card location** commands to verify if the memory and partitions are cleared.

   The following example shows how to verify if the memory and partitions are successfully cleared:

```
<!Verification!>

sysadmin-vm:0_RP0# show controller card-mgr event-history brief location 0/2

Card Event History for: 0/2

Card Event History as seen by Master (0/RP0)
  Current State: ZAPDISK_POWERED_ON

  DATE   TIME (UTC)    STATE                   EVENT
  -----  ------------  ----------------------  ------------------------------
  03/04  22:26:13.400  ZAPDISK_RESET           ev_dm1_power_up_ok
  03/04  22:26:02.630  SYSADMIN_VM_GOING_DOWN  ev_zapdisk_req
  03/04  22:25:46.660  CARD_READY              ev_sysadmin_vm_shutdown
```

```
  03/04  21:58:14.842  OIR_INSERT_NOTIF        if_card_local_init_done
  03/04  21:58:14.841  WAIT_CARD_INFO          ev_card_info_synced
  03/04  21:57:57.219  WAIT_SYSADMIN_VM_READY  ev_sysadmin_vm_booted
  03/04  21:57:45.305  HOST_OS_RUNNING         ev_sysadmin_vm_started
  03/04  21:57:24.371  BOOTLDR_STARTED         ev_host_os_started
  03/04  21:56:04.619  CARD_POWERED_ON         ev_bootldr_started
  03/04  21:55:58.212  CARD_IN_RESET           ev_dm1_power_up_ok
  03/04  21:55:45.397  IMAGE_INSTALLED         ev_ios_install_reset
  03/04  21:55:44.896  INSTALLING_IMAGE        ev_ios_install_done
  03/04  21:54:53.045  WAIT_FIRST_EVENT        ev_ios_install_started
  03/04  21:54:53.043  IDLE                    ev_present

sysadmin-vm:0_RP0# show controller card-mgr event-history brief location 0/6
Card Event History for: 0/6

Card Event History as seen by Master (0/RP0)
  Current State: ZAPDISK_POWERED_ON

  DATE   TIME (UTC)    STATE                  EVENT
  -----  ------------  ---------------------  ------------------------------
  03/04  22:26:14.309  ZAPDISK_RESET          ev_dm1_power_up_ok
  03/04  22:26:03.722  SYSADMIN_VM_GOING_DOWN  ev_zapdisk_req
  03/04  22:25:49.563  CARD_READY             ev_sysadmin_vm_shutdown
  03/04  22:00:32.071  OIR_INSERT_NOTIF       if_card_local_init_done
  03/04  22:00:32.070  WAIT_CARD_INFO         ev_card_info_synced
  03/04  22:00:10.314  WAIT_SYSADMIN_VM_READY  ev_sysadmin_vm_booted
  03/04  21:59:57.999  HOST_OS_RUNNING        ev_sysadmin_vm_started
  03/04  21:59:35.271  BOOTLDR_STARTED        ev_host_os_started
  03/04  21:58:18.244  CARD_POWERED_ON        ev_bootldr_started
  03/04  21:58:11.836  CARD_IN_RESET          ev_dm1_power_up_ok
  03/04  21:57:59.122  IMAGE_INSTALLED        ev_ios_install_reset
  03/04  21:57:58.521  INSTALLING_IMAGE       ev_ios_install_done
  03/04  21:54:53.045  WAIT_FIRST_EVENT       ev_ios_install_started
  03/04  21:54:53.043  IDLE                   ev_present

Aborted: by user
sysadmin-vm:0_RP0# show controller card-mgr event-history brief location 0/RP1
Card Event History for: 0/RP1

Card Event History as seen by Master (0/RP0)
  Current State: ZAPDISK_POWERED_ON

  DATE   TIME (UTC)    STATE                  EVENT
  -----  ------------  ---------------------  ------------------------------
  03/04  22:26:24.730  ZAPDISK_RESET          ev_dm1_power_up_ok
  03/04  22:26:04.503  HOST_GOING_DOWN        ev_zapdisk_req
  03/04  22:26:00.677  SYSADMIN_VM_GOING_DOWN  ev_host_shutdown_started
  03/04  22:25:54.770  CARD_READY             ev_sysadmin_vm_shutdown
  03/04  21:57:28.878  OIR_INSERT_NOTIF       if_card_local_init_done
  03/04  21:57:28.878  WAIT_CARD_INFO         ev_card_info_synced
  03/04  21:57:11.443  WAIT_SYSADMIN_VM_READY  ev_sysadmin_vm_booted
  03/04  21:56:59.228  HOST_OS_RUNNING        ev_sysadmin_vm_started
  03/04  21:56:31.882  BOOTING_IOS_IMAGE      ev_host_os_started
  03/04  21:56:26.466  BOOTING_IOS_IMAGE      ev_boot_kernel
  03/04  21:56:12.834  CARD_POWERED_ON        ev_bootldr_ssd_boot
  03/04  21:56:09.730  CARD_IN_RESET          ev_dm1_power_up_ok
  03/04  21:55:48.701  IMAGE_INSTALLED        ev_ios_install_reset
  03/04  21:55:47.700  INSTALLING_IMAGE       ev_ios_install_done
  03/04  21:54:53.046  WAIT_FIRST_EVENT       ev_ios_install_started
Aborted: by user
sysadmin-vm:0_RP0# show logging | i card_mgr
0/RP0/ADMIN0:Mar  4 22:26:03.240 : card_mgr[3211]: %DRIVER-CARD_MGR-5-ZAPDISK_STARTED :
 Card cleanup started for location 0/2
0/RP0/ADMIN0:Mar  4 22:26:04.332 : card_mgr[3211]: %DRIVER-CARD_MGR-5-ZAPDISK_STARTED :
```

```
 Card cleanup started for location 0/6
0/RP0/ADMIN0:Mar  4 22:26:04.503 : card_mgr[3211]: %DRIVER-CARD_MGR-5-ZAPDISK_STARTED :
 Card cleanup started for location 0/RP1
sysadmin-vm:0_RP0# show reboot-history card location 0/2
Card Reboot History for 0/2
 0
  Reason Code  22
  Reason       "ZAPDISK by user request"
  Src Location 0/RP0
  Src Name     card_mgr
sysadmin-vm:0_RP0# show reboot-history card location 0/6

Card Reboot History for 0/6
 0
    Reason Code  22
  Reason       "ZAPDISK by user request"
  Src Location 0/RP0
  Src Name     card_mgr
sysadmin-vm:0_RP0# show reboot-history card location 0/RPCard Reboot History for 0/RP1
 0
    Reason Code  22
  Reason       "ZAPDISK by user request"
  Src Location 0/RP0
  Src Name     card_mgr

sysadmin-vm:0_RP0# show reboot-history card location 0/RP1
Card Reboot History for 0/RP1
 0
    Reason Code  22
  Reason       "ZAPDISK by user request"
  Src Location 0/RP0
  Src Name     card_mgr
```

