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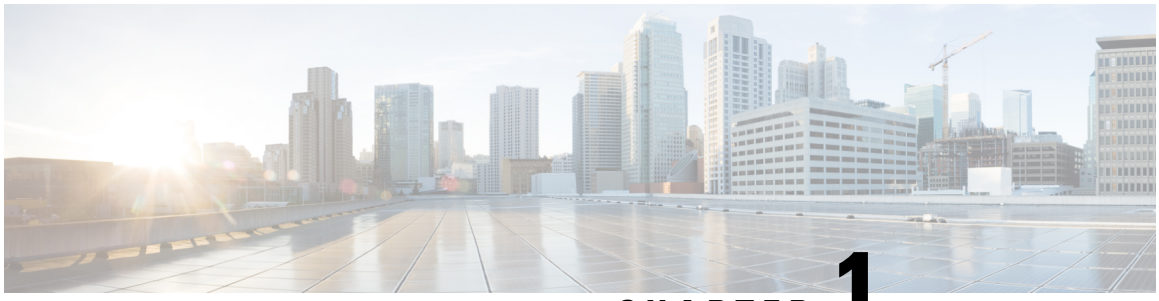


CHAPTER 1

YANG Data Models for System Management Features

This chapter provides information about the YANG data models for System Management features.

- Using YANG Data Models, on page 1

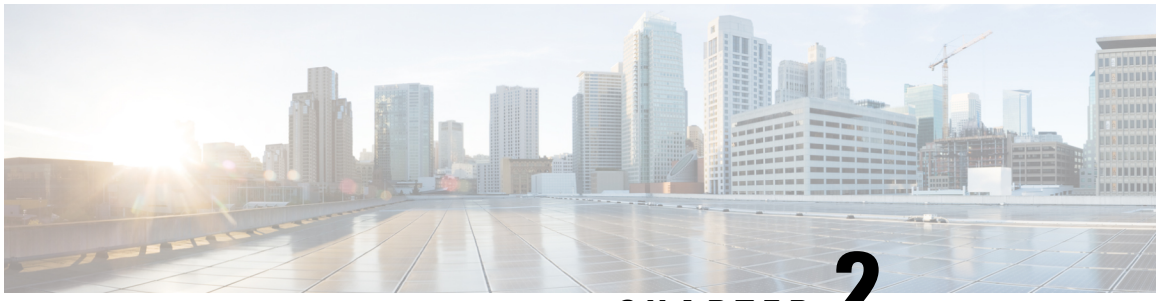
Using YANG Data Models

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 2

Configuring Flexible Command Line Interface

This module describes how to configure and use flexible command line interface (CLI) configuration groups.

- Flexible CLI Configuration Groups, on page 3
- Flexible Configuration Restrictions, on page 3
- Configuring a Configuration Group, on page 5
- Verifying the Configuration of Configuration Groups, on page 7
- Regular Expressions in Configuration Groups, on page 8
- Configuration Examples for Flexible CLI Configuration, on page 20

Flexible CLI Configuration Groups

Flexible command line interface (CLI) configuration groups provide the ability to minimize repetitive configurations by defining a series of configuration statements in a configuration group, and then applying this group to multiple hierarchical levels in the router configuration tree.

Flexible CLI configuration groups utilize regular expressions that are checked for a match at multiple submodes of the configuration tree based on where the group is applied within the hierarchy. If a match is found at a configuration submode, the corresponding configuration defined in the group is inherited within the matched submode.

Flexible CLI configuration groups also provide an auto-inheritance feature. Auto-inheritance means that any change done to a CLI configuration group is automatically applied to the configuration in any matched submodes that have an apply-group at that hierarchical level. This allows you to make a configuration change or addition once, and have it applied automatically in multiple locations, depending on where you have applied the flexible CLI configuration group.

Flexible Configuration Restrictions

Note these restrictions while using flexible configuration groups:

- Flexible CLI configuration groups are not supported in administration configurations and corresponding apply-groups are not supported in administration configurations.
- Use of preconfigured interfaces in configuration groups is not supported.
- Downgrading from an image that supports configuration groups to an image that does not support them is not supported.

- Access lists, quality of service and route policy configurations do not support the use of configuration groups. Configurations such as these are not valid:

```
group g-not-supported
 ipv4 access-list ...
 !
 ipv6 access-list ...
 !
 ethernet-service access-list ...
 !
 class-map ...
 !
 policy-map ...
 !
 route-policy ...
 !
end-group
```

  You can, however, reference such configurations, as shown in this example:

```
group g-reference-ok
 router bgp 6500
  neighbor 7::7
   remote-as 65000
   bfd fast-detect
   update-source Loopback300
   graceful-restart disable
   address-family ipv6 unicast
       route-policy test1 in
    route-policy test2 out
    soft-reconfiguration inbound always
   !
  !
 !
 interface Bundle-Ether1005
   bandwidth 10000000
   mtu 9188
      service-policy output input_1
   load-interval 30
 !
end-group
```

- Some regular expressions are not supported within groups. For example, '?', '|' and '$,' are not supported within groups. Also some characters such as /d and /w are not supported.
  - The choice operator "|" to express multiple match expressions within a regular expression is not supported. For example, these expressions are not supported:

    `Gig.*|Gig.*\..*`—To match on either Gigabit Ethernet main interfaces or Gigabit Ethernet sub-interfaces.

    `Gig.*0/0/0/[1-5]|Gig.*0/0/0/[10-20]`—To match on either Gig.*0/0/0/[1-5] or Gig.*0/0/0/[10-20].

    `'TenGigE.*|HundredGigE.*`—To match on either TenGigE.* or HundredGigE.* .

- Commands that require a node identifier for the **location** keyword are not supported. For example, this configuration is not supported:

```
lpts pifib hardware police location 0/RP0/CPU0
```

- Overlapping regular expressions within a configuration group for the same configuration are not supported. For example:

```
group G-INTERFACE
interface 'gig.*a.*'
  mtu 1500
!
interface 'gig.*e.* '
  mtu 2000
!
end-group

interface gigabitethernet0/0/0/* ---- where * is 0 to 31
  apply-group G-INTERFACE
```

  This configuration is not permitted because it cannot be determined whether the `interface GigabitEthernet0/0/0/*` configuration inherits `mtu 1500` or `mtu 2000`. Both expressions in the configuration group match GigabitEthernet0/0/0/*.

- Up to eight configuration groups are permitted on one apply-group command.

Configuring a Configuration Group

A configuration group includes a series of configuration statements that can be used in multiple hierarchical levels in the router configuration tree. By using regular expressions in a configuration group, you can create generic commands that can be applied in multiple instances.

Use this task to create and use a configuration group.

Note Flexible CLI configurations are not available through the XML interface.

Procedure

Step 1 **configure**

Example:

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

Enters mode.

Step 2 **group** *group-name*

Example:

```
RP/0/RP0/CPU0:router(config)# group g-interf
```

Specifies a name for a configuration group and enters group configuration mode to define the group.The *group-name* argument can have up to 32 characters and cannot contain any special characters.

Step 3 Enter configuration commands, starting from global configuration mode. Use regular expressions for interface names and other variable instances.

Example:

```
RP/0/RP0/CPU0:router(config)# group g-interf
RP/0/RP0/CPU0:router(config-GRP)# interface 'GigabitEthernet.*'
RP/0/RP0/CPU0:router(config-GRP-if)# mtu 1500
```

Specifies the configuration statements that you want included in this configuration group.

For more information regarding the use of regular expressions, see Configuration Group Inheritance with Regular Expressions: Example, on page 17. This example is applicable to all Gigabit Ethernet interfaces.

Step 4 **end-group**

Example:

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

Completes the configuration of a configuration group and exits to global configuration mode.

Step 5 **apply-group**

Example:

```
RP/0/RP0/CPU0:router(config)# interface GigabitEthernet0/2/0/0
RP/0/RP0/CPU0:router(config-if)# apply-group g-interf
```

Adds the configuration of the configuration group into the router configuration applicable at the location that the group is applied. Groups can be applied in multiple locations, and their effect depends on the location and context.

The MTU value from the group g-interf is applied to the interface GigabitEthernet0/2/0/0GigabitEthernet0/0/0/0. If this group is applied in global configuration mode, the MTU value is inherited by all Gigabit Ethernet interfaces that do not have an MTU value configured.

Simple Configuration Group: Example

This example shows how to use configuration groups to add a global configuration to the system:

```
RP/0/RP0/CPU0:router(config)# group g-logging
RP/0/RP0/CPU0:router(config-GRP)# logging trap notifications
RP/0/RP0/CPU0:router(config-GRP)# logging console debugging
RP/0/RP0/CPU0:router(config-GRP)# logging monitor debugging
RP/0/RP0/CPU0:router(config-GRP)# logging buffered 10000000
RP/0/RP0/CPU0:router(config-GRP)# end-group

RP/0/RP0/CPU0:router(config)# apply-group g-logging
```

When this configuration is committed, all commands contained in the g-logging configuration group are committed.

Configuration Group Applied to Different Places: Example

Configuration groups can be applied to different places, and their effect depends on the context within which they are applied. Consider this configuration group:

```
RP/0/RP0/CPU0:router(config)# group g-interfaces
RP/0/RP0/CPU0:router(config-GRP)# interface 'TenGigE.*'
RP/0/RP0/CPU0:router(config-GRP-if)# mtu 1500
RP/0/RP0/CPU0:router(config-GRP-if)# exit
RP/0/RP0/CPU0:router(config-GRP)# interface 'GigabitEthernet.*'
RP/0/RP0/CPU0:router(config-GRP-if)# mtu 1000
RP/0/RP0/CPU0:router(config-GRP-if)# exit
RP/0/RP0/CPU0:router(config-GRP)# interface 'HundredGigE.*'
RP/0/RP0/CPU0:router(config-GRP-if)# mtu 2000
RP/0/RP0/CPU0:router(config-GRP-if)# end-group
```

This group can be applied to Gigabit Ethernet, TenGigE and HundredGigE interface and in each instance the applicable MTU is applied. For instance, in the following example, the Gigabit Ethernet interface is configured to have an MTU of 1000:

```
RP/0/RP0/CPU0:router(config)# interface GigabitEthernet0/2/0/0
RP/0/RP0/CPU0:router(config-if)# apply-group g-interfaces
RP/0/RP0/CPU0:router(config-if)# ipv4 address 2.2.2.2 255.255.255.0
```

In the following example, the TenGigE interface is configured to have an MTU of 1500:

```
RP/0/RP0/CPU0:router(config)# interface TenGigE0/0/0/16
RP/0/RP0/CPU0:router(config-if)# apply-group g-interfaces
RP/0/RP0/CPU0:router(config-if)# ipv4 address 3.3.3.3 255.255.255.0
```

The same configuration group is used in both cases, but only the applicable configuration statements are used.

Verifying the Configuration of Configuration Groups

Use this task to verify the router configuration using configuration groups:

Procedure

	Command or Action	Purpose

Step 1	**show running-config group** [*group-name*]
	Example:
	`RP/0/RP0/CPU0:router# show running-config group`
	
	`group g-int-ge`
	` interface 'GigabitEthernet.*'`
	`  mtu 1000`
	`  negotiation auto`
	` !`
	`end-group`
		Displays the contents of all or a specific configured configuration group.

Step 2	**show running-config**
	Example:
	`show running-config`
	`Example:`
		Displays the running configuration. Any applied groups are displayed. There is no indication as to whether these configuration groups affect the actual configuration or not. In this example, although the group G-INTERFACE-MTU is

	Command or Action	Purpose

	`RP/0/RP0/CPU0:router# show running-config interface group G-INTERFACE-MTU interface 'GigabitEthernet.*' mtu 1500 ! end-group`
	
	`interface GigabitEthernet0/4/1/1 apply-group G-INTERFACE-MTU ! interface GigabitEthernet0/0/0/1 apply-group group G-INTERFACE-MTU mtu 2000`
		applied to interface GigabitEthernet0/0/0/1, the configured MTU value is 2000 and not 1500. This happens if the command mtu 2000 is configured directly on the interface. An actual configuration overrides a configuration group configuration if they are the same.

Step 3	**show running-config inheritance**
	Example:
	`RP/0/RP0/CPU0:router# show running-config inheritance`
	
	`group G-INTERFACE-MTU interface 'GigabitEthernet.*' mtu 1500 ! end-group . . interface GigabitEthernet0/4/1/1 ## Inherited from group G-INTERFACE-MTU mtu 1500 ! interface GigabitEthernet0/0/0/1 mtu 2000 ! . .`
		Displays the inherited configuration wherever a configuration group has been applied.

Step 4	**show running-config interface x/y/z inheritance** *detail*
	Example:
	`RP/0/RP0/CPU0:router# show running-config interface GigabitEthernet0/4/1/1 inheritance detailExample:`
	
	`interface GigabitEthernet0/4/1/1 ## Inherited from group G-INTERFACE-MTU mtu 1500`
		Displays the inherited configuration for a specific configuration command.

Regular Expressions in Configuration Groups

Regular expressions are used in configuration groups to make them widely applicable. Portable Operating System Interface for UNIX (POSIX) 1003.2 regular expressions are supported in the names of configuration statements. Single quotes must be used to delimit a regular expression.

Note Not all POSIX regular expressions are supported.

Regular Expressions for Interface Identifiers

Configuration groups do not accept exact interface identifiers. You must use a regular expression to identify a group of interfaces that are applicable to the configuration group. The regular expression '.*' is not allowed. You must begin the regular expression for an interface identifier with an unambiguous word, followed by the regular expression. For example, to configure Gigabit Ethernet interfaces, use the regular expression 'GigabitEthernet.*'.

To display a list of available interface types for your router configuration, enter **interface ?** at the configuration group prompt:

```
RP/0/RP0/CPU0:router(config-GRP)# interface ?

  ATM              'RegExp': ATM Network Interface(s)
  BVI              'RegExp': Bridge-Group Virtual Interface
  Bundle-Ether     'RegExp': Aggregated Ethernet interface(s)
  GigabitEthernet  'RegExp': GigabitEthernet/IEEE 802.3 interface(s)
  IMA              'RegExp': ATM Network Interface(s)
  Loopback         'RegExp': Loopback interface(s)
  MgmtEth          'RegExp': Ethernet/IEEE 802.3 interface(s)
  Multilink        'RegExp': Multilink network interface(s)
  Null             'RegExp': Null interface
  PW-Ether         'RegExp': PWHE Ethernet Interface
  PW-IW            'RegExp': PWHE VC11 IP Interworking Interface
  Serial           'RegExp': Serial network interface(s)
  tunnel-ip        'RegExp': GRE/IPinIP Tunnel Interface(s)
  tunnel-mte       'RegExp': MPLS Traffic Engineering P2MP Tunnel interface(s)
  tunnel-te        'RegExp': MPLS Traffic Engineering Tunnel interface(s)
  tunnel-tp        'RegExp': MPLS Transport Protocol Tunnel interface
```

Note Although you are required to enter only enough characters for the interface type to be unique, it is recommended that you enter the entire phrase. All interface types used in regular expressions are case-sensitive.

To specify a subinterface, prefix the expression with the characters \. (backslash period). For example, use `interface 'GigabitEthernet.*\..*'` to configure all Gigabit Ethernet subinterfaces.

You can specify Layer 2 transport interfaces or point-to-point interfaces as shown in these examples:

```
group g-l2t
  interface 'Gi.*\..*' l2transport
.
.
end-group
group g-ptp
  interface 'Gi.*\..*' point-to-point
.
.
end-group
```

Regular Expressions for an OSPF Configuration

Exact router process names and OSPF areas cannot be used. You must use a regular expression to specify a process name or group of OSPF areas. To specify that the OSFP area can be either a scalar value or an IP address, use the regular expression '.*', as in this example:

```
group g-ospf
router ospf '.*'
area '.*'
mtu-ignore enable
!
!
end-group
```

To specify that the OSPF area must be an IP address, use the expression '\.' as in this example:

```
group g-ospf-ipaddress
router ospf '.*\..*\..*\..*'
area '.*'
passive enable
!
!
 end-group
```

To specify that the OSPF area must be a scalar value, use the expression '1.*', as in this example:

```
group g-ospf-match-number
router ospf '.*'
area '1.*'
passive enable
!
!
end-group
```

Regular Expressions for a BGP AS

Exact BGP AS values cannot be used in configuration groups. Use a regular expression to specify either AS plain format, or AS dot format as in the format X.Y. To match AS plain format instances, use a simple regular expression. To match AS dot format instances, use two regular expressions separated by a dot, as shown in this example:

```
group g-bgp
router bgp '*'.'*'
address-family ipv4 unicast
!
!
end-group
```

Regular Expressions for ANCP

Exact Access Node Control Protocol (ANCP) sender-name identifiers cannot be used in configuration groups. Because the sender name argument can be either an IP address or a MAC address, you must specify in the regular expression which one is being used. Specify an IP address as `'.*\..*\..*\..*'`; specify a MAC address as `'.*\..*\..*'`.

Resolving to a Uniform Type

Regular expressions must resolve to a uniform type. This is an example of an illegal regular expression:

```
group g-invalid
 interface '.*'
  bundle port-priority 10
 !
interface '.*Ethernet.*'
  bundle port-priority 10
 !
end-group
```

In this example, the **bundle** command is supported for interface type GigabitEthernet but not for interface type 'FastEthernet'. The regular expressions '.*' and '.*Ethernet.*' match both GigabitEthernet and FastEthernet types. Because the **bundle** command is not applicable to both these interface types, they do not resolve to a uniform type and therefore the system does not allow this configuration.

Note If the system cannot determine from the regular expression what the configuration should be, the expression is not considered valid.

Note The regular expression '.*' is not allowed when referring to an interface identifier. You must begin the regular expression for an interface identifier with an unambiguous word, followed by the regular expression. Refer to *Regular Expressions for Interface Identifiers* in this section for more information.

Overlapping Regular Expressions

Regular expressions are used in names of configuration statements within a configuration group. This permits inheritance by the configuration when applied to matching names. Single quotes are used to delimit the regular expression. Overlapping regular expression within a configuration group for the same configuration is permitted.

The example, given below, illustrates the process of creating and applying multiple configuration groups:

```
RP/0//CPU0:router(config)#group FB_flexi_snmp
RP/0//CPU0:router(config-GRP)# snmp-server vrf '.*'
RP/0//CPU0:router(config-GRP-snmp-vrf)# host 1.1.1.1 traps version 2c group_1
RP/0//CPU0:router(config-GRP-snmp-vrf)# host 1.1.1.1 informs version 2c group_1
RP/0//CPU0:router(config-GRP-snmp-vrf)# context group_1

RP/0//CPU0:router(config-GRP-snmp-vrf)#
RP/0//CPU0:router(config-GRP-snmp-vrf)#commit

RP/0//CPU0:router(config-GRP-snmp-vrf)#root
RP/0//CPU0:router(config)#
RP/0//CPU0:router(config)#snmp-server vrf vrf1
RP/0//CPU0:router(config-snmp-vrf)#snmp-server vrf vrf10
RP/0//CPU0:router(config-snmp-vrf)#!
RP/0//CPU0:router(config-snmp-vrf)#snmp-server vrf vrf100
RP/0//CPU0:router(config-snmp-vrf)#
RP/0//CPU0:router(config-snmp-vrf)#commit

RP/0//CPU0:router(config-snmp-vrf)#root
```

```
RP/0//CPU0:router(config)#
RP/0//CPU0:router(config)#apply-group FB_flexi_snmp
RP/0//CPU0:router(config)#do sh running-config group
group FB_flexi_snmp
 snmp-server vrf '.*'
  host 1.1.1.1 traps version 2c group_1
  host 1.1.1.1 informs version 2c group_1
  context group_1
 !
end-group
apply-group FB_flexi_snmp
snmp-server vrf vrf1
!
snmp-server vrf vrf10
!
snmp-server vrf vrf100
!
RP/0//CPU0:ios#show running-config inheritance detail


group FB_flexi_snmp
 snmp-server vrf '.*'
  host 1.1.1.1 traps version 2c group_1
  host 1.1.1.1 informs version 2c group_1
  context group_1
 !
end-group
snmp-server vrf vrf1
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 traps version 2c group_1
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 informs version 2c group_1
 ## Inherited from group FB_flexi_snmp
 context group_1
!
snmp-server vrf vrf10
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 traps version 2c group_1
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 informs version 2c group_1
 ## Inherited from group FB_flexi_snmp
 context group_1
!
snmp-server vrf vrf100
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 traps version 2c group_1
 ## Inherited from group FB_flexi_snmp
 host 1.1.1.1 informs version 2c group_1
 ## Inherited from group FB_flexi_snmp
 context group_1
```

The example given below demonstrates the regular expression. In this example `snmp-server vrf '.*'` and `snmp-server vrf '[\w]+` are two different regular expressions.

```
group FB_flexi_snmp
snmp-server vrf '.*'
host 1.1.1.1 traps version 2c group_1
host 1.1.1.1 informs version 2c group_1
context group_1
!
snmp-server vrf '[\w]+'
```

```
host 2.2.2.2 traps version 2c group_2
host 2.2.2.2 informs version 2c group_2
context group_2
!
end-group
```

This individual regular expression gets combined to all the three expressions - `snmp-server vrf vrf1`, `snmp-server vrf vrf10` and `snmp-server vrf vrf100` as given below.

```
apply-group FB_flexi_snmp
snmp-server vrf vrf1
!
snmp-server vrf vrf10
!
snmp-server vrf vrf100
!
```

In a configuration group, there can be instances of regular expressions overlap. In such cases, the regular expression with the highest priority is activated and inherited, when applied. It has that regular expression, which comes first in the lexicographic order that has the highest priority.

The following example shows how to use overlapping regular expressions and how the expression with higher priority is applied:

```
 group FB_flexi_snmp
 snmp-server vrf '.*'
  host 1.1.1.1 traps version 2c group_1
  host 1.1.1.1 informs version 2c group_1
  context group_1
 !
 snmp-server vrf '[\w]+'
  host 2.2.2.2 traps version 2c group_2
  host 2.2.2.2 informs version 2c group_2
  context group_2
 !
end-group
```

The expression shown below has the highest priority:

```
  group FB_flexi_snmp
  snmp-server vrf '.*'
  host 1.1.1.1 traps version 2c group_1
  host 1.1.1.1 informs version 2c group_1
  context group_1
```

The examples given above, show two different regular expression `snmp-server vrf '.*'` and `snmp-server vrf '[\w]+'`.

The expression below, shows how these two expressions get merged together:

```
apply-group FB_flexi_snmp

snmp-server vrf vrf1
!
snmp-server vrf vrf10
!
snmp-server vrf vrf100
!
```

Any change in a regular expression with lower priority will not affect the inheritance.

Any changes made to an existing regular expression, which is of less (non-top) priority, it will not have any effect on the inheritance.

```
 snmp-server vrf '[\w]+'

 host 2.2.2.2 traps version 2c group_2
 host 2.2.2.2 informs version 2c group_2
 context group_2
```

The expression with the higher priority gets inherited, as shown below:

```
group FB_flexi_snmp

snmp-server vrf '.*'

 host 1.1.1.1 traps version 2c group_1

 host 1.1.1.1 informs version 2c group_1

 context group_1
```

Apply Groups Priority Inheritance

Priority governs inheritance.

Note From the Cisco IOS XR, Release 6.3.1 onwards, you are able to enter the Flexible CLI config group definition, **apply-group** and **exclude-group** command in any order as long as the entire commit has all the group definitions needed.

Apply groups priority inheritance helps flexible configuration groups to handle common configuration statements between groups. When multiple configuration groups have common configuration statements, the inheritance priority is such that the configuration statements present in inner groups have precedence over those configuration statements present in outer groups. In case of tiebreakers, the priority is assigned in accordance to the lexicographical order of regular expressions. User defined order of commands are not accepted.

For example, a configuration statement in configuration group ONE has precedence over another group. A configuration statement in configuration group SEVEN is used only if it does not exist in any other group. Within a configuration group, inheritance priority is the longest match.

```
   apply-group SIX SEVEN
    router ospf 0
   apply-group FOUR FIVE
    area 0
   apply-group THREE
    interface GigabitEthernet0/0/0/0
   apply-group ONE TWO

  !
 !
!
```

The above example shows two scenarios. The inner most group (**apply-group ONE TWO**) has the highest priority. Case 1

The first scenario shows which group gets the priority. The example states which group is applied between different configuration groups (different groups with nothing in common). While applying group one (ONE TWO), all the seven groups matches the interface `interface GigabitEthernet0/0/0/0`- is applied.

Case 2

Here, when all have the same (common) configuration, group one will be active. That is `apply-group ONE TWO` is active. If group ONE is deleted, then group TWO will be active.