4. Power-Down the Card - Shut down the card.

Automatic Fabric Link Shutdown

Table 78: Feature History Table

Feature Name	Release Information	Feature Description
Automatic Fabric Link Shutdown	Release 7.4.1	If a fabric link goes down 30 times in 24 hours, this feature automatically shuts down the faulty fabric link. In doing so, any traffic blackholes that lead to traffic losses are avoided.

This feature enables automatic shutdown of faulty fabric link that experiences excessive flapping. The shutdown is triggered if a fabric link flaps for more than 30 times within 24 hours. With the faulty link being shut down, the traffic moves to a stable link avoiding any traffic disruption.

An error message on the console and a syslog entry captures the fault details for further troubleshooting.

```
0/FC5/ADMIN0:May 24 23:20:58.460 UTC: sfe_driver[7560]: %FABRIC-SFE_DRVR-4-LINK_SHUT :
[7560] : link 0/FC5/0/137 is too noisy and will be shut down
```

This feature is supported on:

- All Cisco NCS 5500 series modular routers
- NCS-55A1-36H-SE, NCS-55A1-36H-S, NCS-5502-SE, and NCS-5502 fixed port routers

To recover the faulty fabric link:

- Reboot the fabric card in modular routers
- Reboot the fixed port routers

If there's traffic drop even after reboot, contact Cisco Technical Support.

System Logs during RSP Switchover

Table 79: Feature History Table

Feature Name	Release Information	Feature Description
RSP Slot Location in Syslog	Release 7.8.1	When an RSP switchover occurs, the router logs the active RSP slot location in the syslog message. This helps you quickly identify the active RSP slot from your router's system log messages. In earlier releases, the RSP switchover Syslog message didn't include the active RSP slot location.

In the event of an RSP switchover, the router logs the following syslog messages:

```
RP/0/1/CPU0:Feb 19 09:08:00.655 UTC: rmf_svr[436]: %HA-REDCON-6-GO_ACTIVE : this card going
 active
RP/1/1/CPU0:Mar 8 11:43:29.041 UTC: rmf_svr[147]: %HA-REDCON-6-GO_STANDBY : this card going
 standby, location RP/1/1/CPU0
```

From Cisco IOS XR Release 7.8.1 onwards, the RSP switchover syslog message for the active RSP includes the RSP slot location as well:

```
RP/0/1/CPU0:Mar  8 11:42:50.876 UTC: rmf_svr[165]: %HA-REDCON-6-GO_ACTIVE : this card going
 active , location RP/0/1/CPU0:
```

Configurable Fault Recovery Attempts

Table 80: Feature History Table

Feature Name	Release Information	Feature Description
Configurable Fault Recovery Attempts	Release 24.3.1	

Feature Name	Release Information	Feature Description
		Introduced in this release on: NCS 5500 modular routers (NCS 5500 line cards; NCS 5700 line cards [Mode: Compatibility; Native]) You can now reduce the risk of traffic loss by controlling fault recovery attempts by a line card, fabric card, shelf controller, or route processor. This feature allows you to specify the number of recovery attempts before the card is shut down, offering greater control and flexibility. This feature is disabled by default. The feature introduces these changes: **CLI**: • **hw-module fault-recovery** **YANG DATA Model**: • New XPaths for Cisco-IOS-XR-hw-module-cfg.yang (see Github, YANG Data Models Navigator) This feature is supported on the Cisco NCS 5500 series modular routers and on these line cards: • NC57-48Q2D-S • NC57-48Q2D-SE-S • NC57-36H6D-S • NC55-24X100G-SE • NC55-36X100G-A-SE • NC55-MOD-A-S • NC55-MOD-A-SE-S • NC55-36X100G-S • NC55-36X100G

Fault Recovery Mechanism

Fault recovery is a mechanism designed to handle faults in hardware components such as line cards, fabric cards, shelf controllers, and route processors. This mechanism ensures that a faulty card does not enter a continuous cycle of automatic recovery attempts, which can lead to operational instability.

How Fault Recovery Mechanism Works

The critical alarms lead to hardware module reload for recovery. Reloading a card shifts the traffic to an alternate path. After the hardware module reload is completed, the traffic streams move back. If the errors persist, the traffic switch may continue until someone eventually brings down the card. Depending on the configured features and the overall capacity and traffic load going through the router, there is a potential for traffic loss if one hardware module keeps reloading and trying to take the traffic load momentarily.

In the previous releases, if a router, line card, fabric card, shelf controller, or a route processor experienced a fault, they used to trigger fault recovery and reboot themselves to be operational. Fault recovery mechanism was time based as the fault recovery count used to reset to zero if the card remained operational for more than an hour. After the fault recovery count exceeded five, then the faulty card was shut down. As power related faults triggered were not frequent, and fault recovery count used to reset to zero, the card never entered the shut down mode. As a result, the card always attempted for fault recovery.

How to Control Fault Recovery Attempts

Rather than reloading hardware modules for fault recovery when the router is carrying live traffic, it is better to power down the affected hardware module and notify users to attempt recovery in a controlled environment. You can set the number of recovery attempts to shut down the card.

With the Cisco IOS XR Software Release 24.3.1, we have introduced the **hw-module fault-recovery** command with which you can set the number of times a fault recovery can take place before permanently shutting down a faulty card.

For example, if you configure the fault recovery count to 1, the router will reboot the faulty module after the first recovery. On the next attempt, the router shuts down or powers off the faulty module.

Restrictions and Guidelines for Configurable Fault Recovery Attempts

Guidelines for Configurable Fault Recovery Attempts

Follow these guidelines for configuring fault recovery attempts:

- Configure the **hw-module fault-recovery** *location* command for each location individually. To apply this configuration to all the locations, specify each location individually and then save your changes.
- This feature is disabled by default.