Configuration Examples Using Regular Expressions

Configuration Group with Regular Expression: Example

This example shows the definition of a configuration group for configuring Gigabit Ethernet interfaces with ISIS routing parameters, using regular expressions for the exact interface:

```
RP/0/RP0/CPU0:router(config)# group g-isis-gige
RP/0/RP0/CPU0:router(config-GRP)# router isis '.*'
RP/0/RP0/CPU0:router(config-GRP-isis)# interface 'GigabitEthernet.*'
RP/0/RP0/CPU0:router(config-GRP-isis-if)# lsp-interval 20
RP/0/RP0/CPU0:router(config-GRP-isis-if)# hello-interval 40
RP/0/RP0/CPU0:router(config-GRP-isis-if)# address-family ipv4 unicast
RP/0/RP0/CPU0:router(config-GRP-isis-if-af)# metric 10
RP/0/RP0/CPU0:router(config-GRP-isis-if-af)# end-group
RP/0/RP0/CPU0:router(config)#
```

To illustrate the use of this configuration group, assume that you want to configure these Gigabit Ethernet interfaces with the ISIS routing parameters:

```
router isis green
 interface GigabitEthernet0/0/0/0
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
   metric 10
  !
 !
```

```
 interface GigabitEthernet0/0/0/1
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
   metric 10
  !
 !
 interface GigabitEthernet0/0/0/2
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
   metric 10
  !
 !
 interface GigabitEthernet0/0/0/3
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
   metric 10
  !
 !
!
```

There are three possible ways to use the configuration group to configure these interfaces. The first is by applying the group within the interface configuration, as shown here:

```
router isis green
 interface GigabitEthernet0/0/0/0
     apply-group g-isis-gige
  !
 !
 interface GigabitEthernet0/0/0/1
     apply-group g-isis-gige
  !
 !
 interface GigabitEthernet0/0/0/2
     apply-group g-isis-gige
  !
 !
 interface GigabitEthernet0/0/0/3
     apply-group g-isis-gige
  !
 !
```

In this situation, only the interfaces to which you apply the configuration group inherit the configuration.

The second way to configure these interfaces using the configuration group is to apply the configuration group within the **router isis** configuration, as shown here:

```
router isis green
    apply-group g-isis-gige
 interface GigabitEthernet0/0/0/0
 !
 interface GigabitEthernet0/0/0/1
 !
 interface GigabitEthernet0/0/0/2
 !
 interface GigabitEthernet0/0/0/3
 !
```

```
!
```

In this way, any other Gigabit Ethernet interfaces that you configure in the ISIS green configuration also inherit these configurations.

The third way to configure these interfaces using the configuration group is to apply the group at the global level as shown here:

```
   apply-group g-isis-gige
router isis green
 interface GigabitEthernet0/0/0/0
 !
 interface GigabitEthernet0/0/0/1
 !
 interface GigabitEthernet0/0/0/2
 !
 interface GigabitEthernet0/0/0/3
 !
!
```

In this example, the configuration of the group is applied to all Gigabit Ethernet interfaces configured for ISIS.

Configuration Group Inheritance with Regular Expressions: Example

Local Configuration Has Precedence Over Configuration Group

An explicit configuration takes precedence over a configuration applied from a configuration group. For example, assume that this configuration is running on the router:

```
router ospf 100
 packet-size 1000
!
```

You configure this configuration group, apply it, and commit it to the configuration.

```
RP/0/RP0/CPU0:router(config)# group g-ospf
RP/0/RP0/CPU0:router(config-GRP)# router ospf '.*'
RP/0/RP0/CPU0:router(config-GRP-ospf)# nsf cisco
RP/0/RP0/CPU0:router(config-GRP-ospf)# packet-size 3000
RP/0/RP0/CPU0:router(config-GRP-ospf)# end-group

RP/0/RP0/CPU0:router(config)# apply-group g-ospf
```

The result is effectively this configuration:

```
router ospf 100
 packet-size 1000
 nsf cisco
```

Note that `packet-size 3000` is not inherited from the configuration group because the explicit local configuration has precedence.

Compatible Configuration Is Inherited

The configuration in the configuration group must match the configuration on the router to be inherited. If the configuration does not match, it is not inherited. For example, assume that this configuration is running on the router:

```
router ospf 100
 auto-cost disable
!
```

You configure this configuration and commit it to the configuration.

```
RP/0/RP0/CPU0:router(config)# group g-ospf
RP/0/RP0/CPU0:router(config-GRP)# router ospf '.*'
RP/0/RP0/CPU0:router(config-GRP-ospf)# area '.*'
RP/0/RP0/CPU0:router(config-GRP-ospf-ar)# packet-size 2000
RP/0/RP0/CPU0:router(config-GRP-ospf)# end-group

RP/0/RP0/CPU0:router(config)# apply-group g-ospf

RP/0/RP0/CPU0:router(config)# router ospf 200
RP/0/RP0/CPU0:router(config-ospf)# area 1
```

The result is effectively this configuration:

```
router ospf 100
  auto-cost disable

router ospf 200
  area 1
  packet-size 2000
```

The packet size is inherited by the ospf 200 configuration, but not by the ospf 100 configuration because the area is not configured.

Layer 2 Transport Configuration Group: Example

This example shows how to configure and apply a configuration group with Layer 2 transport subinterfaces:

```
RP/0/RP0/CPU0:router(config)# group g-l2trans-if
RP/0/RP0/CPU0:router(config-GRP)# interface 'TenGigE.*\..*' l2transport
RP/0/RP0/CPU0:router(config-GRP)# mtu 1514
RP/0/RP0/CPU0:router(config-GRP)# end-group

RP/0/RP0/CPU0:router(config)# interface TenGigE0/0/0/0.1 l2transport
RP/0/RP0/CPU0:router(config-if)# apply-group g-l2trans-if
```

When this configuration is committed, the Ten Gigabit Ethernet interface 0/0/0/0.1 inherits the 1514 MTU value. This is the output displayed from the **show running-config inheritence** command for the Ten Gigabit Ethernet interface:

```
interface TenGigE0/0/0/0.1 l2transport
 ## Inherited from group g-l2trans-if
 mtu 1514
!
```

Configuration Group Precedence: Example

When similar configuration statements are contained in multiple configuration groups, groups applied in inner configuration modes take precedence over groups applied in outer modes. This example shows two configuration groups that configure different cost values for OSPF.

```
RP/0/RP0/CPU0:router(config)# group g-ospf2
RP/0/RP0/CPU0:router(config-GRP)# router ospf '.*'
RP/0/RP0/CPU0:router(config-GRP-ospf)# area '.*'
RP/0/RP0/CPU0:router(config-GRP-ospf-ar)# cost 2
RP/0/RP0/CPU0:router(config-GRP-ospf-ar)# end-group

RP/0/RP0/CPU0:router(config)# group g-ospf100
RP/0/RP0/CPU0:router(config-GRP)# router ospf '.*'
RP/0/RP0/CPU0:router(config-GRP-ospf)# area '.*'
RP/0/RP0/CPU0:router(config-GRP-ospf-ar)# cost 100
RP/0/RP0/CPU0:router(config-GRP-ospf-ar)# end-group
```

If these configuration groups are applied as follows, the cost 2 specified in g-ospf2 is inherited by OSPF area 0 because the group is applied in a more inner configuration mode. In this case, the configuration in group g-ospf100 is ignored.

```
RP/0/RP0/CPU0:router(config)# router ospf 0
RP/0/RP0/CPU0:router(config-ospf)# apply-group g-ospf100
RP/0/RP0/CPU0:router(config-ospf)# area 0
RP/0/RP0/CPU0:router(config-ospf-ar)# apply-group g-ospf2
```

Changes to Configuration Group are Automatically Inherited: Example

When you make changes to a configuration group that is committed and applied to your router configuration, the changes are automatically inherited by the router configuration. For example, assume that this configuration is committed:

```
group g-interface-mtu
 interface ‘GigabitEthernet.*’
  mtu 1500
 !
end-group

interface POS0/0/0/0
 apply-group g-interface-mtu
!
```

Now you change the configuration group as in this example:

```
RP/0/RP0/CPU0:router(config)# group g-interface-mtu
RP/0/RP0/CPU0:router(config-GRP)# interface 'GigabitEthernet.*'
RP/0/RP0/CPU0:router(config-GRP-if)# mtu 2000
```

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

When this configuration group is committed, the MTU configuration for interface GigabitEthernet0/0/0/0 is automatically updated to 2000.

Configuration Examples for Flexible CLI Configuration

Basic Flexible CLI Configuration: Example

This example shows that the Media Access Control (MAC) accounting configuration from the gd21 configuration group is applied to all Gigabit Ethernet interfaces in slot 2, ports 1 to 9.

1. Configure the configuration group that configures MAC accounting:

```
RP/0/RP0/CPU0:router# show running group gd21

group gd21
interface 'GigabitEthernet0/0/0/2[1-9]'
description general interface inheritance check
load-interval 30
mac-accounting ingress
mac-accounting egress
!
end-group
```

2. Check that the corresponding apply-group is configured in global configuration or somewhere in the hierarchy:

```
RP/0/RP0/CPU0:router# show running | in apply-group gd21

Building configuration...
apply-group gd21
```

3. Check the concise local view of the configuration of some of the interfaces:

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

interface GigabiEthernet0/0/0/21
!
interface GigabitEthernet0/0/0/22
!
```

4. Verify that the match and inheritance occur on these interfaces:

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

interface GigabitEthernet0/0/0/21
## Inherited from group gd21
description general interface inheritance check
## Inherited from group gd21
load-interval 30
## Inherited from group gd21
```

```
mac-accounting ingress
## Inherited from group gd21
mac-accounting egress
!
Interface GigabitEthernet0/0/0/22
## Inherited from group gd21
description general interface inheritance check
## Inherited from group gd21
load-interval 30
## Inherited from group gd21
mac-accounting ingress
## Inherited from group gd21
mac-accounting egress
!
!
```

5. Verify that the inherited configuration actually takes effect:

```
RP/0/RP0/CPU0:router# show mac-accounting GigabitEthernet0/0/0/21

GigabitEthernet0/0/0/21
  Input (96 free)
    6c9c.ed35.90fd:  1271 packets, 98426 bytes
        Total: 1271 packets, 98426 bytes
  Output (96 free)
    6c9c.ed35.90fd:   774 packets, 63265 bytes
        Total: 774 packets, 63264 bytes
```

Interface MTU Settings for Different Interface Types: Example

This example shows that an MTU value is configured on different interface types.

1. Configure an interface MTU configuration group and apply this group:

```
RP/0/RP0/CPU0:router# show running group l2tr

group l2tr
interface 'GigabitEthernet0/0/0/3.*'
mtu 1500
!
interface 'GigabitEthernet0/0/0/9\..*'
mtu 1400
!
interface 'GigabitEthernet0/0/0/9\..*' l2transport
mtu 1400
!
end-group

RP/0/RP0/CPU0:router# show running | inc apply-group

Building configuration...

apply-group l2tr
```

2. Check the concise view and the inheritance view of the various interfaces:

```
RP/0/RP0/CPU0:router# show running interface gigabitEthernet0/0/0/30

interface GigabitEthernet0/0/0/30
!
RP/0/RP0/CPU0:router# show running interface gigabitEthernet0/0/0/30  inheritance detail

interface GigabitEthernet0/0/0/30
## Inherited from group l2tr
mtu 1500
!

RP/0/RP0/CPU0:router# show running interface gigabitEthernet0/0/0/9.800

interface GigabitEthernet0/0/0/9.800
  encapsulation dot1q 800
!

RP/0/RP0/CPU0:router# show running interface gigabitEthernet0/0/0/9.800 inheritance
detail

interface GigabitEthernet0/0/0/9.800
## Inherited from group l2tr
mtu 1400
encapsulation dot1q800
!

RP/0/RP0/CPU0:router# show running interface gigabitEthernet0/0/0/9.250

interface GigabitEthernet0/0/0/9.250 l2transport
  encapsulation dot1q 250
!

RP/0/RP0/CPU0:router# show running interface  gigabitEthernet0/0/0/9.800 inheritance
detail

interface GigabitEthernet0/0/0/9.250 l2transport
encapsulation dot1q250
## Inherited from group l2tr
mtu 1400
!
```

3. Verify that the correct values from the group do take effect:

```
RP/0/RP0/CPU0:router# show interface gigabitEthernet 0/0/0/30

GigabitEthernet0/0/0/30 is down, line protocol is down
  Interface state transitions: 0
  Hardware is GigabitEthernet, address is 0026.9824.ee56 (bia 0026.9824.ee56)
  Internet address is Unknown
  MTU 1500 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 1000Mb/s, link type is force-up
  output flow control is off, input flow control is off
  loopback not set,
  Last input never, output never
  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
     0 packets output, 0 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

RP/0/RP0/CPU0:router# show interface gigabitEthernet 0/0/0/9.801

GigabitEthernet0/0/0/9.801 is up, line protocol is up
  Interface state transitions: 1
  Hardware is VLAN sub-interface(s), address is 0026.9824.ee41
  Internet address is Unknown
  MTU 1400 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation 802.1Q Virtual LAN, VLAN Id 801,  loopback not set,
  Last input never, output never
  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 packets output, 0 bytes, 0 total output drops
     Output 0 broadcast packets, 0 multicast packets


RP/0/RP0/CPU0:router# show interface gigabitEthernet 0/0/0/9.250

GigabitEthernet0/0/0/9.250 is up, line protocol is up
  Interface state transitions: 1
  Hardware is VLAN sub-interface(s), address is 0026.9824.ee41
  Layer 2 Transport Mode
  MTU 1400 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
     reliability Unknown, txload Unknown, rxload Unknown
  Encapsulation 802.1Q Virtual LAN,
    Outer Match: Dot1Q VLAN 250
    Ethertype Any, MAC Match src any, dest any
  loopback not set,
  Last input never, output never
  Last clearing of "show interface" counters never
     0 packets input, 0 bytes
     0 input drops, 0 queue drops, 0 input errors
     0 packets output, 0 bytes

     0 output drops, 0 queue drops, 0 output errors
```

ACL Referencing: Example

This example shows how to reference access-lists on a number of interfaces using configuration groups.

1. Configure the configuration group and apply-group:

```
RP/0/RP0/CPU0:router# show running group acref

group acref
 interface 'GigabitEthernet0/0/0/3.*'
```

```
  ipv4 access-group adem ingress
  ipv4 access-group adem egress
 !
end-group

RP/0/RP0/CPU0:router# show running | inc apply-group

Building configuration...

apply-group isis l2tr isis2 mpp bundle1 acref
```

2. Check the concise and inheritance view of the matching configurations:

```
RP/0/RP0/CPU0:router# show running interface gigabitEthernet 0/0/0/30

interface GigabitEthernet0/0/0/30
!

RP/0/RP0/CPU0:router# show running interface GigabitEthernet 0/0/0/30 inheritance detail

interface GigabitEthernet0/0/0/30
 ## Inherited from group l2tr
 mtu 1500
 ## Inherited from group acref
 ipv4 access-group adem ingress
 ## Inherited from group acref
 ipv4 access-group adem egress
!

RP/0/RP0/CPU0:router# show running interface gigabitEthernet 0/0/0/31

interface GigabitEthernet0/0/0/31
!

RP/0/RP0/CPU0:router# show running interface GigabitEthernet 0/0/0/31 inheritance detail

interface GigabitEthernet0/0/0/31
 ## Inherited from group l2tr
 mtu 1500
 ## Inherited from group acref
 ipv4 access-group adem ingress
 ## Inherited from group acref
 ipv4 access-group adem egress
```

3. Check that the ACL group configuration actually got configured by using a traffic generator and watching that denied traffic is dropped.

ISIS Hierarchical Configuration: Example

This example illustrates inheritance and priority handling with two ISIS groups using an ISIS configuration.

1. Configure the local ISIS configuration:

```
RP/0/RP0/CPU0:router# show running router isis

router isis vink
```

```
 net 49.0011.2222.2222.2222.00
 address-family ipv4 unicast
  mpls traffic-eng level-1-2
  mpls traffic-eng router-id Loopback0
  redistribute connected
 !
 interface Bundle-Ether1
  address-family ipv4 unicast
  !
 !
 interface Bundle-Ether2
 !
 interface Loopback0
 !
 interface TenGigE0/0/0/0.3521
  address-family ipv4 unicast
  !
 !
 interface TenGigE0/0/0/0.3522
  address-family ipv4 unicast
  !
 !
 interface TenGigE0/0/0/0.3523
  address-family ipv4 unicast
  !
 !
 interface TenGigE0/0/0/0.3524
  address-family ipv4 unicast
  !
 !
 interface TenGigE0/0/0/0.3525
  address-family ipv4 unicast
  !
 !
 interface TenGigE0/0/0/0.3526
 !
 interface TenGigE0/0/0/0.3527
 !
 interface TenGigE0/0/0/0.3528
 !
 interface TenGigE0/0/0/1
  address-family ipv4 unicast
  !
 !
!
```

2. Configure two ISIS groups and apply these to the configuration:

```
RP/0/RP0/CPU0:router# show running group isis

group isis
 router isis '.*'
  address-family ipv4 unicast
   mpls traffic-eng level-1-2
   mpls traffic-eng router-id Loopback0
   redistribute connected
   redistribute ospf 1 level-1-2
  !
  interface 'TenGig.*'
   lsp-interval 40
   hello-interval 15
   address-family ipv4 unicast
```

```
    metric 50
   !
  !
  interface 'Bundle-Ether.*'
   address-family ipv4 unicast
    metric 55
   !
  !
 !
end-group

RP/0/RP0/CPU0:router# show running group isis2

group isis2
 router isis '.*'
 !
 router isis '^(vink)'
  address-family ipv4 unicast
  !
  interface '(^Ten)Gig.*'
  !
  interface '^(Ten)Gig.*'
   address-family ipv4 unicast
    metric 66
   !
  !
 !
end-group

RP/0/RP0/CPU0:router# show running | inc apply-group

Building configuration...

apply-group isis  l2tr  isis2  mpp  bundle1  acref
```

3. Check the inheritance view of the ISIS configuration:

```
RP/0/RP0/CPU0:router# show running router isis inheritance detail

router isis vink
 net 49.0011.2222.2222.2222.00
 address-family ipv4 unicast
  mpls traffic-eng level-1-2
  mpls traffic-eng router-id Loopback0
  redistribute connected
  ## Inherited from group isis
  redistribute ospf 1 level-1-2
 !
 interface Bundle-Ether1
  address-family ipv4 unicast
   ## Inherited from group isis
   metric 55
  !
 !
 interface Bundle-Ether2
  ## Inherited from group isis
  address-family ipv4 unicast
   ## Inherited from group isis
   metric 55
  !
 !
 interface Loopback0
```

```
!
interface TenGigE0/0/0/0.3521
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/0/0/0.3522
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/0/0/0.3523
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/0/0/0.3524
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/0/0/0.3525
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/0/0/0.3525
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 ## Inherited from group isis
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/0/0/0.3527
 ## Inherited from group isis
```

```
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 ## Inherited from group isis
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/0/0/0.3528
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 ## Inherited from group isis
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
interface TenGigE0/0/0/1
 ## Inherited from group isis
 lsp-interval 40
 ## Inherited from group isis
 hello-interval 15
 address-family ipv4 unicast
  ## Inherited from group isis
  metric 50
 !
!
!
```

4. Verify the actual functionality:

```
RP/0/RP0/CPU0:router# show isis interface TenGigE0/0/0/0.3528 | inc Metric

Metric (L1/L2):         50/50
```

OSPF Hierarchy: Example

This example illustrates hierarchical inheritance and priority. The configuration that is lower in hierarchy gets the highest priority.

1. Configure a local OSPF configuration:

```
RP/0/RP0/CPU0:router# show running router ospf

router ospf 1
 apply-group go-c
 nsr
 router-id 121.121.121.121
 nsf cisco
 redistribute connected
 address-family ipv4 unicast
 area 0
  apply-group go-b
  interface GigabitEthernet0/0/0/0
   apply-group go-a
```

```
  !
  interface GigabitEthernet0/0/0/1
  !
  interface GigabitEthernet0/0/0/3
  !
  interface GigabitEthernet0/0/0/4
  !
  interface GigabitEthernet0/0/0/21
   bfd minimum-interval 100
   bfd fast-detect
   bfd multiplier 3
  !
  interface TenGigE0/0/0/0.3891
  !
  interface TenGigE0/0/0/0.3892
  !
  interface TenGigE0/0/0/0.3893
  !
  interface TenGigE0/0/0/0.3894
  !
 !
!
router ospf 100
!
router ospf 1000
!
router ospf 1001
!
```

2. Configure a configuration group and apply it in a configuration submode:

```
RP/0/RP0/CPU0:router# show running group go-a

group go-a
 router ospf '.*'
  area '.*'
   interface 'Gig.*'
    cost 200
   !
  !
 !
end-group

RP/0/RP0/CPU0:router# show running group go-b

group go-b
 router ospf '.*'
  area '.*'
   interface 'Gig.*'
    cost 250
   !
  !
 !
end-group

RP/0/RP0/CPU0:router# show running group go-c

group go-c
 router ospf '.*'
  area '.*'
   interface 'Gig.*'
    cost 300
   !
```

```
  !
 !

end-group
```

3. Check the inheritance view and verify that the apply-group in the lowest configuration submode gets the highest priority:

```
RP/0/RP0/CPU0:router# show running router ospf 1 inheritance detail

router ospf 1
 nsr
 router-id 121.121.121.121
 nsf cisco
 redistribute connected
 address-family ipv4 unicast
 area 0
  interface GigabitEthernet0/0/0/0
   ## Inherited from group go-a
   cost 200                    << apply-group in lowest submode  gets highest priority

  !
  interface GigabitEthernet0/0/0/1
   ## Inherited from group go-b
   cost 250
  !
  interface GigabitEthernet0/0/0/3
   ## Inherited from group go-b
   cost 250
  !
  interface GigabitEthernet0/0/0/4
   ## Inherited from group go-b
   cost 250
  !
  interface GigabitEthernet0/0/0/21
   bfd minimum-interval 100
   bfd fast-detect
   bfd multiplier 3
   ## Inherited from group go-b
   cost 250
  !
  interface TenGigE0/0/0/0.3891
  !
  interface TenGigE0/0/0/0.3892
  !
  interface TenGigE0/0/0/0.3893
  !
  interface TenGigE0/0/0/0.3894
  !
 !
!
```

4. Check the functionality of the cost inheritance through the groups:

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

GigabitEthernet0/0/0/0 is up, line protocol is up
  Internet Address 1.0.1.1/30, Area 0
  Process ID 1, Router ID 121.121.121.121, Network Type BROADCAST, Cost: 200
  Transmit Delay is 1 sec, State DR, Priority 1, MTU 1500, MaxPktSz 1500
  Designated Router (ID) 121.121.121.121, Interface address 1.0.1.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

```
  Non-Stop Forwarding (NSF) enabled
    Hello due in 00:00:02
  Index 5/5, flood queue length 0
  Next 0(0)/0(0)
  Last flood scan length is 1, maximum is 40
  Last flood scan time is 0 msec, maximum is 7 msec
  LS Ack List: current length 0, high water mark 0
  Neighbor Count is 1, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
  Multi-area interface Count is 0
```

Link Bundling Usage: Example

This example shows how to configure interface membership in a bundle link:

1. Configure the configuration groups:

```
RP/0/RP0/CPU0:router# show running group bundle1

group bundle1
 interface 'GigabitEthernet0/1/0/1[1-6]'
  bundle id 1 mode active
 !
end-group

RP/0/RP0/CPU0:router# show running | inc apply-group

Building configuration...

apply-group isis l2tr  isis2  mpp  bundle1
```

2. Check the local configuration:

```
RP/0/RP0/CPU0:router# show running interface gigabitEthernet 0/1/0/11

interface GigabitEthernet0/1/0/11
!

RP/0/RP0/CPU0:router# show running interface Bundle-Ether1

interface Bundle-Ether1
 ipv4 address 108.108.1.1 255.255.255.0
 bundle maximum-active links 10
 bundle minimum-active links 5
!
```

3. Check the inheritance configuration view:

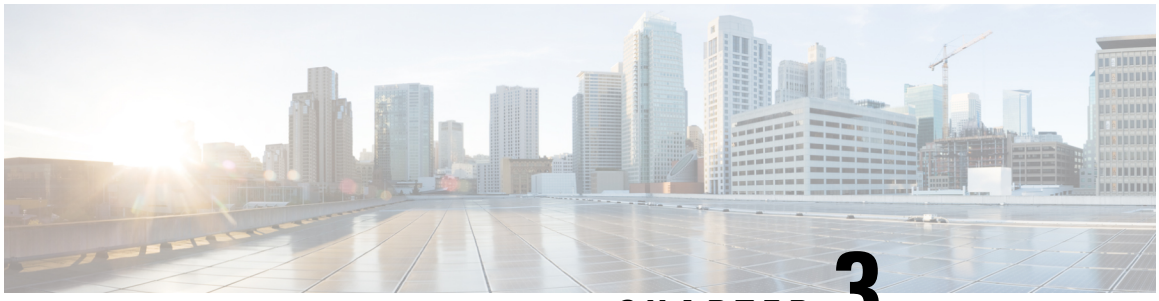
```
RP/0/RP0/CPU0:router# show running interface GigabitEthernet 0/1/0/11  inheritance detail

interface GigabitEthernet0/1/0/11
 ## Inherited from group bundle1
 bundle id 1 mode active
!
```

4. Check that the inheritance configuration took effect:

```
RP/0/RP0/CPU0:router# show interface Bundle-Ether1

Bundle-Ether1 is up, line protocol is up
  Interface state transitions: 1
  Hardware is Aggregated Ethernet interface(s), address is 0024.f71f.4bc3
  Internet address is 108.108.1.1/24
  MTU 1514 bytes, BW 6000000 Kbit (Max: 6000000 Kbit)
     reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation ARPA,
  Full-duplex, 6000Mb/s
  loopback not set,
  ARP type ARPA, ARP timeout 04:00:00
    No. of members in this bundle: 6
      GigabitEthernet0/1/0/11      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/12      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/13      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/14      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/15      Full-duplex  1000Mb/s     Active
      GigabitEthernet0/1/0/16      Full-duplex  1000Mb/s     Active
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  5 minute input rate 8000 bits/sec, 1 packets/sec
  5 minute output rate 3000 bits/sec, 1 packets/sec
     2058 packets input, 1999803 bytes, 426 total input drops
     0 drops for unrecognized upper-level protocol
     Received 1 broadcast packets, 2057 multicast packets
              0 runts, 0 giants, 0 throttles, 0 parity
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     1204 packets output, 717972 bytes, 0 total output drops
     Output 2 broadcast packets, 1202 multicast packets
     0 output errors, 0 underruns, 0 applique, 0 resets
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
```



CHAPTER 3

Configuring Manageability

This module describes the configuration required to enable the Extensible Markup Language (XML) agent services. The XML Parser Infrastructure provides parsing and generation of XML documents with Document Object Model (DOM), Simple Application Programming Interface (API) for XML (SAX), and Document Type Definition (DTD) validation capabilities:

- DOM allows customers to programmatically create, manipulate, and generate XML documents.
- SAX supports user-defined functions for XML tags.
- DTD allows for validation of defined document types.

- Information about XML Manageability, on page 33
- How to Configure Manageability, on page 33
- Configuration Examples for Manageability, on page 34

Information about XML Manageability

The Cisco IOS XR Extensible Markup Language (XML) API provides a programmable interface to the router for use by external management applications. This interface provides a mechanism for router configuration and monitoring utilizing XML formatted request and response streams. The XML interface is built on top of the Management Data API (MDA), which provides a mechanism for Cisco IOS XR components to publish their data models through MDA schema definition files.

Cisco IOS XR software provides the ability to access the router via XML using a dedicated TCP connection, Secure Socket Layer (SSL), or a specific VPN routing and forwarding (VRF) instance.

How to Configure Manageability

Configuring the XML Agent

This explains how to configure the XML agent.

Procedure

	Command or Action	Purpose
Step 1	**xml agent** [**ssl**] **Example:** `RP/0/RP0/CPU0:router(config)# xml agent ssl`	Enables Extensible Markup Language (XML) requests over a dedicated TCP connection and enters XML agent configuration mode. Use the **ssl** keyword to enable XML requests over Secure Socket Layer (SSL).
Step 2	**iteration on size** *iteration-size* **Example:** `RP/0/RP0/CPU0:router(config-xml-agent)# iteration on size 500`	Configures the iteration size for large XML agent responses in KBytes. The default is 48.
Step 3	**session timeout** *timeout* **Example:** `RP/0/RP0/CPU0:router(config-xml-agent)# session timeout 5`	Configures an idle timeout for the XML agent in minutes. By default, there is no timeout.
Step 4	**throttle** {**memory** *size* | **process-rate** *tags*} **Example:** `RP/0/RP0/CPU0:router(config-xml-agent)# throttle memory 300`	Configures the XML agent processing capabilities. • Specify the memory size in Mbytes. Values can range from 100 to 600. In IOS XR 64 bit, the values range from 100 to 1024. The default is 300. • Specify the process-rate as the number of tags that the XML agent can process per second. Values can range from 1000 to 30000. By default the process rate is not throttled.
Step 5	**vrf** { **vrfname** | **default**} [**ipv4 access-list** *access-list-name*] **Example:** `RP/0/RP0/CPU0:router(config-xml-agent)# vrf vrf1`	Configures the dedicated agent or SSL agent to receive and send messages via the specified VPN routing and forwarding (VRF) instance.

Configuration Examples for Manageability

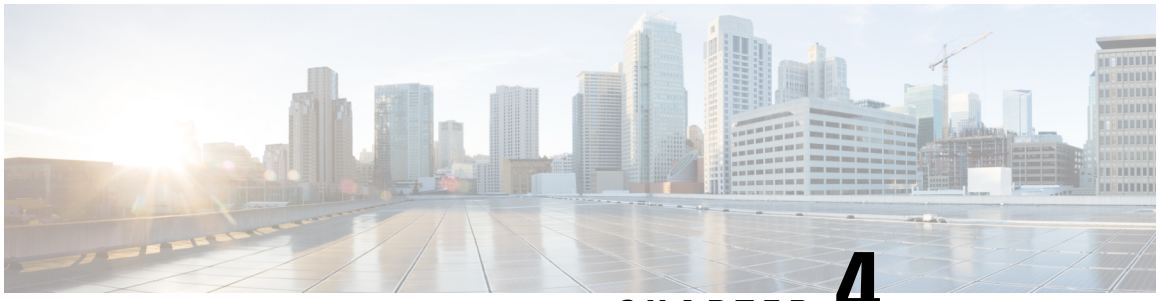
Enabling VRF on an XML Agent: Example

The following example shows how to configure the XML SSL agent to receive and send messages through VRF1, VRF2, and the default VRF:

```
RP/0/RP0/CPU0:router(config)# xml agent ssl
RP/0/RP0/CPU0:router(config-xml-ssl)# vrf VRF1
RP/0/RP0/CPU0:router(config-xml-ssl-vrf)# vrf VRF2
```

The following example removes access for VRF2 from the dedicated XML agent:

```
RP/0/RP0/CPU0:router(config)# xml agent ssl
RP/0/RP0/CPU0:router(config-xml-ssl)# no vrf VRF2
```



CHAPTER 4

Configuring Object Tracking

This module describes the configuration of object tracking on your Cisco IOS XR network. For complete descriptions of the commands listed in this module, see **Additional References** section. To locate documentation for other commands that might appear in the course of performing a configuration task, see **Technical Documentation** section in the Additional References topic.

- Configuring Object Tracking, on page 37
- Prerequisites for Implementing Object Tracking, on page 37
- Information about Object Tracking, on page 38
- How to Implement Object Tracking, on page 38
- Configuration Examples for Configuring Object Tracking, on page 47
- Additional References, on page 50

Configuring Object Tracking

This module describes the configuration of object tracking on your Cisco IOS XR network. For complete descriptions of the commands listed in this module, see **Additional References** section. To locate documentation for other commands that might appear in the course of performing a configuration task, see **Technical Documentation** section in the Additional References topic.

Prerequisites for Implementing Object Tracking

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.

Note Object Tracking is an optional package. You must check if this package is installed on your system by running the command **show install active summary**.

Information about Object Tracking

Object tracking is a mechanism to track an object and to take an action on another object with no relationship to the tracked objects, based on changes to the properties of the object being tracked.

Each tracked object is identified by a unique name specified on the tracking command-line interface (CLI). Cisco IOS XR processes then use this name to track a specific object.

The tracking process periodically polls the tracked object and reports any changes to its state in terms of its being up or down, either immediately or after a delay, as configured by the user.

Multiple objects can also be tracked by means of a list, using a flexible method for combining objects with Boolean logic. This functionality includes:

- **Boolean AND function—**When a tracked list has been assigned a Boolean AND function, each object defined within a subset must be in an up state, so that the tracked object can also be in the up state.
- **Boolean OR function—**When the tracked list has been assigned a Boolean OR function, it means that at least one object defined within a subset must also be in an up state, so that the tracked object can also be in the up state.

How to Implement Object Tracking

This section describes the various object tracking procedures.

Tracking the Line Protocol State of an Interface

Perform this task in global configuration mode to track the line protocol state of an interface.

A tracked object is considered up when a line protocol of the interface is up.

After configuring the tracked object, you may associate the interface whose state should be tracked and specify the number of seconds to wait before the tracking object polls the interface for its state.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/RP0/CPU0:router(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.

	Command or Action	Purpose
Step 3	**type line-protocol state** **Example:** `RP/0/RP0/CPU0:router(config-track)# type line-protocol state`	Creates a track based on the line protocol of an interface.
Step 4	**interface** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config-track-line-prot)# interface atm 0/2/0/0.1`	Specifies the interface to track the protocol state. • *type*—Specifies the interface type. For more information, use the question mark (?) online help function. • *interface-path-id*—Identifies a physical interface or a virtual interface. **Note** Use the **show interfaces** command to see a list of all possible interfaces currently configured on the router. **Note** The loopback and null interfaces are always in the up state and, therefore, cannot be tracked.
Step 5	**exit** **Example:** `RP/0/RP0/CPU0:router(config-track-line-prot)# exit`	Exits the track line protocol configuration mode.
Step 6	(Optional) **delay** {**up** *seconds* | **down** *seconds*} **Example:** `RP/0/RP0/CPU0:router(config-track)# delay up 10`	Schedules the delay that can occur between tracking whether the object is up or down.

Step 7	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RP0/CPU0:router(config-track)# end`
	or
	`RP/0/RP0/CPU0:router(config-track)# 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.

	Command or Action	Purpose
		• 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.

Tracking IP Route Reachability

When a host or a network goes down on a remote site, routing protocols notify the router and the routing table is updated accordingly. The routing process is configured to notify the tracking process when the route state changes due to a routing update.

A tracked object is considered up when a routing table entry exists for the route and the route is accessible.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/RP0/CPU0:router(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type route reachability** **Example:** `RP/0/RP0/CPU0:router(config-track)# type route reachability vrf internet`	Configures the routing process to notify the tracking process when the state of the route changes due to a routing update.
Step 4	Use one of the following commands: • **vrf** *vrf-table-name* • **route ipv4** *IP-prefix/mask*	Configures the type of IP route to be tracked, which can consist of either of the following, depending on your router type: • *vrf-table-name*—A VRF table name.

	Command or Action	Purpose

	Example:
	`RP/0/RP0/CPU0:router(config-track-route)# vrf vrf-table-4`
	or
	`RP/0/RP0/CPU0:router(config-track-route)# route ipv4 10.56.8.10/16`
		• *IP-prefix/mask*—An IP prefix consisting of the network and subnet mask (for example, 10.56.8.10/16).

Step 5	**exit** **Example:** `RP/0/RP0/CPU0:router(config-track-line-prot)# exit`	Exits the track line protocol configuration mode.
Step 6	(Optional) **delay** {**up** *seconds* | **down** *seconds*} **Example:** `RP/0/RP0/CPU0:router(config-track)# delay up 10`	Schedules the delay that can occur between tracking whether the object is up or down.
Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes, and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration mode, without committing the configuration changes.

Building a Track Based on a List of Objects

Perform this task in the global configuration mode to create a tracked list of objects (which, in this case, are lists of interfaces or prefixes) using a Boolean expression to determine the state of the list.

A tracked list contains one or more objects. The Boolean expression enables two types of calculations by using either AND or OR operators. For example, when tracking two interfaces, using the AND operator, up means that *both* interfaces are up, and down means that *either* interface is down.

Note An object must exist before it can be added to a tracked list.

The NOT operator is specified for one or more objects and negates the state of the object.

After configuring the tracked object, you must associate the interface whose state should be tracked and you may optionally specify the number of seconds to wait before the tracking object polls the interface for its state.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/RP0/CPU0:router(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type list boolean** { **and** | **or** } **Example:** `RP/0/RP0/CPU0:router(config-track)# type list boolean and`	Configures a Boolean list object and enters track list configuration mode. • **boolean**—Specifies that the state of the tracked list is based on a Boolean calculation. • **and**—Specifies that the list is up if all objects are up, or down if one or more objects are down. For example when tracking two interfaces, up means that both interfaces are up, and down means that either interface is down. • **or**—Specifies that the list is up if at least one object is up. For example, when tracking two interfaces, up means that either interface is up, and down means that both interfaces are down.
Step 4	**object** *object-name* [**not**] **Example:** `RP/0/RP0/CPU0:router(config-track-list)# object 3 not`	Specifies the object to be tracked by the list • *obect-name*—Name of the object to track. • **not**—Negates the state of the object.
Step 5	**exit** **Example:** `RP/0/RP0/CPU0:router(config-track-line-prot)# exit`	Exits the track line protocol configuration mode.

	Command or Action	Purpose
Step 6	(Optional) **delay** {**up** *seconds* | **down** *seconds*} **Example:** `RP/0/RP0/CPU0:router(config-track)# delay up 10`	Schedules the delay that can occur between tracking whether the object is up or down.

Step 7	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RP0/CPU0:router(config-track)# end`
	or
	`RP/0/RP0/CPU0:router(config-track)# 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.

Building a Track Based on a List of Objects - Threshold Percentage

Perform this task in the global configuration mode to create a tracked list of objects (which, in this case, are lists of interfaces or prefixes) using a threshold percentage to determine the state of the list.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:**	Enters mode.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router# configure`	
Step 2	**track** *track-name* **Example:** `RP/0/RP0/CPU0:router(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type list threshold percentage** **Example:** `RP/0/RP0/CPU0:router(config-track)# type list threshold percentage`	Configures a track of type threshold percentage list.

Step 4	**object** *object-name*
	Example:
	`RP/0/RP0/CPU0:router(config-track-list-threshold)# object 1`
	`RP/0/RP0/CPU0:router(config-track-list-threshold)# object 2`
	`RP/0/RP0/CPU0:router(config-track-list-threshold)# object 3`
	`RP/0/RP0/CPU0:router(config-track-list-threshold)# object 4`
		Configures object 1, object 2, object 3 and object 4 as members of track type track1.

Step 5	**threshold percentage up** *percentage* **down** *percentage* **Example:** `RP/0/RP0/CPU0:router(config-track-list-threshold)# threshold percentage up 50 down 33`	Configures the percentage of objects that need to be UP or DOWN for the list to be considered UP or Down respectively. For example, if object 1, object 2, and object 3 are in the UP state and object 4 is in the DOWN state, the list is considered to be in the UP state.

Step 6	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RP0/CPU0:router(config-track)# end`
	or
	`RP/0/RP0/CPU0:router(config-track)# 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

	Command or Action	Purpose
		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.

Building a Track Based on a List of Objects - Threshold Weight

Perform this task in the global configuration mode to create a tracked list of objects (which, in this case, are lists of interfaces or prefixes) using a threshold weight to determine the state of the list.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**track** *track-name* **Example:** `RP/0/RP0/CPU0:router(config)# track track1`	Enters track configuration mode. • *track-name*—Specifies a name for the object to be tracked.
Step 3	**type list threshold weight** **Example:** `RP/0/RP0/CPU0:router(config-track)# type list threshold weight`	Configures a a track of type, threshold weighted list.

Step 4	**object** *object-name* **weight** *weight*
	Example:
	`RP/0/RP0/CPU0:router(config-track-list-threshold)# object 1 weight 10`
	`RP/0/RP0/CPU0:router(config-track-list-threshold)# object 2 weight 5`
	`RP/0/RP0/CPU0:router(config-track-list-threshold)# object 3 weight 3`
		Configures object 1, object 2 and object 3 as members of track t1 and with weights 10, 5 and 3 respectively.

	Command or Action	Purpose
Step 5	**threshold weight up** *weight* **down** *weight* **Example:** `RP/0/RP0/CPU0:router(config-track-list-threshold)# threshold weight up 10 down 5`	Configures the range of weights for the objects that need to be UP or DOWN for the list to be considered UP or DOWN respectively. In this example, the list is considered to be in the DOWN state because objects 1 and 2 are in the UP state and the cumulative weight is 15 (not in the 10-5 range).

Step 6	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RP0/CPU0:router(config-track)# end`
	or
	`RP/0/RP0/CPU0:router(config-track)# 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.

Tracking IPSLA Reachability

Use this task to enable the tracking of the return code of IP service level agreement (SLA) operations.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**track** *track-name* **Example:** `RP/0/RP0/CPU0:router(config)# track t1`	Enters track configuration mode. **Note** Special characters are not allowed in a *track-name*.
Step 3	**type rtr** *ipsla-no* **reachability** **Example:** `RP/0/RP0/CPU0:router(config-track)# type rtr 100 reachability`	Specifies the IP SLA operation ID to be tracked for reachability. Values for the *ipsla-no* can range from1 to 2048.
Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring IPSLA Tracking: Example

This example shows the configuration of IPSLA tracking:

```
RP/0/RP0/CPU0:router(config)# track track1
RP/0/RP0/CPU0:router(config-track)# type rtr 1 reachability
RP/0/RP0/CPU0:router(config-track)# delay up 5
RP/0/RP0/CPU0:router(config-track)# delay down 10
```

Configuration Examples for Configuring Object Tracking

Tracking Whether the Interface Is Up or Down: Running Configuration Example

```
track connection100
  type list boolean and
    object object3 not
    delay up 10
    !
interface service-ipsec 23
  line-protocol track connection100
```

```
  !
```

Tracking the Line Protocol State of an Interface: Running Configuration Example

In this example, traffic arrives from interface service-ipsec1 and exits through interface gigabitethernet0/0/0/3:

```
track IPSec1
  type line-protocol state
    interface gigabitethernet0/0/0/3
    !
interface service-ipsec 1
  ipv4 address 70.0.0.1 255.255.255.0
  profile vrf1_profile_ipsec
  line-protocol track IPSec1
  tunnel source 80.0.0.1
  tunnel destination 80.0.0.2
  service-location preferred-active 0/0/1
  !
```

This example displays the output from the **show track** command after performing the previous example:

```
RP/0/RP0/CPU0:router# show run track

  Track IPSec1
  Interface GigabitEthernet0_0_0_3 line-protocol
  !
    Line protocol is UP
    1 change, last change 10:37:32 UTC Thu Sep 20 2007
    Tracked by:
    service-ipsec1
    !
```

Tracking IP Route Reachability: Running Configuration Example

In this example, traffic arriving from interface service-ipsec1 has its destination in network 7.0.0.0/24. This tracking procedure follows the state of the routing protocol prefix to signal when there are changes in the routing table.

```
track PREFIX1
  type route reachability
    route ipv4 7.0.0.0/24
    !
  interface service-ipsec 1
  vrf 1
  ipv4 address 70.0.0.2 255.255.255.0
  profile vrf_1_ipsec
  line-protocol track PREFIX1
  tunnel source 80.0.0.2
  tunnel destination 80.0.0.1
  service-location preferred-active 0/2/0
```

Building a Track Based on a List of Objects: Running Configuration Example

In this example, traffic arriving from interface service-ipsec1 exits through interface gigabitethernet0/0/0/3 and interface ATM 0/2/0/0.1. The destination of the traffic is at network 7.0.0.0/24.

If either one of the interfaces or the remote network goes down, the flow of traffic must stop. To do this, we use a Boolean AND expression.

```
track C1
 type route reachability
  route ipv4 3.3.3.3/32
 !
!
track C2
 type route reachability
  route ipv4 1.2.3.4/32
 !
!
track C3
 type route reachability
  route ipv4 10.0.20.2/32
 !
!
track C4
 type route reachability
  route ipv4 10.0.20.0/24
 !
!
track OBJ
 type list boolean and
  object C1
  object C2
 !
!
track OBJ2
 type list boolean or
  object C1
  object C2
 !
```

Configuring IPSLA based Object Tracking: Configuration Example

This example shows the configuration of IPSLA based object tracking, including the ACL and IPSLA configuration:

ACL configuration:

```
RP/0/RP0/CPU0:router(config)# ipv4 access-list abf-track
RP/0/RP0/CPU0:router(config-ipv4-acl)# 10 permit any nexthop track track1 1.2.3.4
```

Object tracking configuration:

```
RP/0/RP0/CPU0:router(config)# track track1
RP/0/RP0/CPU0:router(config-track)# type rtr 1 reachability
RP/0/RP0/CPU0:router(config-track)# delay up 5
```

```
RP/0/RP0/CPU0:router(config-track)# delay down 10
```

IPSLA configuration:

```
RP/0/RP0/CPU0:router(config)# ipsla
RP/0/RP0/CPU0:router(config-ipsla)# operation 1
RP/0/RP0/CPU0:router(config-ipsla-op)# type icmp echo
RP/0/RP0/CPU0:router(config-ipsla-icmp-echo)# source address 2.3.4.5
RP/0/RP0/CPU0:router(config-ipsla-icmp-echo)# destination address 1.2.3.4
RP/0/RP0/CPU0:router(config-ipsla-icmp-echo)# frequency 60
RP/0/RP0/CPU0:router(config-ipsla-icmp-echo)# exit
RP/0/RP0/CPU0:router(config-ipsla-op)# exit
RP/0/RP0/CPU0:router(config-ipsla)# schedule operation 1
RP/0/RP0/CPU0:router(config-ipsla-sched)# start-time now
RP/0/RP0/CPU0:router(config-ipsla-sched)# life forever
```

Additional References

The following sections provide references related to implementing object tracking for IPSec network security.

Related Documents

Related Topic	Document Title
IP SLA configuration information	*Implementing IP Service Level Agreements on System Monitoring Configuration Guide for Cisco NCS 560 Series Routers*
IP SLA commands	*IP Service Level Agreement Commands on System Monitoring Command Reference for Cisco NCS 5500 Series Routers and Cisco NCS 540 and NCS 560 Series Routers*

Standards

Standards	Title
No new or modified standards are supported by this feature, and support for existing standards has not been modified by this feature.	—

MIBs

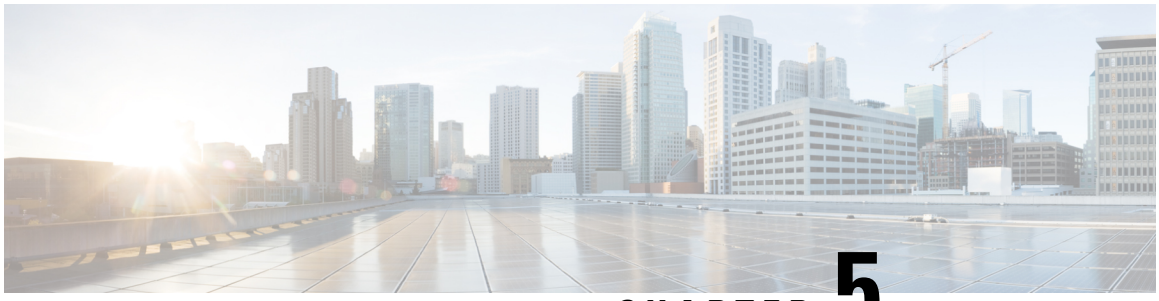
MIBs	MIBs Link
—	To locate and download MIBs using Cisco IOS XR software, use the Cisco MIB Locator found at the following URL and choose a platform under the Cisco Access Products menu: https://cfnng-stg.cisco.com/mibs.

RFCs

RFCs	Title
RFC 2401	*Security Architecture for the Internet Protocol*

Technical Assistance

Description	Link
The Cisco Technical Support website contains thousands of pages of searchable technical content, including links to products, technologies, solutions, technical tips, and tools. Registered Cisco.com users can log in from this page to access even more content.	http://www.cisco.com/cisco/web/support/index.html



CHAPTER 5

Configuring Physical and Virtual Terminals

Line templates define standard attribute settings for incoming and outgoing transport over physical and virtual terminal lines (vtys). Vty pools are used to apply template settings to ranges of vtys.

This module describes the tasks you need to implement physical and virtual terminals on your Cisco IOS XR network.

- Prerequisites for Implementing Physical and Virtual Terminals, on page 53
- Information About Implementing Physical and Virtual Terminals, on page 53
- How to Implement Physical and Virtual Terminals on Cisco IOS XR Software, on page 56
- Configuration Examples for Implementing Physical and Virtual Terminals, on page 60

Prerequisites for Implementing Physical and Virtual Terminals

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.

Information About Implementing Physical and Virtual Terminals

To implement physical and virtual terminals, you need to understand the concepts in this section.

Tip You can programmatically manage the physical and virtual terminals using `openconfig-system-terminal.yang` OpenConfig data model. To get started with using data models, see the *Programmability Configuration Guide*.

Line Templates

The following line templates are available in the Cisco IOS XR software.

- Default line template—The default line template that applies to a physical and virtual terminal lines.
- Console line template—The line template that applies to the console line.

- User-defined line templates—User-defined line templates that can be applied to a range of virtual terminal lines.