Restrictions for Configurable Fault Recovery Attempts

These restrictions apply when you configure fault recovery attempts:

- When you configure the **hw-module fault-recovery** *location* command, the router prompt displays the *location all* option, but it is not functional.

Configure Fault Recovery Attempts

Configuration Examples

This configuration example shows how to configure a fault recovery attempt on the fabric card FC0.

```
Router#configure
Router (config)#hw-module fault-recovery location 0/FC0 count 1
Router(config)#commit
```

This configuration example shows how to configure fault recovery on multiple locations.

```
Router#configure
Router (config)#hw-module fault-recovery location 0/FC1 count 1
Router (config)#hw-module fault-recovery location 0/RP0 count 2
Router (config)#hw-module fault-recovery location 0/FT2 count 1
Router(config)#commit
```

Note If you do not specify the fault-recovery count for **location**, the router sets the **count** value to three by default.

Verification

Use **show running-config formal | include hw-module** command to display the number of times a card can initiate recovery attempts before shutting down .

```
Router#show running-config formal | include hw-module
Building configuration...
hw-module fault-recovery location 0/FC0 count 1
```

The following system log is generated when the number of fault recovery attempts on the card exceeds the configured count:

```
Router:Dec 4 15:44:25.247 PST: shelfmgr[121]: %PLATFORM-SHELFMGR-4-CARD_SHUTDOWN : Shutting
down 0/FC0: Fault retry attempts exceeded configured count(1)
```

Use the **show reboot history** command to get the reason of card shutting down. In the following example, it shows that the card was shut down due to **Fault retry attempts exceeded configured count(1)**.

```
Router:ios#show reboot history location 0/FC0 detail
Mon Dec  4 15:44:55.827 PST
------------------------------------------------------------------------------
No   Attribute       Value
------------------------------------------------------------------------------
1    Time (PST)      Dec 04 2023 15:44:22
     Cause Code      0x0800000d
     Cause String    REBOOT_CAUSE_FM
     Graceful Reload No
     Kdump Requested No
     Reason          Fault retry attempts exceeded configured count(1)
```

Use the **show platform** command to see the current state of the card that was shut down because of Fault recovery handling feature.

```
Router:ios#show platform
Mon Oct 2 21:08:03.383 UTC

Location  Card Type        HW State         SW State       Config State
------------------------------------------------------------------------------
```

```
0/0       NC55-36X100G     POWERED_OFF     SW_INACTIVE     NSHUT
0/1       NC55-36X100G-S   OPERATIONAL     OPERATIONAL     NSHUT
0/2       NC55-36X100G-S   OPERATIONAL     OPERATIONAL     NSHUT
0/3       NC55-36X100G     OPERATIONAL     OPERATIONAL     NSHUT
0/6       NC55-36X100G-S   OPERATIONAL     OPERATIONAL     NSHUT
0/8       NC55-36X100G-S   OPERATIONAL     OPERATIONAL     NSHUT
0/15      NC55-36X100G     OPERATIONAL     OPERATIONAL     NSHUT
0/RP0     NC55-RP          OPERATIONAL     OPERATIONAL     NSHUT
0/RP1     NC55-RP          OPERATIONAL     OPERATIONAL     NSHUT
0/FC0     NC55-5516-FC     SHUT DOWN       OPERATIONAL     NSHUT
0/FC1     NC55-5516-FC     OPERATIONAL     OPERATIONAL     NSHUT
0/FC2     NC55-5516-FC     OPERATIONAL     OPERATIONAL     NSHUT
0/FC3     NC55-5516-FC     OPERATIONAL     OPERATIONAL     NSHUT
0/FC4     NC55-5516-FC     OPERATIONAL     OPERATIONAL     NSHUT
0/FC5     NC55-5516-FC     OPERATIONAL     OPERATIONAL     NSHUT
0/FT0     NC55-5516-FAN    OPERATIONAL     N/A             NSHUT
0/FT1     NC55-5516-FAN    OPERATIONAL     N/A             NSHUT
0/FT2     NC55-5516-FAN    OPERATIONAL     N/A             NSHUT
0/PM0     N9K-PAC-3000W-B  OPERATIONAL     N/A             NSHUT
16/07/24, 14:58
Router#
```