Line Template Configuration Mode

Changes to line template attributes are made in line template configuration mode. To enter line template configuration mode, issue the **line** command from XR Config mode, specifying the template to be modified. These line templates can be configured with the **line** command:

- console—console template
- default—default template
- template—user-defined template

After you specify a template with the **line** command, the router enters line template configuration mode where you can set the terminal attributes for the specified line. This example shows how to specify the attributes for the console:

```
RP/0/RP0/CPU0:router(config)# line console
RP/0/RP0/CPU0:router(config-line)#
```

From line template configuration mode, use the online help feature (**?**) to view all available options. Some useful options include:

- absolute-timeout—Specifies a timeout value for line disconnection.
- escape-character—Changes the line escape character.
- exec-timeout—Specifies the EXEC timeout.
- length—Sets the number of lines displayed on the screen.
- session-limit—Specifies the allowable number of outgoing connections.
- session-timeout—Specifies an interval for closing the connection if there is no input traffic.
- timestamp—Displays the timestamp before each command.
- width—Specifies the width of the display terminal.

Note The *default* session-limit for line template is applicable to Telnet sessions only. It is not applicable for SSH sessions.

Line Template Guidelines

The following guidelines apply to modifying the console template and to configuring a user-defined template:

- Modify the templates for the physical terminal lines on the router (the console port) from line template configuration mode. Use the **line console** command from XR Config mode to enter line template configuration mode for the console template.

- Modify the template for virtual lines by configuring a user-defined template with the **line** *template-name* command, configuring the terminal attributes for the user-defined template from line template configuration, and applying the template to a range of virtual terminal lines using the **vty pool** command.

Note Before creating or modifying the vty pools, enable the telnet server using the **telnet server** command in XR Config mode. See Cisco IOS XR IP Addresses and Services Configuration Guide and Cisco IOS XR IP Addresses and Services Command Reference for more information.

Terminal Identification

The physical terminal lines for the console port is identified by its location, expressed in the format of *rack*/*slot*/*module* , on the active or standby route processor (RP) where the respective console port resides. For virtual terminals, physical location is not applicable; the Cisco IOS XR software assigns a vty identifier to vtys according to the order in which the vty connection has been established.

vty Pools

Each virtual line is a member of a pool of connections using a common line template configuration. Multiple vty pools may exist, each containing a defined number of vtys as configured in the vty pool. The Cisco IOS XR software supports the following vty pools by default:

- Default vty pool—The default vty pool consists of five vtys (vtys 0 through 4) that each reference the default line template.
- Default fault manager pool—The default fault manager pool consists of six vtys (vtys 100 through 105) that each reference the default line template.

In addition to the default vty pool and default fault manager pool, you can also configure a user-defined vty pool that can reference the default template or a user-defined template.

When configuring vty pools, follow these guidelines:

- The vty range for the default vty pool must start at vty 0 and must contain a minimum of five vtys.
- The vty range from 0 through 99 can reference the default vty pool.
- The vty range from 5 through 99 can reference a user-defined vty pool.
- The vty range from 100 is reserved for the fault manager vty pool.
- The vty range for fault manager vty pools must start at vty 100 and must contain a minimum of six vtys.
- A vty can be a member of only one vty pool. A vty pool configuration will fail if the vty pool includes a vty that is already in another pool.
- If you attempt to remove an active vty from the active vty pool when configuring a vty pool, the configuration for that vty pool will fail.

How to Implement Physical and Virtual Terminals on Cisco IOS XR Software

Modifying Templates

This task explains how to modify the terminal attributes for the console and default line templates. The terminal attributes that you set will modify the template settings for the specified template.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.

Step 2	**line** {**console** | **default**}
	Example:
	`RP/0/RP0/CPU0:router(config)# line console`
	or
	`RP/0/RP0/CPU0:router(config)# line default`
		Enters line template configuration mode for the specified line template.
		• **console** —Enters line template configuration mode for the console template.
		• **default** —Enters line template configuration mode for the default line template.

Step 3	Configure the terminal attribute settings for the specified template using the commands in line template configuration mode.	—

Step 4	Use one of the following commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RP0/CPU0:router(config-line)# end`
	or
	`RP/0/RP0/CPU0:router(config-line)# 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

	Command or Action	Purpose
		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.

Creating and Modifying vty Pools

This task explains how to create and modify vty pools.

You can omit Step 3 to Step 5 (**line template** and **exit** commands) if you are configuring the default line template to reference a vty pool.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**telnet** {**ipv4** | **ipv6**} **server max-servers** *limit* **Example:** `RP/0/RP0/CPU0:router(config)# telnet ipv4 server max-servers 10`	Specifies the number of allowable Telnet servers. Up to 100 Telnet servers are allowed. **Note** By default no Telnet servers are allowed. You must configure this command in order to enable the use of Telnet servers.
Step 3	**line template** *template-name* **Example:** `RP/0/RP0/CPU0:router(config)# line template 1`	Enters line template configuration mode for a user-defined template.
Step 4	Configure the terminal attribute settings for the specified line template using the commands in line template configuration mode.	—
Step 5	**exit** **Example:**	Exits line template configuration mode and returns the router to global configuration mode.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config-line)# exit`	

Step 6	**vty-pool** {**default** | *pool-name* | **eem**} *first-vty last-vty* [**line-template** {**default** | *template-name*}]
	Example:
	`RP/0/RP0/CPU0:router(config)#vty-pool default 0 5 line-template default`
	or
	`RP/0/RP0/CPU0:router(config)#vty-pool pool1 5 50 line-template template1`
	or
	`RP/0/RP0/CPU0:router(config)#vty-pool eem 100 105 line-template template1`
	`RP/0/RP0/CPU0:router(config)#vty-pool default 0 5 line-template template1`
		Creates or modifies vty pools.
		• If you do not specify a line template with the **line-template** keyword, a vty pool defaults to the default line template.
		• **default** —Configures the default vty pool.
		  • The default vty pool must start at vty 0 and must contain a minimum of five vtys (vtys 0 through 4).
		  • You can resize the default vty pool by increasing the range of vtys that compose the default vty pool.
		• *pool-name* —Creates a user-defined vty pool.
		  • A user-defined pool must start at least at vty 5, depending on whether the default vty pool has been resized.
		  • If the range of vtys for the default vty pool has been resized, use the first range value free from the default line template. For example, if the range of vtys for the default vty pool has been configured to include 10 vtys (vty 0 through 9), the range value for the user-defined vty pool must start with vty 10.
		• **eem** —Configures the embedded event manager pool.
		  • The default embedded event manager vty pool must start at vty 100 and must contain a minimum of six vtys (vtys 100 through 105).
		• **line-template** *template-name* —Configures the vty pool to reference a user-defined template.

Step 7	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions:

	Command or Action	Purpose
		• **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Monitoring Terminals and Terminal Sessions

This task explains how to monitor terminals and terminal sessions using the **show** EXEC commands available for physical and terminal lines.

Note The commands can be entered in any order.

Procedure

	Command or Action	Purpose

Step 1	(Optional) **show line** [**aux location** *node-id* | **console location** *node-id* | **vty** *number*]
	Example:
	`RP/0/RP0/CPU0:router# show line`
		Displays the terminal parameters of terminal lines.
		• Specifying the **show line aux location** *node-id* EXEC command displays the terminal parameters of the auxiliary line.
		• Specifying the **show line console location** *node-id* EXEC command displays the terminal parameters of the console.
		  • For the **location** *node-id* keyword and argument, enter the location of the Route Processor (RP) on which the respective auxiliary or console port resides.
		  • The *node-id* argument is expressed in the format of *rack*/*slot*/*module* .
		• Specifying the **show line vty** *number* EXEC command displays the terminal parameters for the specified vty.

	Command or Action	Purpose
Step 2	(Optional) **show terminal** **Example:** `RP/0/RP0/CPU0:router# show terminal`	Displays the terminal attribute settings for the current terminal line.
Step 3	(Optional) **show users** **Example:** `RP/0/RP0/CPU0:router# show users`	Displays information about the active lines on the router.

Configuration Examples for Implementing Physical and Virtual Terminals

Modifying the Console Template: Example

This configuration example shows how to modify the terminal attribute settings for the console line template:

```
RP/0/RP0/CPU0:router# show running-config line console
line console
  exec-timeout 0 0
  escape-character 0x5a
  session-limit 10
  disconnect-character 0x59
  session-timeout 100
  transport input telnet
  transport output telnet
```

In this configuration example, the following terminal attributes are applied to the console line template:

- The EXEC time out for terminal sessions is set to 0 minutes, 0 seconds. Setting the EXEC timeout to 0 minutes and 0 seconds disables the EXEC timeout function; thus, the EXEC session for the terminal session will never time out.
- The escape character is set to the 0x5a hexadecimal value (the 0x5a hexadecimal value translates into the “Z” character).
- The session limit for outgoing terminal sessions is set to 10 connections.
- The disconnect character is set to 0x59 hexadecimal value (the 0x59 hexadecimal character translates into the “Y” character).
- The session time out for outgoing terminal sessions is set to 100 minutes (1 hour and 40 minutes).
- The allowed transport protocol for incoming terminal sessions is Telnet.
- The allowed transport protocol for outgoing terminal sessions is Telnet.

To verify that the terminal attributes for the console line template have been applied to the console, use the **show line** command:

```
RP/0/RP0/CPU0:router:router# show line console location 0/0/CPU0
Tue Nov 24 03:10:24.656 UTC
Tty             Speed     Overruns           Acc I/O
*con0/0/CPU0      9600       0/0               -/-

Line "con0_RP1_CPU0", Location "0/RP1/CPU0", Type "Console"
Length: 24 lines, Width: 80 columns
Baud rate (TX/RX) is 9600, "No" Parity, 2 stopbits, 8 databits
Template: console
Capabilities: Timestamp Enabled
Allowed transports are telnet.
```

Modifying the Default Template: Example

This configuration example shows how to override the terminal settings for the default line template:

```
line default
  exec-timeout 0 0
  width 512
  length 512
```

In this example, the following terminal attributes override the default line template default terminal attribute settings:

- The EXEC timeout for terminal sessions is set to 0 minutes and 0 seconds. Setting the EXEC timeout to 0 minutes and 0 seconds disables the EXEC timeout function; thus, the EXEC session for the terminal session will never time out (the default EXEC timeout for the default line template is 10 minutes).
- The width of the terminal screen for the terminals referencing the default template is set to 512 characters (the default width for the default line template is 80 characters).
- The length, the number of lines that will display at one time on the terminal referencing the default template, is set to 512 lines (the default length for the default line template is 24 lines).

Configuring a User-Defined Template to Reference the Default vty Pool: Example

This configuration example shows how to configure a user-defined line template (named test in this example) for vtys and to configure the line template test to reference the default vty pool:

```
line template test
  exec-timeout 100 0
  width 100
  length 100
  exit
vty-pool default 0 4 line-template test
```

Configuring a User-Defined Template to Reference a User-Defined vty Pool: Example

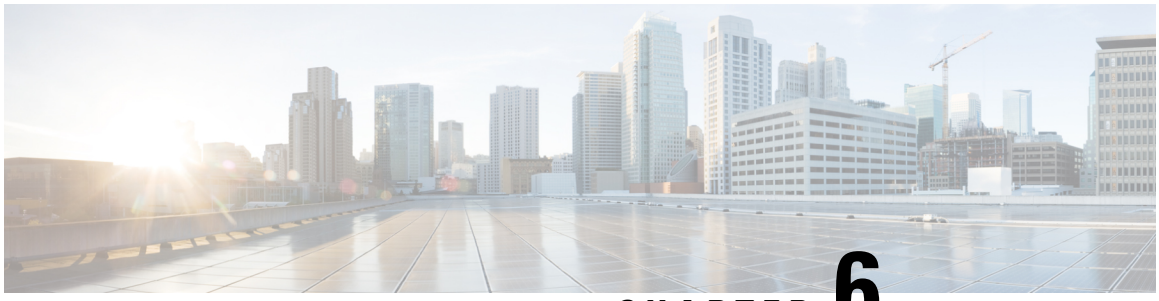
This configuration example shows how to configure a user-defined line template (named test2 in this example) for vtys and to configure the line template test to reference a user-defined vty pool (named pool1 in this example):

```
line template test2
  exec-timeout 0 0
  session-limit 10
  session-timeout 100
  transport input all
  transport output all
  exit
vty-pool pool1 5 50 line-template test2
```

Configuring a User-Defined Template to Reference the Fault Manager vty Pool: Example

This configuration example shows how to configure a user-defined line template (named test3 in this example) for vtys and to configure the line template test to reference the fault manager vty pool:

```
line template test3
  width 110
  length 100
  session-timeout 100
  exit
  vty-pool eem 100 105 line-template test3
```



CHAPTER 6

Configuring Simple Network Management Protocol

Simple Network Management Protocol (SNMP) is an application-layer protocol that provides a message format for communication between SNMP managers and agents. SNMP provides a standardized framework and a common language used for the monitoring and management of devices in a network.

This module describes the tasks you need to implement SNMP on your Cisco IOS XR network.

- Prerequisites for Implementing SNMP, on page 63
- Restrictions for SNMP use on Cisco IOS XR Software, on page 63
- Information about Implementing SNMP, on page 64
- Session MIB support on subscriber sessions , on page 69
- How to Implement SNMP on Cisco IOS XR Software, on page 71

Prerequisites for Implementing SNMP

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.

Restrictions for SNMP use on Cisco IOS XR Software

SNMP outputs are only 32-bits wide and therefore cannot display any information greater than 2^{32}. 2^{32} is equal to 4.29 Gigabits.

Note A 10 Gigabit interface is greater than 2^{32}, so if you are trying to display speed information regarding the interface, you might see concatenated results.

To display correct speed of an interface greater than 10 Gigabit, ifHighSpeed can be used.

The recommended maximum number of object identifiers (OIDs) that can be accommodated in a single SNMP request is 75. A request with more than 75 OIDs can result in SNMP requests being dropped with SNMP polling timeout.

Information about Implementing SNMP

To implement SNMP, you need to understand the concepts described in this section.

SNMP Functional Overview

The SNMP framework consists of three parts:

- SNMP manager
- SNMP agent
- Management Information Base (MIB)

SNMP Manager

The SNMP manager is the system used to control and monitor the activities of network hosts using SNMP. The most common managing system is called a *network management system* (NMS). The term NMS can be applied to either a dedicated device used for network management, or the applications used on such a device. A variety of network management applications are available for use with SNMP. These features range from simple command-line applications to feature-rich graphical user interfaces (such as the CiscoWorks 2000 line of products).

SNMP Agent

The SNMP agent is the software component within the managed device that maintains the data for the device and reports these data, as needed, to managing systems. The agent and MIB reside on the router. To enable the SNMP agent, you must define the relationship between the manager and the agent.

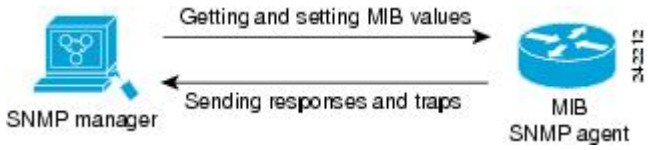
MIB

The *Management Information Base* (MIB) is a virtual information storage area for network management information, which consists of collections of managed objects. Within the MIB there are collections of related objects, defined in MIB modules. MIB modules are written in the SNMP MIB module language, as defined in STD 58, RFC 2578, RFC 2579, and RFC 2580. Note that individual MIB modules are also referred to as MIBs; for example, the Interfaces Group MIB (IF-MIB) is a MIB module within the MIB on your system.

The SNMP agent contains MIB variables whose values the SNMP manager can request or change through Get or Set operations. A manager can get a value from an agent or store a value into that agent. The agent gathers data from the MIB, the repository for information about device parameters and network data. The agent can also respond to manager requests to get or set data.

This figure illustrates the communications relationship between the SNMP manager and agent. A manager can send the agent requests to get and set MIB values. The agent can respond to these requests. Independent of this interaction, the agent can send unsolicited notifications (traps) to the manager to notify the manager of network conditions.

Figure 1: Communication Between an SNMP Agent and Manager



IP-MIB Support

RFC4293 IP-MIB was specifically designed to provide IPv4 and IPv6 statistics individually. The **ipIfStatsTable** defined in RFC 4293, lists the interface specific statistics. IPv6 statistics support in ipIfStatsTable was added earlier but, IOS-XR implementation of IP-MIB did not support IPv4 statistics as per RFC4293 in earlier releases.

From Release 6.3.2 onwards, IOS-XR implementation of IP-MIB supports IPv4 statistics as per RFC4293. This will enable you to collect the IPV4 and IPv6 statistics separately for each interface. The **ipIfStatsTable** is indexed by two **sub-ids address type (IPv4 or IPv6)** and the **interface ifindex[1]**. The implementation of IP-MIB support for IPv4 and IPv6 is separated from Release 6.3.2 for better readability and maintainability.

The list of OIDs added to the **ipIfStatsTable** for IPv4 statistics are:

- ipIfStatsInReceives
- ipIfStatsHCInReceives
- ipIfStatsInOctets
- ipIfStatsHCInOctets
- ipIfStatsOutTransmits
- ipIfStatsHCOutTransmits
- ipIfStatsOutOctets
- ipIfStatsHCOutOctets
- ipIfStatsDiscontinuityTime

For more information on the list of new OIDs added for iPv4 statistics, see SNMP OID Navigator.

SNMP Versions

Cisco IOS XR software supports the following versions of SNMP:

- Simple Network Management Protocol Version 1 (SNMPv1)
- Simple Network Management Protocol Version 2c (SNMPv2c)
- Simple Network Management Protocol Version 3 (SNMPv3)

Both SNMPv1 and SNMPv2c use a community-based form of security. The community of managers able to access the agent MIB is defined by an IP address access control list and password.

SNMPv2c support includes a bulk retrieval mechanism and more detailed error message reporting to management stations. The bulk retrieval mechanism supports the retrieval of tables and large quantities of information, minimizing the number of round-trips required. The SNMPv2c improved error handling support includes expanded error codes that distinguish different kinds of error conditions; these conditions are reported through a single error code in SNMPv1. Error return codes now report the error type. Three kinds of exceptions are also reported: no such object exceptions, no such instance exceptions, and end of MIB view exceptions.

SNMPv3 is a security model. A *security model* is an authentication strategy that is set up for a user and the group in which the user resides. A *security level* is the permitted level of security within a security model. A combination of a security model and a security level will determine which security mechanism is employed

when an SNMP packet is handled. See Security Models and Levels for SNMPv1, v2, v3, on page 66 for a list of security levels available in SNMPv3. The SNMPv3 feature supports RFCs 3411 to 3418.

You must configure the SNMP agent to use the version of SNMP supported by the management station. An agent can communicate with multiple managers; for this reason, you can configure the Cisco IOS-XR software to support communications with one management station using the SNMPv1 protocol, one using the SNMPv2c protocol, and another using SMNPv3.

Comparison of SNMPv1, v2c, and v3

SNMP v1, v2c, and v3 all support the following operations:

- get-request—Retrieves a value from a specific variable.
- get-next-request—Retrieves the value following the named variable; this operation is often used to retrieve variables from within a table. With this operation, an SNMP manager does not need to know the exact variable name. The SNMP manager searches sequentially to find the needed variable from within the MIB.
- get-response—Operation that replies to a get-request, get-next-request, and set-request sent by an NMS.
- set-request—Operation that stores a value in a specific variable.
- trap—Unsolicited message sent by an SNMP agent to an SNMP manager when some event has occurred.

This table identifies other key SNMP features supported by the SNMP v1, v2c, and v3.

Table 1: SNMPv1, v2c, and v3 Feature Support

Feature	SNMP v1	SNMP v2c	SNMP v3
Get-Bulk Operation	No	Yes	Yes
Inform Operation	No	Yes (No on the Cisco IOS XR software)	Yes (No on the Cisco IOS XR software)
64 Bit Counter	No	Yes	Yes
Textual Conventions	No	Yes	Yes
Authentication	No	No	Yes
Privacy (Encryption)	No	No	Yes
Authorization and Access Controls (Views)	No	No	Yes

Security Models and Levels for SNMPv1, v2, v3

The security level determines if an SNMP message needs to be protected from disclosure and if the message needs to be authenticated. The various security levels that exist within a security model are as follows:

- noAuthNoPriv—Security level that does not provide authentication or encryption.
- authNoPriv—Security level that provides authentication but does not provide encryption.

- authPriv—Security level that provides both authentication and encryption.

Three security models are available: SNMPv1, SNMPv2c, and SNMPv3. The security model combined with the security level determine the security mechanism applied when the SNMP message is processed.

The below table identifies what the combinations of security models and levels mean.

Table 2: SNMP Security Models and Levels

Model	Level	Authentication	Encryption	What Happens
v1	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
v2c	noAuthNoPriv	Community string	No	Uses a community string match for authentication.
v3	noAuthNoPriv	Username	No	Uses a username match for authentication.
v3	authNoPriv	HMAC-MD5 or HMAC-SHA	No	Provides authentication based on the HMAC[1]-MD5[2] algorithm or the HMAC-SHA[3].
v3	authPriv	HMAC-MD5 or HMAC-SHA	DES	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Provides DES[4] 56-bit encryption in addition to authentication based on the CBC[5] DES (DES-56) standard.
v3	authPriv	HMAC-MD5 or HMAC-SHA	3DES	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Provides 168-bit 3DES[6] level of encryption.
v3	authPriv	HMAC-MD5 or HMAC-SHA	AES	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Provides 128-bit AES[7] level of encryption.

1 Hash-Based Message Authentication Code
2 Message Digest 5
3 Secure Hash Algorithm
4 Data Encryption Standard
5 Cipher Block Chaining
6 Triple Data Encryption Standard
7 Advanced Encryption Standard

Use of 3DES and AES encryption standards requires that the security package (k9sec) be installed. For information on installing software packages, see *Upgrading and Managing Cisco IOS XR Software*.

SNMPv3 Benefits

SNMPv3 provides secure access to devices by providing authentication, encryption and access control. These added security benefits secure SNMP against the following security threats:

- Masquerade—The threat that an SNMP user may assume the identity of another SNMP user to perform management operations for which that SNMP user does not have authorization.

- Message stream modification—The threat that messages may be maliciously reordered, delayed, or replayed (to an extent that is greater than can occur through the natural operation of a subnetwork service) to cause SNMP to perform unauthorized management operations.
- Disclosure—The threat that exchanges between SNMP engines could be eavesdropped. Protecting against this threat may be required as a matter of local policy.

In addition, SNMPv3 provides access control over protocol operations on SNMP managed objects.

SNMPv3 Costs

SNMPv3 authentication and encryption contribute to a slight increase in the response time when SNMP operations on MIB objects are performed. This cost is far outweighed by the security advantages provided by SNMPv3.

This table shows the order of response time (from least to greatest) for the various security model and security level combinations.

Table 3: Order of Response Times from Least to Greatest

Security Model	Security Level
SNMPv2c	noAuthNoPriv
SNMPv3	noAuthNoPriv
SNMPv3	authNoPriv
SNMPv3	authPriv

User-Based Security Model

SNMPv3 User-Based Security Model (USM) refers to SNMP message-level security and offers the following services:

- Message integrity—Ensures that messages have not been altered or destroyed in an unauthorized manner and that data sequences have not been altered to an extent greater than can occur nonmaliciously.
- Message origin authentication—Ensures that the claimed identity of the user on whose behalf received data was originated is confirmed.
- Message confidentiality—Ensures that information is not made available or disclosed to unauthorized individuals, entities, or processes.

SNMPv3 authorizes management operations only by configured users and encrypts SNMP messages.

USM uses two authentication protocols:

- HMAC-MD5-96 authentication protocol
- HMAC-SHA-96 authentication protocol

USM uses Cipher Block Chaining (CBC)-DES (DES-56) as the privacy protocol for message encryption.

View-Based Access Control Model

The View-Based Access Control Model (VACM) enables SNMP users to control access to SNMP managed objects by supplying read, write, or notify access to SNMP objects. It prevents access to objects restricted by

views. These access policies can be set when user groups are configured with the **snmp-server group** command.

MIB Views

For security reasons, it is often valuable to be able to restrict the access rights of some groups to only a subset of the management information within the management domain. To provide this capability, access to a management object is controlled through MIB views, which contain the set of managed object types (and, optionally, the specific instances of object types) that can be viewed.

Access Policy

Access policy determines the access rights of a group. The three types of access rights are as follows:

- read-view access—The set of object instances authorized for the group when objects are read.
- write-view access—The set of object instances authorized for the group when objects are written.
- notify-view access—The set of object instances authorized for the group when objects are sent in a notification.

IP Precedence and DSCP Support for SNMP

SNMP IP Precedence and differentiated services code point (DSCP) support delivers QoS specifically for SNMP traffic. You can change the priority setting so that SNMP traffic generated in a router is assigned a specific QoS class. The IP Precedence or IP DSCP code point value is used to determine how packets are handled in weighted random early detection (WRED).

After the IP Precedence or DSCP is set for the SNMP traffic generated in a router, different QoS classes cannot be assigned to different types of SNMP traffic in that router.

The IP Precedence value is the first three bits in the type of service (ToS) byte of an IP header. The IP DSCP code point value is the first six bits of the differentiate services (DiffServ Field) byte. You can configure up to eight different IP Precedence markings or 64 different IP DSCP markings.

Session MIB support on subscriber sessions

SNMP monitoring requires information about subscribers of all types. The CISCO-SUBSCRIBER-SESSION-MIB is defined to model per-subscriber data as well as aggregate subscriber (PPPoE) data. It is required to support notifications (traps) for aggregate session counts crossing configured thresholds. Generic MIB Data Collector Manager (DCM) support for CISCO-SUBSCRIBER-SESSION-MIB, helps faster data collection and also better handling of parallel data.

SNMP Notifications

A key feature of SNMP is the ability to generate notifications from an SNMP agent. These notifications do not require that requests be sent from the SNMP manager. On Cisco IOS XR software, unsolicited (asynchronous) notifications can be generated only as *traps*. Traps are messages alerting the SNMP manager to a condition on the network. Notifications can indicate improper user authentication, restarts, the closing of a connection, loss of connection to a neighbor router, or other significant events.

Note Inform requests (inform operations) are supported in Cisco IOS XR software.

Traps are less reliable than informs because the receiver does not send any acknowledgment when it receives a trap. The sender cannot determine if the trap was received. An SNMP manager that receives an inform request acknowledges the message with an SNMP response protocol data unit (PDU). If the manager does not receive an inform request, it does not send a response. If the sender never receives a response, the inform request can be sent again. Thus, informs are more likely to reach their intended destination.

However, traps are often preferred because informs consume more resources in the router and in the network. Unlike a trap, which is discarded as soon as it is sent, an inform request must be held in memory until a response is received or the request times out. Also, traps are sent only once, and an inform may be retried several times. The retries increase traffic and contribute to a higher overhead on the network. Thus, traps and inform requests provide a trade-off between reliability and resources.

Figure 2: Trap Received by the SNMP Manager

In this illustration, the agent router sends a trap to the SNMP manager. Although the manager receives the trap, it does not send any acknowledgment to the agent. The agent has no way of knowing that the trap reached its destination.

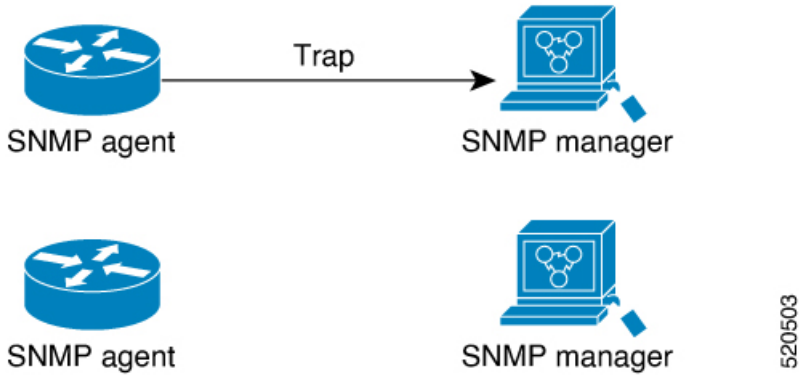
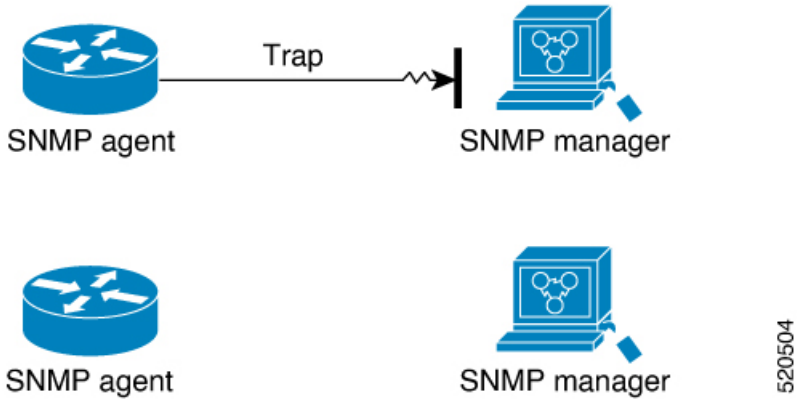


Figure 3: Trap Not Received by the SNMP Manager

In this illustration, the agent sends a trap to the manager, but the trap does not reach the manager. Because the agent has no way of knowing that the trap did not reach its destination, the trap is not sent again. The manager never receives the trap.



Session Types

The supported session types are:

- PPPoE
- IP SUB PKT
- IP SUB DHCP

How to Implement SNMP on Cisco IOS XR Software

This section describes how to implement SNMP.

The **snmp-server** commands enable SNMP on Management Ethernet interfaces by default. For information on how to enable SNMP server support on other inband interfaces, see the *Implementing Management Plane Protection on Cisco IOS XR Software* module in *System Security Configuration Guide*.

Configuring SNMPv3

This task explains how to configure SNMPv3 for network management and monitoring.

Note No specific command enables SNMPv3; the first **snmp-server** global configuration command (config), that you issue enables SNMPv3. Therefore, the sequence in which you issue the **snmp-server** commands for this task does not matter.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	(Optional) **snmp-server engineid local** *engine-id* **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server engineID local 00:00:00:09:00:00:00:a1:61:6c:20:61`	Specifies the identification number of the local SNMP engine.
Step 3	**snmp-server view** *view-name oid-tree* {**included** | **excluded**} **Example:**	Creates or modifies a view record.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config)# snmp-server view view_name 1.3.6.1.2.1.1.5 included`	
Step 4	**snmp-server group** *name* {**v1** | **v2c** | **v3** {**auth** | **noauth** | **priv**}} [**read** *view*] [**write** *view*] [**notify** *view*] [*access-list-name*] **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server group group_name v3 noauth read view_name1 write view_name2`	Configures a new SNMP group or a table that maps SNMP users to SNMP views.
Step 5	**snmp-server user** *username groupname* {**v1** | **v2c** | **v3** [**auth** {**md5** | **sha**} {**clear** | **encrypted**} *auth-password* [**priv des56** {**clear** | **encrypted**} *priv-password*]]} [*access-list-name*] **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server user noauthuser group_name v3`	Configures a new user to an SNMP group.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 7	(Optional) **show snmp** **Example:** `RP/0/RP0/CPU0:router# show snmp`	Displays information about the status of SNMP.
Step 8	(Optional) **show snmp engineid** **Example:** `RP/0/RP0/CPU0:router# show snmp engineid`	Displays information about the local SNMP engine.

	Command or Action	Purpose
Step 9	(Optional) **show snmp group** **Example:** `RP/0/RP0/CPU0:router# show snmp group`	Displays information about each SNMP group on the network.
Step 10	(Optional) **show snmp users** **Example:** `RP/0/RP0/CPU0:router# show snmp users`	Displays information about each SNMP username in the SNMP users table.
Step 11	(Optional) **show snmp view** **Example:** `RP/0/RP0/CPU0:router# show snmp view`	Displays information about the configured views, including the associated MIB view family name, storage type, and status.

Configuring SNMPv3: Examples

Setting an Engine ID

This example shows how to set the identification of the local SNMP engine:

```
config
snmp-server engineID local 00:00:00:09:00:00:00:a1:61:6c:20:61
```

Note After the engine ID has been configured, the SNMP agent restarts.

Verifying the Identification of the Local SNMP Engines

This example shows how to verify the identification of the local SNMP engine:

```
show snmp engineid

SNMP engineID 00000009000000a1ffffffff
```

Creating a View

There are two ways to create a view:

- You can include the object identifier (OID) of an ASN.1 subtree of a MIB family from a view by using the **included** keyword of the **snmp-server view** command.
- You can exclude the OID subtree of the ASN.1 subtree of a MIB family from a view by using the **excluded** keyword of the **snmp-server view** command.

This example shows how to create a view that includes the sysName (1.3.6.1.2.1.1.5) object:

```
config
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1.5 included
```

This example shows how to create a view that includes all the OIDs of a system group:

```
config
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1 included
```

This example shows how to create a view that includes all the OIDs under the system group except the sysName object (1.3.6.1.2.1.1.5), which has been excluded:

```
config
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1 included
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1.5 excluded
```

Verifying Configured Views

This example shows how to display information about the configured views:

```
RP/0/RP0/CPU0:router# show snmp view

  v1default 1.3.6.1 - included nonVolatile active
  SNMP_VIEW1 1.3.6.1.2.1.1 - included nonVolatile active
  SNMP_VIEW1 1.3.6.1.2.1.1.5 - excluded nonVolatile active
```

Creating Groups

If you do not explicitly specify a notify, read, or write view, the Cisco IOS XR software uses the v1 default (1.3.6.1). This example shows how to create a group that utilizes the default view:

```
RP/0/RP0/CPU0:router# snmp-server group group-name v3 auth
```

The following configuration example shows how to create a group that has read access to all the OIDs in the system except the sysUpTime object (1.3.6.1.2.1.1.3), which has been excluded from the view applied to the group, but write access only to the sysName object (1.3.6.1.2.1.1.5):

```
!
  snmp-server view view_name1 1.3.6.1.2.1.1 included
  snmp-server view view_name1 1.3.6.1.2.1.1.3 excluded
  snmp-server view view_name2 1.3.6.1.2.1.1.5 included
  snmp-server group group_name1 v3 auth read view_name1 write view_name2
  !
```

Verifying Groups

This example shows how to verify the attributes of configured groups:

```
RP/0/RP0/CPU0:router# show snmp group

  groupname: group_name1                  security model:usm
  readview : view_name1                   writeview: view_name2
  notifyview: v1default
  row status: nonVolatile
```

Creating and Verifying Users

Given the following SNMPv3 view and SNMPv3 group configuration:

```
!
  snmp-server view view_name 1.3.6.1.2.1.1 included
  snmp-server group group_name v3 noauth read view_name write view-name
  !
```

This example shows how to create a noAuthNoPriv user with read and write view access to a system group:

```
config
  snmp-server user noauthuser group_name v3
```

Note The user must belong to a noauth group before a noAuthNoPriv user can be created.

This example shows how to verify the attributes that apply to the SNMP user:

```
RP/0/RP0/CPU0:router# show snmp user

  User name: noauthuser
  Engine ID: localSnmpID
  storage-type: nonvolatile active
```

Given the following SNMPv3 view and SNMPv3 group configuration:

```
!
  snmp-server view SNMP_VIEW1 1.3.6.1.2.1.1 included
  snmp-server group SNMP_GROUP1 v3 auth notify SNMP_VIEW1 read SNMP_VIEW1 write SNMP_VIEW1
 !
```

This example shows how to create a user with authentication (including encryption), read, and write view access to a system group:

```
config
  snmp-server user userv3authpriv SNMP_GROUP1 v3 auth md5 password123 priv aes 128 password123
```

Given the following SNMPv3 view and SNMPv3 group configuration:

```
!
  snmp-server view view_name 1.3.6.1.2.1.1 included
  snmp group group_name v3 priv read view_name write view_name
  !
```

This example shows how to create authNoPriv user with read and write view access to a system group:

```
RP/0/RP0/CPU0:router# snmp-server user authuser group_name v3 auth md5 clear auth_passwd
```

Note Because the group is configured at a security level of Auth, the user must be configured as "auth" at a minimum to access this group ("priv" users could also access this group). The authNoPriv user configured in this group, authuser, must supply an authentication password to access the view. In the example, auth_passwd is set as the authentication password string. Note that **clear** keyword is specified before the auth_passwd password string. The **clear** keyword indicates that the password string being supplied is unencrypted.

This example shows how to verify the attributes that apply to SNMP user:

```
RP/0/RP0/CPU0:router# show snmp user

  User name: authuser
  Engine ID: localSnmpID
  storage-type: nonvolatile active
```

Given the following SNMPv3 view and SNMPv3 group configuration:

```
!
  snmp view view_name 1.3.6.1.2.1.1 included
  snmp group group_name v3 priv read view_name write view_name
  !
```

This example shows how to create an authPriv user with read and write view access to a system group:

```
config
  snmp-server user privuser group_name v3 auth md5 clear auth_passwd priv des56 clear
priv_passwd
```

Note Because the group has a security level of Priv, the user must be configured as a "priv" user to access this group. In this example, the user, privuser, must supply both an authentication password and privacy password to access the OIDs in the view.

This example shows how to verify the attributes that apply to the SNMP user:

```
RP/0/RP0/CPU0:router# show snmp user

  User name: privuser
  Engine ID: localSnmpID
  storage-type: nonvolatile active
```

Configuring SNMP Trap Notifications

This task explains how to configure the router to send SNMP trap notifications.

Note You can omit #unique_78 if you have already completed the steps documented under the #unique_78 task.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**snmp-server group** *name* {**v1 v2 v3** {**auth** | **noauth** | **priv**}} [**read** *view*] **write** *view*] [**notify** *view*] [*access-list-name*] **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server group group_name v3 noauth read view_name1 writer view_name2`	Configures a new SNMP group or a table that maps SNMP users to SNMP views.
Step 3	**snmp-server user** *username groupname* {**v1 v2c v3** {**auth** | **md5** | **sha**} {**clear** | **encrypted**} *auth-password*] [**priv des56** {**clear** | *access-list-name*] **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server group group_name v3 noauth read view_name1 writer view_name2`	Configures a new SNMP group or a table that maps SNMP users to SNMP views.
Step 4	[**snmp-server host** *address* [**traps**] [**version** {**1** | **2c** | **3** [**auth** | **priv**]}] *community-string* [**udp-port** *port*] [*notification-type*] **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server host 12.26.25.61 traps version 3 noauth userV3noauth`	Specifies SNMP trap notifications, the version of SNMP to use, the security level of the notifications, and the recipient (host) of the notifications.

	Command or Action	Purpose
Step 5	**snmp-server traps** [*notification-type*] **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server traps bgp`	Enables the sending of trap notifications and specifies the type of trap notifications to be sent. • If a trap is not specified with the *notification-type* argument, all supported trap notifications are enabled on the router. To display which trap notifications are available on your router, enter the **snmp-server traps ?** command.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.
Step 7	(Optional) **show snmp host** **Example:** `RP/0/RP0/CPU0:router# show snmp host`	Displays information about the configured SNMP notification recipient (host), port number, and security model.

Configuring Trap Notifications: Example

The following example configures an SNMP agent to send out different types of traps. The configuration includes a v2c user, a noAuthNoPriv user, anauthNoPriv user, and an AuthPriv user.

Note The default User Datagram Protocol (UDP) port is 161. If you do not a specify a UDP port with the **udp-port** keyword and *port* argument, then the configured SNMP trap notifications are sent to port 161.

```
!
  snmp-server host 10.50.32.170 version 2c public udp-port 2345
  snmp-server host 10.50.32.170 version 3 auth userV3auth udp-port 2345
  snmp-server host 10.50.32.170 version 3 priv userV3priv udp-port 2345
  snmp-server host 10.50.32.170 version 3 noauth userV3noauth udp-port 2345
  snmp-server user userv2c groupv2c v2c
  snmp-server user userV3auth groupV3auth v3 auth md5 encrypted 140F0A13
 snmp-server user userV3priv groupV3priv v3 auth md5 encrypted 021E1C43 priv des56 encrypted
```

```
1110001C
 snmp-server user userV3noauth groupV3noauth v3 LROwner
 snmp-server view view_name 1.3 included
 snmp-server community public RW
 snmp-server group groupv2c v2c read view_name
 snmp-server group groupV3auth v3 auth read view_name
 snmp-server group groupV3priv v3 priv read view_name
 snmp-server group groupV3noauth v3 noauth read view_name
 !
```

In the following example, the output of the **show snmp host** commaand shows how to verify the configuration SNMP trap notification recipients host, the recipients of SNMP trap notifications. The output displays the following information:

- IP address of the configured notification host
- UDP port where SNMP notification messages are sent
- Type of trap configured
- Security level of the configured user
- Security model configured

```
Notification host: 10.50.32.170 udp-port: 2345 type: trap
user: userV3auth security model: v3 auth

Notification host: 10.50.32.170 udp-port: 2345 type: trap
user: userV3noauth security model: v3 noauth

Notification host: 10.50.32.170 udp-port: 2345 type: trap
user: userV3priv security model: v3 priv

Notification host: 10.50.32.170 udp-port: 2345 type: trap
user: userv2c security model: v2c
```

Setting the Contact, Location, and Serial Number of the SNMP Agent

This task explains how to set the system contact string, system location string, and system serial number of the SNMP agent.

Note The sequence in which you issue the **snmp-server** commands for this task does not matter.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.

	Command or Action	Purpose

Step 2	(Optional) **snmp-server contact** *system-contact-string*
	Example:
	`RP/0/RP0/CPU0:router(config)# snmp-server contact`
	`Dial System Operator at beeper # 27345`
		Sets the system contact string.

Step 3	(Optional) **snmp-server location** *system-location*
	Example:
	`RP/0/RP0/CPU0:router(config)# snmp-server location`
	`Building 3/Room 214`
		Sets the system location string.

Step 4	(Optional) **snmp-server chassis-id** *serial-number* **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server chassis-id 1234456`	Sets the system serial number.
Step 5	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Defining the Maximum SNMP Agent Packet Size

This task shows how to configure the largest SNMP packet size permitted when the SNMP server is receiving a request or generating a reply.

Note The sequence in which you issue the **snmp-server** commands for this task does not matter.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	(Optional) **snmp-server packetsize** *byte-count* **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server packetsize 1024`	Sets the maximum packet size.
Step 3	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Changing Notification Operation Values

After SNMP notifications have been enabled, you can specify a value other than the default for the source interface, message queue length, or retransmission interval.

This task explains how to specify a source interface for trap notifications, the message queue length for each host, and the retransmission interval.

Note The sequence in which you issue the **snmp-server** commands for this task does not matter.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:**	Enters mode.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router# configure`	
Step 2	(Optional) **snmp-server trap-source** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server trap-source POS 0/0/1/0`	Specifies a source interface for trap notifications.
Step 3	(Optional) **snmp-server queue-length** *length* **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server queue-length 20`	Establishes the message queue length for each notification.
Step 4	(Optional) **snmp-server trap-timeout** *seconds* **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server trap-timeout 20`	Defines how often to resend notifications on the retransmission queue.
Step 5	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Setting IP Precedence and DSCP Values

This task describes how to configure IP Precedence or IP DSCP for SNMP traffic.

Before you begin

SNMP must be configured.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	Use one of the following commands: • **snmp-server ipv4 precedence** *value* • **snmp-server ipv4 dscp** *value* **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server dscp 24`	Configures an IP precedence or IP DSCP value for SNMP traffic.
Step 3	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Setting an IP Precedence Value for SNMP Traffic: Example

The following example shows how to set the SNMP IP Precedence value to 7:

```
configure
  snmp-server ipv4 precedence 7
  exit

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

Setting an IP DSCP Value for SNMP Traffic: Example

The following example shows how to set the IP DSCP value of SNMP traffic to 45:

```
configure
  snmp-server ipv4 dscp 45
  exit

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

Displaying SNMP Context Mapping

The SNMP agent serves queries based on SNMP contexts created by the client features. There is a context mapping table. Each entry in the context mapping table includes a context name, the name of the feature that created the context, and the name of the specific instance of the feature.

Procedure

	Command or Action	Purpose
Step 1	**show snmp context-mapping** **Example:** `RP/0/RP0/CPU0:router# show snmp context-mapping`	Displays the SNMP context mapping table.

Monitoring Packet Loss

It is possible to monitor packet loss by configuring the generation of SNMP traps when packet loss exceeds a specified threshold. The configuration described in this task enables the creation of entries in the MIB tables of the EVENT-MIB. This can then be monitored for packet loss using SNMP GET operations.

Before you begin

Note Entries created in the EVENT-MIB MIB tables using the configuration described in this task cannot be altered using an SNMP SET.

Entries to the EVENT-MIB MIB tables created using an SNMP SET cannot be altered using the configuration described in this task.

Procedure

	Command or Action	Purpose
Step 1	**snmp-server mibs eventmib packet-loss** *type interface-path-id* **falling** *lower-threshold* **interval** *sampling-interval* **rising** *upper-threshold* **Example:**	Generates SNMP EVENT-MIB traps for the interface when the packet loss exceeds the specified thresholds. Up to 100 interfaces can be monitored.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config)# snmp-server mibs eventmib packet-loss TenGigE0/0/0/0 falling 1 interval 5 rising 2`	**falling** *lower-threshold* —Specifies the lower threshold. When packet loss between two intervals falls below this threshold and an mteTriggerRising trap was generated previously, a SNMP mteTriggerFalling trap is generated. This trap is not generated until the packet loss exceeds the upper threshold and then falls back below the lower threshold. **interval** *sampling-interval* —Specifies how often packet loss statistics are polled. This is a value between 5 and 1440 minutes, in multiples of 5. **rising** *upper-threshold* —Specifies the upper threshold. When packet loss between two intervals increases above this threshold, an SNMP mteTriggreRising trap is generated. This trap is not generated until the packet loss drops below the lower threshold and then rises above the upper threshold.

Configuring MIB Data to be Persistent

Many SNMP MIB definitions define arbitrary 32-bit indices for their object tables. MIB implementations often do a mapping from the MIB indices to some internal data structure that is keyed by some other set of data. In these MIB tables the data contained in the table are often other identifiers of the element being modelled. For example, in the ENTITY-MIB, entries in the entPhysicalTable are indexed by the 31-bit value, entPhysicalIndex, but the entities could also be identified by the entPhysicalName or a combination of the other objects in the table.

Because of the size of some MIB tables, significant processing is required to discover all the mappings from the 32-bit MIB indices to the other data which the network management station identifies the entry. For this reason, it may be necessary for some MIB indices to be persistent across process restarts, switchovers, or device reloads. The ENTITY-MIB entPhysicalTable and CISCO-CLASS-BASED-QOS-MIB are two such MIBs that often require index values to be persistent.

Also, because of query response times and CPU utilization during CISCO-CLASS-BASED-QOS-MIB statistics queries, it is desirable to cache service policy statistics.

Procedure

	Command or Action	Purpose
Step 1	(Optional) **snmp-server mibs cbqosmib persist** **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server mibs cbqosmib persist`	Enables persistent storage of the CISCO-CLASS-BASED-QOS-MIB data.

	Command or Action	Purpose
Step 2	**snmp-server ifindex persist** **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server ifindex persist`	Enables ifIndex persistence globally on all Simple Network Management Protocol (SNMP) interfaces.

Configuring LinkUp and LinkDown Traps for a Subset of Interfaces

By specifying a regular expression to represent the interfaces for which you are interested in setting traps, you can enable or disable linkUp and linkDown traps for a large number of interfaces simultaneously.

Before you begin

SNMP must be configured.

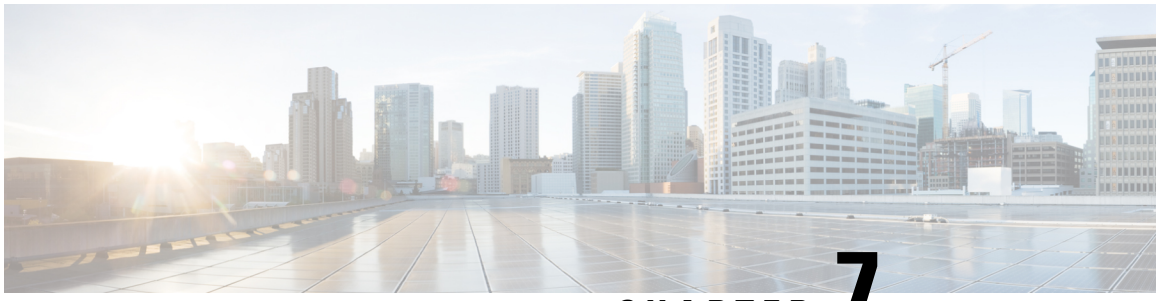
Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.

Step 2	**snmp-server interface subset** *subset-number* **regular-expression** *expression*
	Example:
	`RP/0/RP0/CPU0:router(config)# snmp-server interface subset 10 regular-expression "^Gig[a-zA-Z]+[0-9/]+\."`
	`RP/0/RP0/CPU0:router(config-snmp-if-subset)#`
		Enters snmp-server interface mode for the interfaces identified by the regular expression.
		The subset-number argument identifies the set of interfaces, and also assigns a priority to the subset in the event that an interface is included in more than one subset. Lower numbers have higher priority and their configuration takes precedent over interface subsets with higher numbers.
		The *expression* argument must be entered surrounded by double quotes.
		Refer to the *Understanding Regular Expressions, Special Characters, and Patterns* module in for more information regarding regular expressions.

Step 3	**notification linkupdown disable** **Example:** `RP/0/RP0/CPU0:router(config-snmp-if-subset)# notification linkupdown disable`	Disables linkUp and linkDown traps for all interfaces being configured. To enable previously disabled interfaces, use the **no** form of this command.

	Command or Action	Purpose
Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes, and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration mode, without committing the configuration changes.
Step 5	(Optional) **show snmp interface notification subset** *subset-number* **Example:** `RP/0/RP0/CPU0:router# show snmp interface notification subset 10`	Displays the linkUp and linkDown notification status for all interfaces identified by the subset priority.
Step 6	(Optional) **show snmp interface notification regular-expression** *expression* **Example:** `RP/0/RP0/CPU0:router# show snmp interface notification regular-expression "^Gig[a-zA-Z]+[0-9/]+\."`	Displays the linkUp and linkDown notification status for all interfaces identified by the regular expression.
Step 7	(Optional) **show snmp interface notification** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router# show snmp interface notification tengige`	Displays the linkUp and linkDown notification status for the specified interface.



CHAPTER 7

Configuring Periodic MIB Data Collection and Transfer

This document describes how to periodically transfer selected MIB data from your router to a specified Network Management System (NMS). The periodic MIB data collection and transfer feature is also known as bulk statistics.

- Prerequisites for Periodic MIB Data Collection and Transfer, on page 89
- Information About Periodic MIB Data Collection and Transfer, on page 89
- How to Configure Periodic MIB Data Collection and Transfer, on page 91
- Periodic MIB Data Collection and Transfer: Example, on page 97

Prerequisites for Periodic MIB Data Collection and Transfer

To use periodic MIB data collection and transfer, you should be familiar with the Simple Network Management Protocol (SNMP) model of management information. You should also know what MIB information you want to monitor on your network devices, and the OIDs or object names for the MIB objects to be monitored.

Information About Periodic MIB Data Collection and Transfer

SNMP Objects and Instances

A type (or class) of SNMP management information is called an object. A specific instance from a type of management information is called an object instance (or SNMP variable). To configure a bulk statistics collection, you must specify the object types to be monitored using a bulk statistics object list and the specific instances of those objects to be collected using a bulk statistics schema.

MIBs, MIB tables, MIB objects, and object indices can all be specified using a series of numbers called an object identifier (OID). OIDs are used in configuring a bulk statistics collection in both the bulk statistics object lists (for general objects) and in the bulk statistics schemas (for specific object instances).

Bulk Statistics Object Lists

To group the MIB objects to be polled, you need to create one or more object lists. A bulk statistics object list is a user-specified set of MIB objects that share the same MIB index. Object lists are identified using a name that you specify. Named bulk statistics object lists allow the same configuration to be reused in different bulk statistics schemas.

All the objects in an object list must share the same MIB index. However, the objects do not need to be in the same MIB and do not need to belong to the same MIB table. For example, it is possible to group ifInOctets and a CISCO-IF-EXTENSION-MIB object in the same schema, because the containing tables for both objects are indexed by the ifIndex.

Bulk Statistics Schemas

Data selection for the Periodic MIB Data Collection and Transfer Mechanism requires the definition of a schema with the following information:

- Name of an object list.
- Instance (specific instance or series of instances defined using a wild card) that needs to be retrieved for objects in the specified object list.
- How often the specified instances need to be sampled (polling interval). The default polling interval is 5 minutes.

A bulk statistics schema is also identified using a name that you specify. This name is used when configuring the transfer options.

Bulk Statistics Transfer Options

After configuring the data to be collected, a single virtual file (VFile or *bulk statistics file*) with all collected data is created. This file can be transferred to a network management station using FTP or TFTP. You can specify how often this file should be transferred. The default transfer interval is once every 30 minutes. You can also configure a secondary destination for the file to be used if, for whatever reason, the file cannot be transferred to the primary network management station.

The value of the transfer interval is also the collection period (collection interval) for the local bulk statistics file. After the collection period ends, the bulk statistics file is frozen, and a new local bulk statistics file is created for storing data. The frozen bulk statistics file is then transferred to the specified destination.

By default, the local bulk statistics file is deleted after successful transfer to an network management station.

Benefits of Periodic MIB Data Collection and Transfer

Periodic MIB data collection and transfer (bulk statistics feature) allows many of the same functions as the bulk file MIB (CISCO-BULK-FILE-MIB.my), but offers some key advantages. The main advantage is that this feature can be configured through the CLI and does not require an external monitoring application.

Periodic MIB data collection and transfer is mainly targeted for medium to high-end platforms that have sufficient local storage (volatile or permanent) to store bulk statistics files. Locally storing bulk statistics files helps minimize loss of data during temporary network outages.

This feature also has more powerful data selection features than the bulk file MIB; it allows grouping of MIB objects from different tables into data groups (object lists). It also incorporates a more flexible instance selection mechanism, where the application is not restricted to fetching an entire MIB table.

How to Configure Periodic MIB Data Collection and Transfer

Configuring a Bulk Statistics Object List

The first step in configuring the Periodic MIB Data Collection and Transfer Mechanism is to configure one or more object lists.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**snmp-server mib bulkstat object-list** *list-name* **Example:** `snmp-server mib bulkstat object-list ifMib`	Defines an SNMP bulk statistics object list and enters bulk statistics object list configuration mode.

Step 3	**add** {**oid** | *object-name*}
	Example:
	`RP/0/RP0/CPU0:router(config-bulk-objects)# add 1.3.6.1.2.1.2.2.1.11`
	`RP/0/RP0/CPU0:router(config-bulk-objects)# add ifAdminStatus`
	`RP/0/RP0/CPU0:router(config-bulk-objects)# add ifDescr`
		Adds a MIB object to the bulk statistics object list. Repeat as desired until all objects to be monitored in this list are added.
		Note All the objects in a bulk statistics object list have to be indexed by the same MIB index. However, the objects in the object list do not need to belong to the same MIB or MIB table.
		When specifying an object name instead of an OID (using the add command), only object names with mappings shown in the **show snmp mib object** command output can be used.

Step 4	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session.

	Command or Action	Purpose
		• **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring a Bulk Statistics Schema

The second step in configuring periodic MIB data collection and transfer is to configure one or more schemas.

Before you begin

The bulk statistics object list to be used in the schema must be defined.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.

Step 2	**snmp-server mib bulkstat schema** *schema-name*
	Example:
	`RP/0/RP0/CPU0:router(config)# snmp-server mib`
	`bulkstat schema intE0`
	`RP/0/RP0/CPU0:router(config-bulk-sc)#`
		Names the bulk statistics schema and enters bulk statistics schema mode.

Step 3	**object-list** *list-name*
	Example:
	`RP/0/RP0/CPU0:router(config-bulk-sc)# object-list`
	`ifMib`
		Specifies the bulk statistics object list to be included in this schema. Specify only one object list per schema. If multiple object-list commands are executed, the earlier ones are overwritten by newer commands.

Step 4	Do one of the following: • **instance exact** {**interface** *interface-id* [**sub-if**] | **oid** *oid*} • **instance wild** {**interface** *interface-id* [**sub-if**] | **oid** *oid*} • **instance range start** *oid* **end** *oid*	Specifies the instance information for objects in this schema: • The **instance exact** command indicates that the specified instance, when appended to the object list, represents the complete OID.

	Command or Action	Purpose

	• **instance repetition** *oid* **max** *repeat-number*
	Example:
	`RP/0/RP0/CPU0:router(config-bulk-sc)# instance wild oid 1`
	or
	`RP/0/RP0/CPU0:router(config-bulk-sc)# instance exact interface TenGigE 0/1.25`
	or
	`RP/0/RP0/CPU0:router(config-bulk-sc)# instance range start 1 end 2`
	or
	`RP/0/RP0/CPU0:router(config-bulk-sc)# instance repetition 1 max 4`
		• The **instance wild** command indicates that all subindices of the specified OID belong to this schema. The wild keyword allows you to specify a partial, "wild carded" instance.
		• The **instance range** command indicates a range of instances on which to collect data.
		• The **instance repetition** command indicates data collection to repeat for a certain number of instances of a MIB object.
		Note
		Only one **instance** command can be configured per schema. If multiple **instance** commands are executed, the earlier ones are overwritten by new commands.

Step 5	**poll-interval** *minutes* **Example:** `RP/0/RP0/CPU0:router(config-bulk-sc)# poll-interval 10`	Sets how often data should be collected from the object instances specified in this schema, in minutes. The default is once every 5 minutes. The valid range is from 1 to 20000.
Step 6	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Configuring Bulk Statistics Transfer Options

The final step in configuring periodic MIB data collection and transfer is to configure the transfer options. The collected MIB data are kept in a local file-like entity called a VFile (virtual file, referred to as a bulk statistics file in this document). This file can be transferred to a remote network management station at intervals you specify.

Before you begin

The bulk statistics object lists and bulk statistics schemas must be defined before configuring the bulk statistics transfer options.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**snmp-server mib bulkstat transfer-id** *transfer-id* **Example:** `RP/0/RP0/CPU0:router(config)# snmp-server mib bulkstat transfer bulkstat1`	Identifies the transfer configuration with a name (*transfer-id* argument) and enters bulk statistics transfer configuration mode.
Step 3	**buffer-size** *bytes* **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# buffersize 3072`	(Optional) Specifies the maximum size for the bulk statistics data file, in bytes. The valid range is from 1024 to 2147483647 bytes. The default buffer size is 2048 bytes. **Note** If the maximum buffer size for a bulk statistics file is reached before the transfer interval time expires, all additional data received is deleted. To correct this behavior, you can decrease the polling frequency, or increase the size of the bulk statistics buffer.
Step 4	**format** {**bulkBinary** | **bulkASCII** | **schemaASCII**} **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# format schemaASCII`	(Optional) Specifies the format of the bulk statistics data file (VFile). The default is schemaASCII. **Note** Transfers can only be performed using schemaASCII (cdcSchemaASCII) format. SchemaASCII is a human-readable format that contains parser-friendly hints for parsing data values.

Step 5	**schema** *schema-name*
	Example:
	`RP/0/RP0/CPU0:router(config-bulk-tr)# schema TenGigE`
	`RP/0/RP0/CPU0:router(config-bulk-tr)# schema TenGigE/0-CAR`
		Specifies the bulk statistics schema to be transferred. Repeat this command as desired. Multiple schemas can be associated with a single transfer configuration; all collected data are placed in a single bulk data file (VFile).

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config-bulk-tr)# schema TenGigE`	
Step 6	**transfer-interval** *minutes* **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# transfer-interval 20`	(Optional) Specifies how often the bulk statistics file are transferred, in minutes. The default value is once every 30 minutes. The transfer interval is the same as the collection interval.
Step 7	**url primary** *url* **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# url primary ftp://user:password@host/folder/bulkstat1`	Specifies the network management system (host) that the bulk statistics data file is transferred to, and the protocol to use for transfer. The destination is specified as a Uniform Resource Locator (URL). FTP or TFTP can be used for the bulk statistics file transfer.
Step 8	**url secondary** *url* **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# url secondary tftp://10.1.0.1/tftpboot/user/bulkstat1`	(Optional) Specifies a backup transfer destination and protocol for use in the event that transfer to the primary location fails. FTP or TFTP can be used for the bulk statistics file transfer.
Step 9	**retry** *number* **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# retry 1`	(Optional) Specifies the number of transmission retries. The default value is 0 (in other words, no retries). If an attempt to send the bulk statistics file fails, the system can be configured to attempt to send the file again using this command. One retry includes an attempt first to the primary destination then, if the transmission fails, to the secondary location. For example, if the retry value is 1, an attempt is made first to the primary URL, then to the secondary URL, then to the primary URL again, then to the secondary URL again. The valid range is from 0 to 100. If all retries fail, the next normal transfer occurs after the configured transfer-interval time.
Step 10	**retain** *minutes* **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# retain 60`	(Optional) Specifies how long the bulk statistics file should be kept in system memory, in minutes, after the completion of the collection interval and a transmission attempt is made. The default value is 0. Zero (0) indicates that the file is deleted immediately after the transfer is attempted. The valid range is from 0 to 20000.

	Command or Action	Purpose
		Note If the retry command is used, you should configure a retain interval larger than 0. The interval between retries is the retain interval divided by the retry number. For example, if **retain 10** and **retry 2** are configured, two retries are attempted once every 5 minutes. Therefore, if retain 0 is configured, no retries are attempted.
Step 11	**enable** **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# enable`	Begins the bulk statistics data collection and transfer process for this configuration. • For successful execution of this action, at least one schema with non-zero number of objects must be configured. • Periodic collection and file transfer begins only if this command is configured. Conversely, the **no enable** command stops the collection process. A subsequent **enable** starts the operations again. • Each time the collection process is started using the **enable** command, data is collected into a new bulk statistics file. When the **no enable** command is used, the transfer process for any collected data immediately begins (in other words, the existing bulk statistics file is transferred to the specified management station).
Step 12	**commit** *minutes* **Example:** `RP/0/RP0/CPU0:router(config-bulk-tr)# retain 60`	If the maximum buffer size for a bulk statistics file is reached before the transfer interval time expires, the transfer operation is still initiated, but any bulk statistics data received after the file was full, and before it was transferred, are deleted. To correct this behavior, you can decrease the polling frequency, or increase the size of the bulk statistics buffer. If **retain 0** is configured, no retries are attempted. This is because the interval between retries is the retain value divided by the retry value. For example, if **retain 10** and **retry 2** are configured, retries are attempted once every 5 minutes. Therefore, if you configure the retry command, you should also configure an appropriate value for the retain command.

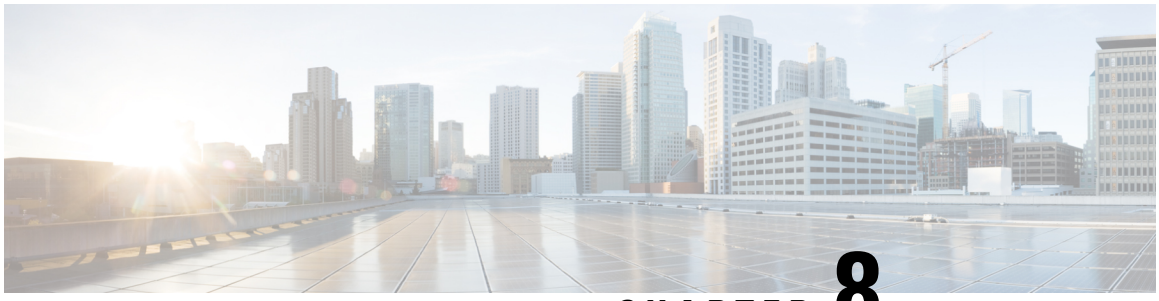
Periodic MIB Data Collection and Transfer: Example

This example shows how to configure periodic MIB data collection and transfer:

```
snmp-server mib bulkstat object-list cempo
add cempMemPoolName
add cempMemPoolType
!
snmp-server mib bulkstat schema cempWild
object-list cempo
instance wild oid 8695772
poll-interval 1
!
snmp-server mib bulkstat schema cempRepeat
object-list cempo
instance repetition 8695772.1 max 4294967295
poll-interval 1
!
snmp-server mib bulkstat transfer-id cempt1
enable
url primary tftp://223.255.254.254/auto/tftp-sjc-users3/username/dumpdcm
schema cempWild
schema cempRepeat
transfer-interval 2
!
```

This example shows sample bulk statistics file content:

```
Schema-def cempt1.cempWild "%u, %s, %s, %d" Epochtime instanceoid
            1.3.6.1.4.1.9.9.221.1.1.1.1.3 1.3.6.1.4.1.9.9.221.1.1.1.1.2
cempt1.cempWild: 1339491515, 8695772.1, processor, 2
cempt1.cempWild: 1339491515, 8695772.2, reserved, 11
cempt1.cempWild: 1339491515, 8695772.3, image, 12
cempt1.cempWild: 1339491575, 8695772.1, processor, 2
cempt1.cempWild: 1339491575, 8695772.2, reserved, 11
cempt1.cempWild: 1339491575, 8695772.3, image, 12
Schema-def cempt1.cempRepeat "%u, %s, %s, %d" Epochtime instanceoid
            1.3.6.1.4.1.9.9.221.1.1.1.1.3 1.3.6.1.4.1.9.9.221.1.1.1.1.2
cempt1.cempRepeat: 1339491515, 8695772.1, processor, 2
cempt1.cempRepeat: 1339491515, 8695772.2, reserved, 11
cempt1.cempRepeat: 1339491515, 8695772.3, image, 12
cempt1.cempRepeat: 1339491515, 26932192.1, processor, 2
cempt1.cempRepeat: 1339491515, 26932192.2, reserved, 11
cempt1.cempRepeat: 1339491515, 26932192.3, image, 12
cempt1.cempRepeat: 1339491515, 35271015.1, processor, 2
cempt1.cempRepeat: 1339491515, 35271015.2, reserved, 11
cempt1.cempRepeat: 1339491515, 35271015.3, image, 12
cempt1.cempRepeat: 1339491515, 36631989.1, processor, 2
cempt1.cempRepeat: 1339491515, 36631989.2, reserved, 11
cempt1.cempRepeat: 1339491515, 36631989.3, image, 12
cempt1.cempRepeat: 1339491515, 52690955.1, processor, 2
cempt1.cempRepeat: 1339491515, 52690955.2, reserved, 11
cempt1.cempRepeat: 1339491515, 52690955.3, image, 12
```



CHAPTER 8

Configuring Cisco Discovery Protocol

Cisco Discovery Protocol (CDP) is a media- and protocol-independent protocol that runs on all Cisco-manufactured equipment including routers, bridges, access and communication servers, and switches. Using CDP, you can view information about all the Cisco devices that are directly attached to the device.

- Prerequisites for Implementing CDP, on page 99
- Information About Implementing CDP, on page 99
- How to Implement CDP on Cisco IOS XR Software, on page 101
- Configuration Examples for Implementing CDP, on page 104

Prerequisites for Implementing CDP

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.

Note CDP is an optional package. You must check if this package is installed on your system by running the command **show install active summary**.

Information About Implementing CDP

CDP is primarily used to obtain protocol addresses of neighboring devices and discover the platform of those devices. CDP can also be used to display information about the interfaces your router uses. CDP is media- and protocol-independent, and runs on all equipment manufactured by Cisco, including routers, bridges, access servers, and switches.

Use of SNMP with the CDP MIB allows network management applications to learn the device type and the SNMP agent address of neighboring devices and to send SNMP queries to those devices. CDP uses the CISCO-CDP-MIB.

CDP runs on all media that support Subnetwork Access Protocol (SNAP), including LAN, Frame Relay, and ATM physical media. CDP runs over the data link layer only. Therefore, two systems that support different network-layer protocols can learn about each other.

Each device configured for CDP sends periodic messages, known as *advertisements*, to a multicast address. Each device advertises at least one address at which it can receive SNMP messages. The advertisements also contain time-to-live, or hold-time, information, which indicates the length of time a receiving device holds CDP information before discarding it. Each device also listens to the periodic CDP messages sent by others to learn about neighboring devices and determine when their interfaces to the media go up or down.

CDP Version-2 (CDPv2) is the most recent release of the protocol and provides more intelligent device tracking features. These features include a reporting mechanism that allows for more rapid error tracking, thereby reducing costly downtime. Reported error messages can be sent to the console or to a logging server, and can cover instances of unmatching native VLAN IDs (IEEE 802.1Q) on connecting ports, and unmatching port duplex states between connecting devices.

CDPv2 **show** commands can provide detailed output on VLAN Trunking Protocol (VTP) management domain and duplex modes of neighbor devices, CDP-related counters, and VLAN IDs of connecting ports.

Type-length-value fields (TLVs) are blocks of information embedded in CDP advertisements. This table summarizes the TLV definitions for CDP advertisements.

Table 4: Type-Length-Value Definitions for CDPv2

TLV	Definition
Device-ID TLV	Identifies the device name in the form of a character string.
Address TLV	Contains a list of network addresses of both receiving and sending devices.
Port-ID TLV	Identifies the port on which the CDP packet is sent.
Capabilities TLV	Describes the functional capability for the device in the form of a device type; for example, a switch.
Version TLV	Contains information about the software release version on which the device is running.
Platform TLV	Describes the hardware platform name of the device, for example, Cisco 4500.
VTP Management Domain TLV	Advertises the system's configured VTP management domain name-string. Used by network operators to verify VTP domain configuration in adjacent network nodes.
Native VLAN TLV	Indicates, per interface, the assumed VLAN for untagged packets on the interface. CDP learns the native VLAN for an interface. This feature is implemented only for interfaces that support the IEEE 802.1Q protocol.
Full/Half Duplex TLV	Indicates status (duplex configuration) of CDP broadcast interface. Used by network operators to diagnose connectivity problems between adjacent network elements.

How to Implement CDP on Cisco IOS XR Software

Enabling CDP

To enable CDP, you must first enable CDP globally on the router and then enable CDP on a per-interface basis. This task explains how to enable CDP globally on the router and then enable CDP on an interface.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**cdp** **Example:** `RP/0/RP0/CPU0:router(config)# cdp`	Enables CDP globally.
Step 3	**interface** *type interface-path-id* **Example:** `RP/0/RP0/CPU0:router(config)# int TenGigE 0/5/0/11`	Enters interface configuration mode.
Step 4	**cdp** **Example:** `RP/0/RP0/CPU0:router(config-if)# cdp`	Enables CDP on an interface.
Step 5	Use the **commit** or **end** command.	**commit** —Saves the configuration changes and remains within the configuration session. **end** —Prompts user to take one of these actions: • **Yes** — Saves configuration changes and exits the configuration session. • **No** —Exits the configuration session without committing the configuration changes. • **Cancel** —Remains in the configuration session, without committing the configuration changes.

Modifying CDP Default Settings

This task explains how to modify the default version, hold-time setting, and timer settings.

Note The commands can be entered in any order.

Procedure

	Command or Action	Purpose
Step 1	**configure** **Example:** `RP/0/RP0/CPU0:router# configure`	Enters mode.
Step 2	**cdp advertise v1** **Example:** `RP/0/RP0/CPU0:router(config)# cdp advertise v1`	Configures CDP to use only version 1 (CDPv1) in communicating with neighboring devices. • By default, when CDP is enabled, the router sends CDPv2 packets. CDP also sends and receives CDPv1 packets if the device with which CDP is interacting does not process CDPv2 packets. • In this example, the router is configured to send and receive only CDPv1 packets.
Step 3	**cdp holdtime** *seconds* **Example:** `RP/0/RP0/CPU0:router(config)# cdp holdtime 30`	Specifies the amount of time that the receiving networking device will hold a CDP packet sent from the router before discarding it. • By default, when CDP is enabled, the receiving networking device holds a CDP packet for 180 seconds before discarding it. **Note** The CDP hold time must be set to a higher number of seconds than the time between CDP transmissions, which is set with the **cdp timer** command. • In this example, the value of hold-time for the *seconds* argument is set to 30.
Step 4	**cdp timer** *seconds* **Example:**	Specifies the frequency at which CDP update packets are sent.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router(config)# cdp timer 20`	• By default, when CDP is enabled, CDP update packets are sent at a frequency of once every 60 seconds. **Note** A lower timer setting causes CDP updates to be sent more frequently. • In this example, CDP update packets are configured to be sent at a frequency of once every 20 seconds.

Step 5	Use the **commit** or **end** command.
	Example:
	`RP/0/RP0/CPU0:router(config)# commit`
	`OR`
	`RP/0/RP0/CPU0:router(config)# end`
		commit —Saves the configuration changes and remains within the configuration session.
		end —Prompts user to take one of these actions:
		• **Yes** — Saves configuration changes and exits the configuration session.
		• **No** —Exits the configuration session without committing the configuration changes.
		• **Cancel** —Remains in the configuration session, without committing the configuration changes.

Step 6	(Optional) **show cdp** **Example:** `RP/0/RP0/CPU0:router# show cdp`	Displays global CDP information. The output displays the CDP version running on the router, the hold time setting, and the timer setting.

Monitoring CDP

This task shows how to monitor CDP.

Note The commands can be entered in any order.

Procedure

	Command or Action	Purpose
Step 1	**show cdp entry** {***** | *entry-name*} [**protocol** | **version**] **Example:**	Displays information about a specific neighboring device or all neighboring devices discovered using CDP.

	Command or Action	Purpose
	`RP/0/RP0/CPU0:router# show cdp entry *`	
Step 2	**show cdp interface** [*type interface-path-id* | **location** *node-id*] **Example:** `RP/0/RP0/CPU0:router# show cdp interface pos 0/0/0/1`	Displays information about the interfaces on which CDP is enabled.
Step 3	**show cdp neighbors** [*type interface-path-id* | **location** *node-id*] [**detail**] **Example:** `RP/0/RP0/CPU0:router# show cdp neighbors`	Displays detailed information about neighboring devices discovered using CDP.
Step 4	**show cdp traffic** [**location** *node-id*] **Example:** `RP/0/RP0/CPU0:router# show cdp traffic`	Displays information about the traffic gathered between devices using CDP.

Configuration Examples for Implementing CDP

Enabling CDP: Example

The following example shows how to configure CDP globally and then enable CDP on Ethernet interface TenGigE 0/5/0/11:

```
cdp
interface 0/5/0/11
cdp
```

Modifying Global CDP Settings: Example

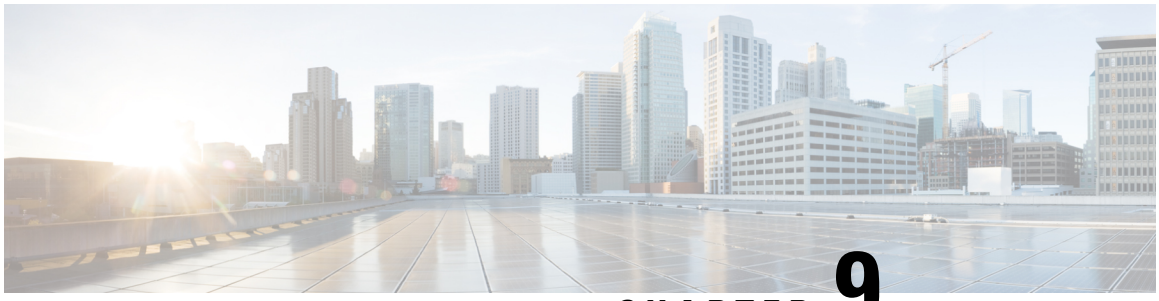
The following example shows how to modify global CDP settings. In this example, the timer setting is set to 20 seconds, the hold-time setting is set to 30 seconds, and the version of CDP used to communicate with neighboring devices is set to CDPv1:

```
cdp timer 20
cdp holdtime 30
cdp advertise v1
```

The following example shows how to use the **show cdp** command to verify the CDP global settings:

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

```
Global CDP information:
Sending CDP packets every 20 seconds
Sending a holdtime value of 30 seconds
Sending CDPv2 advertisements is not enabled
```



CHAPTER 9

Upgrading Field-Programmable Device

An FPD is a field programmable logic device which contains non-volatile, re-programmable memory to define its internal wiring and functionality. The contents of this non-volatile memory are called the FPD image or FPD firmware. Over the lifespan of an FPD, FPD firmware images may need upgrades for bug fixes or functionality improvements. These upgrades are performed in the field with minimum system impact.

- Prerequisites for FPD Image Upgrades, on page 107
- Overview of FPD Image Upgrade Support, on page 107
- FPD upgrade service, on page 108

Prerequisites for FPD Image Upgrades

You must install the FPD pie before you install the SMUs or Service Packs. If you install the SMU or Service Packs before the FPD pie, the FPDs on the line card may not upgrade. In such cases, you must remove the SMUs and Service Packs and reload the router.

Overview of FPD Image Upgrade Support

An FPD image is used to upgrade the software on an FPD.

FPD versions must be compatible with the Cisco IOS XR software that is running on the router; if an incompatibility exists between an FPD version and the Cisco IOS XR software, the device with the FPGA may not operate properly until the incompatibility is resolved.

Note Downgrade of FPDs is not recommended.

Note FPD auto upgrade is not supported on this router.

FPD upgrade service

The main tasks of the FPD upgrade service are:

- Check FPD image version to decide if a specific firmware image needs an upgrade or not.
- Automatic FPD Image Upgrade (if enabled).
- Manual FPD Image Upgrade using the **upgrade hw-module fpd** command.
- Invoke the appropriate device driver with a name of the new image to load.

An FPD image package is used to upgrade FPD images. The **install activate** command is used to place the FPD binary files into the expected location on the boot devices.

Supported Upgrade Methods

Method	Remarks
Manual Upgrade	Upgrade using CLI, force upgrade supported.
Auto Upgrade	Upgrade using install SMU activation or during image upgrade. User can enable/disable auto upgrade feature.

Important FPD auto upgrade is not supported on this router in releases before Cisco IOS XR Release 7.3.2.

Determining Upgrade Requirement

Use the **show hw-module fpd** command to determine if an FPD upgrade is required. Check for NEED UPGD in the Status column.

Example

```
Router: #show hw - module fpd

Wed Dec 14 07:08:08.424 UTC

Auto-upgrade:Disabled
                                                                          FPD Versions
                                                                          ==============
Location   Card type             HWver FPD device       ATR Status     Running   Programd
-------------------------------------------------------------------------------------------

0/0        NC55-18H18F           1.0   MIFPGA               NEED UPGD   7.01      7.01

0/0        NC55-18H18F           1.0   Bootloader           CURRENT     1.14      1.14
0/0        NC55-18H18F           1.0   IOFPGA               CURRENT     0.07      0.07
0/0        NC55-18H18F           1.0   SATA-M600-MCT        CURRENT     0.23      0.23
```

Use the **show fpd package** command to find out which FPGAs are supported with your current software release and minimum hardware requirements for each module.

Manual FPD Upgrade

Manual FPD upgrade is performed using the **upgrade hw-module fpd** command. All cards or all FPGA in a card can be upgraded. If reload is required to activate FPD, the upgrade should be complete. Interface module (IMs) and RSPs cannot be reloaded during the process of the FPD upgrade.

FPD upgrade is transaction-based:

- Each fpd upgrade CLI execution is one transaction.
- Only one transaction is allowed at any given time.
- One transaction may include one or many FPD upgrades

The **force** option can be used to forcibly upgrade the FPD (regardless of whether it is required or not). It triggers all FPDs to be upgraded or downgraded. The **force** option can also be used to downgrade or upgrade the FPGAs even after the version check. However, the **force** option must be used cautiously and only to recover a component from a failed upgrade.

Note

- Sometimes, FPDs can have primary and backup images.
- Force FPD upgrade with **upgrade hw-module location all fpd all force** command affects forwarding over BVI interface. You must reload involved locations to recover.
- The use of the **force** option when performing an FPD upgrade is not recommended except under explicit direction from Cisco engineering or TAC for a one-time purpose only.
- FPD upgrade should be performed in Admin mode only.
- A new FPD upgrade should be issued only when previous FPD upgrades have been completed on the same FPD with the following syslog message:

```
RP/0/RP0/CPU0:May 10 10:11:44.414 UTC: fpd-serv[205]: %INFRA-FPD_Manager-1-UPGRADE_ALERT
 : FPD Upgrade Completed (use "show hw-module fpd" to check upgrade status)
```

These entries are applicable for Cisco N540-FH-CSR-SYS and Cisco N540-FH-AGG-SYS routers.

- Perform a manual upgrade of the DPFPGA after the software downgrade to Cisco IOS XR Releases 7.3.2, 7.4.x, 7.5.1, or 7.6.2 from higher image versions.

  DPFPGA ports:

  - On N540-FH-CSR-SYS: Ports 0-13
  - On N540-FH-AGG-SYS: Ports 0-23

- These entries are the commands used to upgrade FPD firmware for specific hardware modules.
  - On N540-FH-CSR-SYS: The command **upgrade hw-module location 0/rP0/CPU0 fpd DpFpga force** is used in Cisco IOS XR software to upgrade the FPD firmware.
  - On N540-FH-AGG-SYS: The command **upgrade hw-module location 0/rP0/CPU0 fpd DpFpgaEth force** is used in Cisco IOS XR software to upgrade the FPD firmware Ethernet bundle.
  - On N540-FH-AGG-SYS: The command **upgrade hw-module location 0/rP0/CPU0 fpd DpFpgaCpri force** is used in Cisco IOS XR software to upgrade the FPD firmware CPRI bundle.

- Execute the software downgrade to Cisco IOS XR Releases 7.5.1, 7.5.2, or 7.6.2 from higher image versions with the SMU integrated into the maintenance release.

How to Upgrade FPD Images

- Migrate the software to a later Cisco IOS XR software release.
- Swap IMs or RSPs from a system running a different Cisco IOS XR software release.
- Insert a new IM or RSP.

In the event of an FPD incompatibility with your card, you might receive the following error message:

```
LC/0/0/CPU0:Jul 5 03:00:18.929 UTC: optics_driver[220]: %L2-OPTICS-3-BAD_FPGA_IMAGE :
Detected bad MI FPGA image programmed in MI FPGA SPI flash in 0/0/CPU0 location: Failed to
 validate meta data CRC
LC/0/0/CPU0:Jul 5 03:00:19.019 UTC: optics_driver[220]: %L2-OPTICS-3-BACKUP_FPGA_LOADED :
Detected Backup FPGA image running on 0/0/CPU0 - primary image corrupted (@0x8c = 0x44)
RP/0/RP0/CPU0:Jul 5 03:00:48.987 UTC: fpd-serv[301]: %PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR
 :FPD-NEED-UPGRADE :DECLARE :0/0:
```

Upgrades to the Cisco IOS XR software might result in an FPD incompatibility. Ensure that you perform the FPD upgrade procedure and resolve all incompatibilities, for the cards to function properly.

Note The use of the **force** option when performing a FPD upgrade is not recommended except under explicit direction from Cisco engineering or TAC for a one-time purpose only.

Before you begin

- The FPD upgrade procedure is performed while the card is online. At the end of the procedure the card must be reloaded before the FPD upgrade is complete. To reload the card, you can use the **hw-module location <location> reload** command in Admin mode, during the next maintenance window. The upgrade procedure is not complete until the card is reloaded.
- During the FPD upgrade, you *must not* do the following:
  - Reload, perform an online insertion and removal (OIR) of a line card (LC), or power down the chassis. Doing so may cause the node to enter an unusable state.
  - Press **Ctrl-C** if the console appears to hang without any output. Doing so may abort the upgrade.
- If you are not sure whether a card requires an FPD upgrade, you can install the card and use the **show hw-module fpd** command to determine if the FPD image on the card is compatible with the currently running Cisco IOS XR software release.

Configuration Examples for FPD Image Upgrade

The following examples indicates the use of commands associated with the FPD image upgrade procedure.

show fpd package Command Output: Example

Use the **show fpd package** command in System Admin EXEC mode to find out which IMs and RSPs are supported with your current Cisco IOS XR software release, which FPD image package you need for each

IM or RSP, and what the minimum hardware requirements are for each module. If multiple FPD images are available for your card, they are listed as Subtype fpga2, fpga3, and so on.

Note The FPD name used in the FPD Description column of the output of the `show fpd package` command includes the last ten characters of DCO-PID. Depending on the slot and port numbers, the FPD name is appended with DCO_0, DCO_1, or DCO_2. For example, the FPD names for `CFP2-WDM-D-1HL` in port 0 and port 1 are `-WDM-D-1HL_DCO_0` and `WDM-D-1HL_DCO_1` respectively.

The following example shows a sample output from the **show fpd package** command:

```
sysadmin_vm:0_RP0# show fpd package
Fri Oct 16 07:20:50.021 UTC

================================ ============================================
                                        Field Programmable Device Package
                                 ============================================
                                              Req      SW       Min Req   Min Req
Card Type            FPD Description          Reload   Ver      SW Ver    Board Ver
================== ========================== ====== ======= ======== =========
------------------------------------------------------------------------------
A900-IMA8CS1Z-CC     IMFPGA                    YES     1.96     1.96     0.0
------------------------------------------------------------------------------
A900-IMA8CS1Z-M      IMFPGA                    YES     1.96     1.96     0.0
------------------------------------------------------------------------------
A900-IMA8Z           IMFPGA                    YES    17.05    17.05     0.0
------------------------------------------------------------------------------
A900-IMA8Z-CC        IMFPGA                    YES    17.05    17.05     0.0
------------------------------------------------------------------------------
A900-IMA8Z-L         IMFPGA                    YES     1.45     1.45     0.0
------------------------------------------------------------------------------
A900-PWR1200-A       DCA-PriMCU(A)             NO      0.11     0.11     0.0
                     DCA-SecMCU(A)             NO      1.04     1.04     0.0
------------------------------------------------------------------------------
A900-PWR1200-D       LIT-PriMCU(A)             NO      2.04     0.04     0.0
                     LIT-SecMCU(A)             NO      1.23     1.23     0.0
------------------------------------------------------------------------------
A907-FAN-E           PSOC(A)                   NO      1.65     1.65     0.0
                     PSOC(A)                   NO      1.66     1.66     0.4
------------------------------------------------------------------------------
N560-4-FAN-H         PSOC(A)                   NO    177.02   177.02     0.0
------------------------------------------------------------------------------
N560-4-FAN-H-CC      PSOC(A)                   NO    177.02   177.02     0.0
------------------------------------------------------------------------------
N560-4-PWR-FAN       PSOC(A)                   NO    177.08   177.08     0.0
------------------------------------------------------------------------------
N560-4-PWR-FAN-CC    PSOC(A)                   NO    177.08   177.08     0.0
------------------------------------------------------------------------------
N560-4-RSP4          ADM(A)                    NO      1.06     1.06     0.0
                     IOFPGA(A)                 YES     0.64     0.64     0.0
                     PRIMARY-BIOS(A)           YES     0.17     0.17     0.0
                     SATA(A)                   YES     2.10     2.10     0.0
------------------------------------------------------------------------------
N560-4-RSP4-CC       ADM(A)                    NO      1.06     1.06     0.0
                     IOFPGA(A)                 YES     0.64     0.64     0.0
                     PRIMARY-BIOS(A)           YES     0.17     0.17     0.0
                     SATA(A)                   YES     2.10     2.10     0.0
------------------------------------------------------------------------------
N560-4-RSP4E         ADM(A)                    NO      1.06     1.06     0.0
                     IOFPGA(A)                 YES     0.64     0.64     0.0
```

```
                    PRIMARY-BIOS(A)           YES     0.17    0.17    0.0
                    SATA(A)                   YES     2.10    2.10    0.0
--------------------------------------------------------------------------------
N560-4-RSP4E-CC     ADM(A)                    NO      1.06    1.06    0.0
                    IOFPGA(A)                 YES     0.64    0.64    0.0
                    PRIMARY-BIOS(A)           YES     0.17    0.17    0.0
                    SATA(A)                   YES     2.10    2.10    0.0
--------------------------------------------------------------------------------
N560-FAN-H          PSOC(A)                   NO      2.02    2.02    0.0
--------------------------------------------------------------------------------
N560-IMA-8Q/4L      IMFPGA                    YES     1.08    1.08    0.0
--------------------------------------------------------------------------------
N560-IMA1W          CFP2-D-DCO                NO     38.273  38.273   0.0
                    CFP2-DE-DCO               NO     38.273  38.273   0.0
                    CFP2-DET-DCO              NO     38.273  38.273   0.0
                    CFP2-DETS-DCO             NO     38.273  38.273   0.0
                    CFP2-DS-DCO               NO     38.273  38.273   0.0
                    CFP2-DS100-DCO            NO     38.273  38.273   0.0
                    IMFPGA                    YES     1.24    1.24    0.0
--------------------------------------------------------------------------------
N560-IMA2C-CC       IMFPGA                    YES     5.04    5.04    0.0
--------------------------------------------------------------------------------
N560-PWR1200-D-E    QCS-PriMCU(A)             NO      1.82    1.82    0.0
                    QCS-SecMCU(A)             NO      1.84    1.84    0.0
--------------------------------------------------------------------------------
N560-RSP4           ADM(A)                    NO      1.06    1.06    0.0
                    IOFPGA(A)                 YES     0.64    0.64    0.0
                    PRIMARY-BIOS(A)           YES     0.17    0.17    0.0
                    SATA(A)                   YES     2.10    2.10    0.0
--------------------------------------------------------------------------------
N560-RSP4-E         ADM(A)                    NO      1.06    1.06    0.0
                    IOFPGA(A)                 YES     0.64    0.64    0.0
                    PRIMARY-BIOS(A)           YES     0.17    0.17    0.0
                    SATA(A)                   YES     2.10    2.10    0.0
--------------------------------------------------------------------------------
NCS560-IMA2C        IMFPGA                    YES     5.04    5.04    0.0
--------------------------------------------------------------------------------
NCS560-IMA2C-DD     IMFPGA                    YES     1.24    1.24    0.0
--------------------------------------------------------------------------------
NCS560-IMA2C-L      IMFPGA                    YES     1.24    1.24    0.0
```

upgrade hw-module fpd Command Output: Example

Use the **upgrade hw-module fpd** command to upgrade the FPD image. The upgrade can be executed for all FPDs or for specific FPDs that need an upgrade. To upgrade all FPDs, use **upgrade hw-module fpd all location all** command. To upgrade a specific FPD image type, use the FPD subtype value in the **upgrade hw-module fpd** command.

```
RP/0/RP0/CPU0:ios# upgrade hw-module location 0/RP0 fpd ADM
Wed Oct 28 07:46:49.805 UTC
upgrade command issued (use "show hw-module fpd" to check upgrade status)
RP/0/RP0/CPU0:ios#RP/0/RP0/CPU0:Oct 28 07:46:51.949 UTC: optics_driver[222]:
%PKT_INFRA-FM-2-FAULT_CRITICAL : ALARM_CRITICAL :OPTICS RX POWER LANE-0 LOW ALARM :CLEAR :
 Optics0/11/0/1:  Optics0/11/0/1
0/RP0/ADMIN0:Oct 28 07:46:54.154 UTC: fpdserv[4899]: %INFRA-FPD_Manager-1-UPGRADE_ALERT :
Upgrade for the following FPDs has been committed:
0/RP0/ADMIN0:Oct 28 07:46:54.154 UTC: fpdserv[4899]: %INFRA-FPD_Manager-1-UPGRADE_ALERT :
Location           FPD name             Force
0/RP0/ADMIN0:Oct 28 07:46:54.154 UTC: fpdserv[4899]: %INFRA-FPD_Manager-1-UPGRADE_ALERT :
================================================
0/RP0/ADMIN0:Oct 28 07:46:54.154 UTC: fpdserv[4899]: %INFRA-FPD_Manager-1-UPGRADE_ALERT :
0/RP0              ADM                  FALSE
0/RP0/ADMIN0:Oct 28 07:46:59.203 UTC: control_driver[3690]: %INFRA-FPD_Driver-6-UPGRADE_RESULT
```

```
 : Upgrade completes 20 percent for fpd ADM@location 0/RP0.
RP/0/RP0/CPU0:ios#0/RP0/ADMIN0:Oct 28 07:47:09.204 UTC: control_driver[3690]:
%INFRA-FPD_Driver-6-UPGRADE_RESULT : Upgrade completes 70 percent for fpd ADM@location
0/RP0.
0/RP0/ADMIN0:Oct 28 07:47:10.854 UTC: control_driver[3690]: %INFRA-FPD_Driver-1-UPGRADE_ALERT
 : FPD ADM@0/RP0 image programming completed with UPGRADE DONE state Info: [image 1.05 to
1.06 version]
0/RP0/ADMIN0:Oct 28 07:47:10.855 UTC: control_driver[3690]: %INFRA-FPD_Driver-1-UPGRADE_ALERT
 : FPD ADM @location 0/RP0 FPD upgraded and activated!
0/RP0/ADMIN0:Oct 28 07:47:10.857 UTC: shelf_mgr[3705]: %INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL
 : Card: 0/RP0 software state going to Operational
0/RP0/ADMIN0:Oct 28 07:47:10.857 UTC: shelf_mgr[3705]: %INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL
 : Card: 0/RP0 hardware state going to Operational
RP/0/RP0/CPU0:Oct 28 07:47:17.931 UTC: fpd-serv[393]: %INFRA-FPD_Manager-1-UPGRADE_ALERT :
  FPD Upgrade Completed(use "show hw-module fpd" to check upgrade status)
0/RP0/ADMIN0:Oct 28 07:47:19.155 UTC: fpdserv[4899]: %INFRA-FPD_Manager-1-UPGRADE_ALERT :
 FPD Upgrade Completed(use "show hw-module fpd" to check upgrade status)
RP/0/RP0/CPU0:ios#
```

show platform Command Output: Example

Use the **show platform** command to verify that the IM is up and running.

```
RP/0/RP1/CPU0:router# show platform
Tue Oct 20 04:42:31.936 UTC
Node              Type                        State             Config state
--------------------------------------------------------------------------------
0/0/CPU0          A900-IMA8CS1Z-M             OPERATIONAL       NSHUT
0/1/CPU0          A900-IMA8CS1Z-M             OPERATIONAL       NSHUT
0/2/CPU0          A900-IMA8CS1Z-M             OPERATIONAL       NSHUT
0/4/CPU0          A900-IMA8Z-L                OPERATIONAL       NSHUT
0/5/CPU0          A900-IMA8Z-L                OPERATIONAL       NSHUT
0/7/CPU0          N560-IMA1W                  OPERATIONAL       NSHUT
0/9/CPU0          N560-IMA2C-DD               OPERATIONAL       NSHUT
0/10/CPU0         A900-IMA8Z                  OPERATIONAL       NSHUT
0/11/CPU0         A900-IMA8Z-L                OPERATIONAL       NSHUT
0/RP0/CPU0        N560-RSP4-E(Standby)        UNKNOWN           NSHUT
0/RP1/CPU0        N560-RSP4-E(Active)         IOS XR RUN        NSHUT
0/FT0/CPU0        N560-FAN-H                  OPERATIONAL       NSHUT
0/PM2/CPU0        A900-PWR1200-A              OPERATIONAL       NSHUT
```

Auto FPD Upgrade

Table 5: Feature History Table

Feature Name	Release Information	Feature Description
Auto FPD Upgrade	Release 7.3.2	This functionality enables automatic upgrade and reload for field-programmable devices (FPDs) whenever the Cisco IOS XR image has a newer FPD version. This functionality upgrades all route processors and line card FPDs simultaneously while displaying upgrade triggers on the console.

Effective Cisco IOS XR Release 7.3.2, you can enable automatic upgrade of FPD by using the “fpd auto-upgrade enable” command.

Note Automatic upgrade of FPD is not supported in Cisco IOS XR Release 7.4.1.

To automatically upgrade all FPDs, use:

```
RP/0/RP0/CPU0:IOS(config)#fpd auto-upgrade enable
```

To reload the interface modules following the fpd auto-upgrade, use:

```
 RP/0/RP0/CPU0:IOS(config)#fpd auto-reload enable
```

Limitations and Usage Guidelines

Limitations

- FPD auto-upgrade should be enabled only in the XR VM and *not* in the System Admin VM.
- With auto-upgrade enabled, if any card is in RELOAD REQUIRED state, auto-upgrade is re-triggered during any SSO or FPD-serv process restart.
- When an interface module (IM) or route processor (RP) is in RELOAD REQUIRED state and auto-upgrade is enabled, FPD upgrades are triggered again.
- With auto-upgrade enabled, if line card is inserted, an auto-upgrade is triggered. During this phase optics alarms are generated. If auto-reload is not enabled, you must reload the line cards manually to clear these alarms.
- SATA allows you to upgrade or downgrade when an FPD version change is available. Therefore, when auto-upgrade is enabled, the system automatically downgrades if lower versions are available. This behavior is specific only to SATA FPDs.
- FPD auto-reload is applicable for line cards only. Line cards are automatically reloaded after the fpd auto-upgrade process is completed.
- You must disable auto-upgrade during XR ISSU; otherwise, the router goes into a state where redundancy cannot be achieved. In this case, standby RP must be reloaded to achieve redundancy.
-
- TimingICs do not support **auto fpd upgrade** on NCS5500 Series Routers as the TimingIC requires a card reload immediately after upgrade. For the same reason, the TimingICs are not upgraded if the user specifies **location all** in the **auto fpd upgrade** command. To upgrade a TimingIC FPD, specify the FPD name along with the card location. For example, **upgrade hw-module fpd TimngIC-A location 0/RP0/cpu0.**

Usage Guidelines—Online Insertion of Line Cards

When a line card with a lower FPD version is inserted, one of the following scenarios apply:

- If fpd auto-upgrade and auto-reload are enabled, and a new line card is inserted, the system upgrades the line card FPDs automatically with the latest FPDs and reloads the line cards.
- If fpd auto-upgrade and auto-reload are both disabled, no action is required.
- If fpd auto-upgrade is enabled and auto-reload is disabled, the following alarms are displayed on the console:

```
RP/0/RP1/CPU0:Jun 1 10:05:46.095 UTC: optics_driver[231]: %PKT_INFRA-FM-3-FAULT_MAJOR
: ALARM_MAJOR :OPTICS SUPPORTED_ERROR :DECLARE : Optics0/5/0/6: Optics0/5/0/6
```

```
RP/0/RP1/CPU0:Jun 1 10:05:46.096 UTC: optics_driver[231]: %PKT_INFRA-FM-2-FAULT_CRITICAL
 : ALARM_CRITICAL :OPTICS NOT SUPPORTED :DECLARE : Optics0/5/0/6: Optics0/5/0/6
```

You must reload the line cards manually to clear these alarms

Usage Guidelines—Online Insertion of RPs

When fpd auto-upgrade is enabled and a new RP is inserted, the system upgrades the RP FPDs automatically with the latest FPDs.

Note RPs are not reloaded automatically. You must manually reload the RP or chassis for the latest FPD version to reflect.

Note Reload of active RPs and line cards impacts the network traffic.

```
RP/0/RP0/CPU0:IOS# admin
Mon Jun 28 17:00:39.340 UTC

sysadmin-vm:0_RP1# hw-module location 0/RP1 reload
Mon Jun  28 17:00:52.178 UTC+00:00
Reload hardware module ? [no,yes] yes
#result Card graceful reload request on 0/RP1 succeeded.
RP/0/RP0/CPU0:IOS#

RP/0/RP0/CPU0:ios# show hw-module fpd
Fri Jun  4 10:08:01.784 UTC

Auto-upgrade:Enabled
                                                                          FPD Versions
                                                                          ==============
Location   Card type              HWver FPD device       ATR Status    Running   Programd
-------------------------------------------------------------------------------------------
0/1        N560-IMA2C-DD          0.0   IMFPGA               CURRENT     1.27      1.27
0/3        N560-IMA2C             0.0   IMFPGA               CURRENT     5.01      5.01
0/5        A900-IMA8CS1Z-M        0.0   IMFPGA               CURRENT     1.98      1.98
0/RP0      N560-4-RSP4            0.0   ADM                  CURRENT     1.06      1.06
0/RP0      N560-4-RSP4            0.0   IOFPGA               CURRENT     0.64      0.64
0/RP0      N560-4-RSP4            0.0   PRIMARY-BIOS         CURRENT     0.18      0.18
0/RP0      N560-4-RSP4            0.0   SATA                 CURRENT     2.10      2.10
0/RP1      N560-4-RSP4            0.0   ADM                  CURRENT     1.06      1.06
0/RP1      N560-4-RSP4            0.0   IOFPGA               CURRENT     0.64      0.64
0/RP1      N560-4-RSP4            0.0   PRIMARY-BIOS         CURRENT     0.19      0.19
0/RP1      N560-4-RSP4            0.0   SATA                 CURRENT     2.10      2.10
0/FT0      N560-4-PWR-FAN         0.1   PSOC                 CURRENT   177.08    177.08
0/FT1      N560-4-FAN-H           0.1   PSOC                 CURRENT   177.02    177.02
0/FT2      N560-4-FAN-H           0.1   PSOC                 CURRENT   177.02    177.02
RP/0/RP0/CPU0:ios#
```

Table 6: Action Required on FPDs After Auto Upgrade

FPD	Action Required
IOFPGA	Manual reload required
ADM	Upgraded version available immediately

FPD	Action Required
PRIMARY-BIOS	Manual reload required
SATA	Upgraded version available immediately
PSOC	Upgraded version available immediately
IMFPGA	Manual reload required, if auto-reload is not configured

Configuring Auto FPD During System Upgrade

In case of Software upgrade (without ISSU), configure the **fpd auto-upgrade enable** command. All the FPDs are automatically upgraded in the currently installed image (V1). After the upgrade, the router automatically reloads and comes up with the new image (V2) with the upgraded FPDs already running. No additional reloads are required.

Note System reloads are part of the SU process, therefore you can disable the FPD auto reload functionality by using the **fpd auto-reload disable** command.

1. **Enable FPD auto-upgrade**

```
RP/0/RP0/CPU0:IOS#conf
RP/0/RP0/CPU0:IOS(config)#fpd auto-upgrade enable
RP/0/RP0/CPU0:IOS#commit
```

2. **Check for FPD Versions**

```
RP/0/RP0/CPU0:Router#show hw-module fpd
Mon Jun 28 21:41:19.187 UTC

Auto-upgrade:Enabled
                                                                          FPD Versions
                                                                          ==============
Location   Card type            HWver FPD device       ATR Status    Running   Programd

-------------------------------------------------------------------------------------------
0/2        NCS4200-1T16G-PS      0.0   IMFPGA               CURRENT     1.98      1.98

0/3        A900-IMA8CS1Z-M       0.0   IMFPGA               CURRENT     1.95      1.95

0/4        A900-IMA8Z            0.0   IMFPGA               CURRENT    17.05     17.05

0/5        A900-IMA8Z-L          0.0   IMFPGA               CURRENT     1.48      1.48

0/8        NCS4200-1T16G-PS      0.0   IMFPGA               CURRENT     1.98      1.98

0/9       N560-IMA1W           66.32 CFP2-DS-DCO          CURRENT    38.27397  38.27397

0/9        N560-IMA1W            0.0   IMFPGA               CURRENT     1.28      1.28

0/15       NCS4200-1T16G-PS      0.0   IMFPGA               CURRENT     1.98      1.98

0/RP0      N560-RSP4             0.0   ADM                  CURRENT     1.06      1.06

0/RP0      N560-RSP4             0.0   IOFPGA               CURRENT     0.64      0.64
```

```
0/RP0      N560-RSP4            0.0   PRIMARY-BIOS        CURRENT     0.19       0.19
0/RP0      N560-RSP4            0.0   SATA                CURRENT     1.30       1.30
0/RP1      N560-RSP4            0.0   ADM                 CURRENT     1.05       1.05
0/RP1      N560-RSP4            0.0   IOFPGA              CURRENT     0.64       0.64
0/RP1      N560-RSP4            0.0   PRIMARY-BIOS        CURRENT     0.19       0.19
0/RP1      N560-RSP4            0.0   SATA                CURRENT     1.30       1.30
0/FT0      N560-FAN-H           1.0   PSOC                CURRENT     2.02       2.02

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

3. **Check that Auto Upgrades are Triggered for FPDs with Newer Versions Available**

Note At this step, all RSP, IMs, and fan FPD upgrades are initiated and completed. All cards are upgraded *before* the router reloads.

```
RP/0/RP1/CPU0:UUT-RSP4# copy tftp://<ncs560-mini-x-7.3.2.iso> harddisk:/
RP/0/RP0/CPU0:IOS#install add source harddisk: ncs560-mini-x-7.3.2.iso
ncs560-mcast-2.0.0.0-r732.x86_64.rpm ncs560-mgbl-2.0.0.0-r732.x86_64.rpm
ncs560-mpls-1.0.0.0-r732.x86_64.rpm
RP/0/RP0/CPU0:IOS#install ncs560-mini-x-7.3.2 ncs560-mcast-2.0.0.0-r732.x86_64
ncs560-mgbl-2.0.0.0-r732.x86_64 ncs560-mpls-1.0.0.0-r732.x86_64
RP/0/RP0/CPU0:IOS#install commit

RP/0/RP0/CPU0:ROUTER# install activate ncs560-mini-x-7.3.2.28I
Mon Jun 28 21:30:17.673 UTC
2021-06-28 21:30:20 Install operation 31 started by root123:
  install activate pkg ncs560-mini-x-7.3.2.28I
2021-06-28 21:30:20 Package list:
2021-06-28 21:30:20     ncs560-mini-x-7.3.2.28I
RP/0/RP0/CPU0:Jun 28 21:32:41.204 UTC: sdr_instmgr[1213]: %PKT_INFRA-FM-6-FAULT_INFO :
INSTALL-IN-PROGRESS :DECLARE :0/RP0/CPU0: INSTALL_IN_PROGRESS Alarm : being DECLARED for
 the system
This install operation will reload the system, continue?
 [yes/no]:[yes] yes
2021-06-28 21:33:01 Install operation will continue in the background
 ...
RP/0/RP0/CPU0:ROUTER#RP/0/RP0/CPU0:Jun 28 21:41:40.910 UTC: fpd-serv[168]:
%PKT_INFRA-FM-3-FAULT_MAJOR : ALARM_MAJOR :FPD-NEED-UPGRADE :DECLARE :0/RP0:
RP/0/RP0/CPU0:Jun 28 21:41:41.159 UTC: fpd-serv[168]: %PKT_INFRA-FM-3-FAULT_MAJOR :
ALARM_MAJOR :FPD-NEED-UPGRADE :CLEAR :0/RP0:
0/RP0/ADMIN0:Jun 28 21:41:42.565 UTC: control_driver[3205]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD SATA@0/RP0 image programming completed with
UPGRADE DONE state Info: [SDD firmware upgraded from 1.30 to 2.10]
0/RP0/ADMIN0:Jun 28 21:41:42.566 UTC: control_driver[3205]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD SATA @location 0/RP0 FPD upgraded and activated!

0/RP0/ADMIN0:Jun 28 21:41:42.570 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP0 software state going to Operational

0/RP0/ADMIN0:Jun 28 21:41:42.570 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP0 hardware state going to Operational

RP/0/RP0/CPU0:Jun 28 21:41:42.486 UTC: fpd-serv[168]: %PKT_INFRA-FM-3-FAULT_MAJOR :
ALARM_MAJOR :FPD-NEED-UPGRADE :DECLARE :0/RP1:
0/RP1/ADMIN0:Jun 28 21:41:44.182 UTC: control_driver[3220]:
```

```
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD SATA@0/RP1 image programming completed with
UPGRADE DONE state Info: [SDD firmware upgraded from 1.30 to 2.10]
0/RP1/ADMIN0:Jun 28 21:41:44.182 UTC: control_driver[3220]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD SATA @location 0/RP1 FPD upgraded and activated!

0/RP1/ADMIN0:Jun 28 21:41:48.905 UTC: control_driver[3220]:
%INFRA-FPD_Driver-6-UPGRADE_RESULT : Upgrade completes 20 percent for fpd ADM@location
0/RP1.
0/RP1/ADMIN0:Jun 28 21:41:48.905 UTC: control_driver[3220]:
%INFRA-FPD_Driver-6-UPGRADE_RESULT : Upgrade completes 50 percent for fpd
PRIMARY-BIOS@location 0/RP1.
0/RP1/ADMIN0:Jun 28 21:42:10.160 UTC: control_driver[3220]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD PRIMARY-BIOS@0/RP1 image programming completed
with UPGRADE DONE state Info: [  Upgrade Complete ]
0/RP1/ADMIN0:Jun 28 21:42:10.161 UTC: control_driver[3220]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD PRIMARY-BIOS @location 0/RP1 upgrade completed.

0/RP1/ADMIN0:Jun 28 21:42:11.060 UTC: control_driver[3220]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD ADM@0/RP1 image programming completed with UPGRADE
 DONE state Info: [image 1.05 to 1.06 version]
0/RP1/ADMIN0:Jun 28 21:42:11.061 UTC: control_driver[3220]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD ADM @location 0/RP1 FPD upgraded and activated!

0/RP0/ADMIN0:Jun 28 21:42:11.062 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP1 software state going to Operational

0/RP0/ADMIN0:Jun 28 21:42:11.062 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP1 hardware state going to Operational

RP/0/RP0/CPU0:Jun 28 21:45:14.615 UTC: fpd_imfpga[121]: %INFRA-FPD_Driver-6-UPGRADE_RESULT
 : Upgrade completes 50 percent for fpd IMFPGA@location 0/5.
RP/0/RP0/CPU0:Jun 28 21:45:14.616 UTC: fpd_imfpga[121]: %INFRA-FPD_Driver-6-UPGRADE_RESULT
 : Upgrade completes 50 percent for fpd IMFPGA@location 0/3.
RP/0/RP0/CPU0:Jun 28 21:48:24.763 UTC: fpd_imfpga[121]: %INFRA-FPD_Driver-6-UPGRADE_RESULT
 : Upgrade completes 90 percent for fpd IMFPGA@location 0/5.

RP/0/RP0/CPU0:ROUTER#RP/0/RP0/CPU0:Jun 28 21:48:43.929 UTC: fpd_imfpga[121]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD IMFPGA@0/5 image programming completed with
UPGRADE DONE state Info: [DONE ]
RP/0/RP0/CPU0:Jun 28 21:48:43.940 UTC: fpd_imfpga[121]: %INFRA-FPD_Driver-1-UPGRADE_ALERT
 : FPD IMFPGA @location 0/5 upgrade completed.
0/RP0/ADMIN0:Jun 28 21:48:45.354 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/5 hardware state going to Operational

0/RP0/ADMIN0:Jun 28 21:48:45.354 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP0 software state going to Operational

0/RP0/ADMIN0:Jun 28 21:48:45.354 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP0 hardware state going to Operational
P/0/RP0/CPU0:Jun 28 21:50:21.630 UTC: fpd_imfpga[121]: %INFRA-FPD_Driver-1-UPGRADE_ALERT
 : FPD IMFPGA@0/3 image programming completed with UPGRADE DONE state Info: [DONE ]
RP/0/RP0/CPU0:Jun 28 21:50:21.642 UTC: fpd_imfpga[121]: %INFRA-FPD_Driver-1-UPGRADE_ALERT
 : FPD IMFPGA @location 0/3 upgrade completed.
0/RP0/ADMIN0:Jun 28 21:50:23.056 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/3 hardware state going to Operational

0/RP0/ADMIN0:Jun 28 21:50:23.056 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP0 software state going to Operational

0/RP0/ADMIN0:Jun 28 21:50:23.057 UTC: shelf_mgr[3220]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP0 hardware state going to Operational
```

4. Check the RP FPD Versions and FPD Status

When the router is operational after the reload, all the RP, IMs, and fan FPDs are upgraded to the latest FPD versions.

```
sysadmin-vm:0_RP1# show hw-module fpd
Mon Jun 28 21:51:20.187 UTC

Auto-upgrade:Enabled
                                                                          FPD Versions
                                                                         ==============
Location   Card type            HWver FPD device       ATR Status    Running   Programd

-----------------------------------------------------------------------------------------
0/2        NCS4200-1T16G-PS      0.0   IMFPGA               CURRENT     1.98      1.98

0/3        A900-IMA8CS1Z-M       0.0   IMFPGA               CURRENT     1.98      1.98

0/4        A900-IMA8Z            0.0   IMFPGA               CURRENT    17.05     17.05

0/5        A900-IMA8Z-L          0.0   IMFPGA               CURRENT     1.49      1.49

0/8        NCS4200-1T16G-PS      0.0   IMFPGA               CURRENT     1.98      1.98

0/9        N560-IMA1W           66.32 CFP2-DS-DCO          CURRENT    38.27397  38.27397

0/9        N560-IMA1W            0.0   IMFPGA               CURRENT     1.28      1.28

0/15       NCS4200-1T16G-PS      0.0   IMFPGA               CURRENT     1.98      1.98

0/RP0      N560-RSP4             0.0   ADM                  CURRENT     1.06      1.06

0/RP0      N560-RSP4             0.0   IOFPGA               CURRENT     0.64      0.64

0/RP0      N560-RSP4             0.0   PRIMARY-BIOS         CURRENT     0.19      0.19

0/RP0      N560-RSP4             0.0   SATA                 CURRENT     2.10      2.10

0/RP1      N560-RSP4             0.0   ADM                  CURRENT     1.05      1.05

0/RP1      N560-RSP4             0.0   IOFPGA               CURRENT     0.64      0.64

0/RP1      N560-RSP4             0.0   PRIMARY-BIOS         CURRENT     0.19      0.96

0/RP1      N560-RSP4             0.0   SATA                 CURRENT     2.10      2.10

0/FT0      N560-FAN-H            1.0   PSOC                 CURRENT     2.02      2.02

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

Configuring Auto FPD During ISSU

ISSU occurs in two phases—in the System Admin VM and then in the XR VM.

In the System Admin VM mode, first execute the **fpd auto-upgrade enable** command. This configuration causes the FPDs on the route processor (RP) to automatically upgrade to the latest versions.

In the XR VM mode, you *must* disable the FPD auto upgrade. This is because IM FPGA upgrades are not automatically triggered as part of ISSU.

Note Less than 50ms traffic loss is expected during ISSU.

Note During both Admin and XR ISSU, always disable the auto reload functionality by using the **fpd auto-reload disable** command.

1. **Enable FPD auto-upgrade in XR VM**

```
RP/0/RP0/CPU0:IOS#conf
RP/0/RP0/CPU0:IOS(config)#fpd auto-upgrade enable
RP/0/RP0/CPU0:IOS#commit
```

2. **Disable FPD auto-reload in XR VM**

```
RP/0/RP0/CPU0:IOS#conf
RP/0/RP0/CPU0:IOS(config)#fpd auto-reload disable
RP/0/RP0/CPU0:IOS#commit
```

3. **Check for FPD Versions**

```
RP/0/RP0/CPU0:iso#show hw-module fpd
Sun Aug  1 19:36:13.869 UTC

Auto-upgrade:Enabled
                                                                          FPD Versions
                                                                          ==============
Location   Card type            HWver FPD device      ATR Status    Running   Programd

--------------------------------------------------------------------------------------
0/11       NCS4200-8T-PS         0.0   IMFPGA              CURRENT    17.05     17.05

0/RP0      NCS4216-RSP-800       0.0   ADM                 CURRENT     1.06      1.06

0/RP0      NCS4216-RSP-800       0.0   IOFPGA              CURRENT     0.78      0.78

0/RP0      NCS4216-RSP-800       0.0   PRIMARY-BIOS        CURRENT     0.21      0.21

0/RP0      NCS4216-RSP-800       0.0   SATA                CURRENT     2.20      2.20

0/RP1      NCS4216-RSP-800       0.0   ADM                 CURRENT     1.06      1.06

0/RP1      NCS4216-RSP-800       0.0   IOFPGA              CURRENT     0.78      0.78

0/RP1      NCS4216-RSP-800       0.0   PRIMARY-BIOS        CURRENT     0.21      0.21

0/RP1      NCS4216-RSP-800       0.0   SATA                CURRENT     2.20      2.20

0/FT0      NCS4216-F2B-FAN       1.0   PSOC                CURRENT     2.02      2.02

0/PM0      A900-PWR1200-A        0.1   DCA-PriMCU          CURRENT     0.13      0.13

0/PM0      A900-PWR1200-A        0.1   DCA-SecMCU          CURRENT     2.03      2.03

0/PM1      A900-PWR1200-A        0.1   DCA-PriMCU          CURRENT     0.13      0.13

0/PM1      A900-PWR1200-A        0.1   DCA-SecMCU          CURRENT     2.03      2.03
RP/0/RP0/CPU0:iso#
```

4. **Perform sysadmin ISSU Upgrade**

Check that FPD upgrades are triggered as part of ISSU:

```
RP/0/RP0/CPU0:IOS#admin
sysadmin-vm:0_RP0# install extract ncs560-mini-x-7.3.2
Mon Aug  2  04:54:17.250 UTC+00:00
```

```
result Mon Aug  2 04:54:18 2021 Install operation 1 (install extract) started by user
 'cafyauto' will continue asynchronously.
sysadmin-vm:0_RP0# 0/RP0/ADMIN0:Aug  2 04:58:47.990 UTC: inst_mgr[4350]:
%INFRA-INSTMGR-2-OPERATION_SUCCESS : Install operation 1 completed successfully
Mon Aug  2 04:58:47 2021 Install operation 1 completed successfully.
sysadmin-vm:0_RP0# install activate issu  host-7.3.2 ncs560-sysadmin-7.3.2
Mon Aug  2  05:26:31.442 UTC+00:00
op-initiated true
operation-id 2
result start-success
id 2
sysadmin-vm:0_RP0# 2021-08-02 05:26:31 Admin install operation 2 started
sysadmin-vm:0_RP0# 2021-08-02 05:26:31 install activate issu host-7.3.2
ncs560-sysadmin-7.3.2
sysadmin-vm:0_RP0# 2021-08-02 05:26:35 Install operation 2 started: ISSU prepare
install activate issu host-7.3.2 ncs560-sysadmin-7.3.2
sysadmin-vm:0_RP0# 0/RP0/ADMIN0:Aug  2 05:30:22.441 UTC: inst_mgr[4350]:
%INFRA-INSTMGR-2-OPERATION_SUCCESS : Install operation 2 completed successfully
2021-08-02 05:30:22 Install operation 2 completed successfully
sysadmin-vm:0_RP0# 2021-08-02 05:30:23 Admin install operation 3 started
sysadmin-vm:0_RP0# 2021-08-02 05:30:23 install activate issu host-7.3.2
ncs560-sysadmin-7.3.2
sysadmin-vm:0_RP0# 2021-08-02 05:30:25 Install operation 3 started: ISSU activate
install activate issu host-7.3.2 ncs560-sysadmin-7.3.2
sysadmin-vm:0_RP0#
sysadmin-vm:0_RP0# 2021-08-02 05:31:10 Admin VM of node 0/RP1 will now reload as part
 of ISSU operation 3
0/RP0/ADMIN0:Aug  2 05:31:17.314 UTC: shelf_mgr[3212]: %INFRA-SHELF_MGR-4-VM_RELOAD :
 Reloading VM on 0/RP1
0/RP0/ADMIN0:Aug  2 05:32:12.842 UTC: shelf_mgr[3212]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP1 software state going to Operational

RP/0/RP0/CPU0:Aug  2 05:33:05.763 UTC: fpd-serv[419]: %PKT_INFRA-FM-3-FAULT_MAJOR :
ALARM_MAJOR :FPD-NEED-UPGRADE :DECLARE :0/RP1:

sysadmin-vm:0_RP0# 2021-08-02 05:33:28 Admin VM of node 0/RP0 will now reload as part
 of ISSU operation 3
RP/0/RP0/CPU0:Aug  2 05:35:44.331 UTC: fpd-serv[419]: %PKT_INFRA-FM-3-FAULT_MAJOR :
ALARM_MAJOR :FPD-NEED-UPGRADE :DECLARE :0/RP0:
0/RP1/ADMIN0:Aug  2 05:36:01.213 UTC: inst_mgr[6351]: %INFRA-INSTMGR-2-OPERATION_SUCCESS
 : Install operation 3 completed successfully
0/RP0/ADMIN0:Aug  2 05:36:29.242 UTC: control_driver[3920]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : Auto fpd triggered for FPD SATA upgrade @ location
 0/RP0 please wait until all fpd upgrades are done
0/RP0/ADMIN0:Aug  2 05:36:29.545 UTC: control_driver[3920]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD SATA@0/RP0 image programming completed with
UPGRADE DONE state Info: [SDD firmware upgraded from 1.30 to 2.10]
0/RP0/ADMIN0:Aug  2 05:36:29.545 UTC: control_driver[3920]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD SATA @location 0/RP0 FPD upgraded and activated!

0/RP1/ADMIN0:Aug  2 05:36:29.557 UTC: shelf_mgr[4032]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP0 software state going to Operational

0/RP1/ADMIN0:Aug  2 05:36:29.557 UTC: shelf_mgr[4032]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP0 hardware state going to Operational

0/RP1/ADMIN0:Aug  2 05:36:29.667 UTC: control_driver[4015]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : Auto fpd triggered for FPD SATA upgrade @ location
 0/RP1 please wait until all fpd upgrades are done
0/RP1/ADMIN0:Aug  2 05:36:29.981 UTC: control_driver[4015]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD SATA@0/RP1 image programming completed with
UPGRADE DONE state Info: [SDD firmware upgraded from 1.30 to 2.10]
0/RP1/ADMIN0:Aug  2 05:36:29.981 UTC: control_driver[4015]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD SATA @location 0/RP1 FPD upgraded and activated!
```

```
0/RP1/ADMIN0:Aug  2 05:36:29.987 UTC: shelf_mgr[4032]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP1 software state going to Operational

0/RP1/ADMIN0:Aug  2 05:36:29.987 UTC: shelf_mgr[4032]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP1 hardware state going to Operational

0/RP1/ADMIN0:Aug  2 05:36:30.059 UTC: control_driver[4015]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : Auto fpd triggered for FPD PRIMARY-BIOS upgrade @
 location 0/RP1 please wait until all fpd upgrades are done
0/RP0/ADMIN0:Aug  2 05:36:31.704 UTC: control_driver[3920]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : Auto fpd triggered for FPD PRIMARY-BIOS upgrade @
 location 0/RP0 please wait until all fpd upgrades are done
0/RP1/ADMIN0:Aug  2 05:36:35.977 UTC: control_driver[4015]:
%INFRA-FPD_Driver-6-UPGRADE_RESULT : Upgrade completes 50 percent for fpd
PRIMARY-BIOS@location 0/RP1.
0/RP0/ADMIN0:Aug  2 05:36:36.706 UTC: control_driver[3920]:
%INFRA-FPD_Driver-6-UPGRADE_RESULT : Upgrade completes 50 percent for fpd
PRIMARY-BIOS@location 0/RP0.
0/RP1/ADMIN0:Aug  2 05:36:55.985 UTC: control_driver[4015]:
%INFRA-FPD_Driver-6-UPGRADE_RESULT : Upgrade completes 100 percent for fpd
PRIMARY-BIOS@location 0/RP1.
0/RP1/ADMIN0:Aug  2 05:36:56.012 UTC: control_driver[4015]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD PRIMARY-BIOS@0/RP1 image programming completed
 with UPGRADE DONE state Info: [  Upgrade Complete ]
0/RP1/ADMIN0:Aug  2 05:36:56.012 UTC: control_driver[4015]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD PRIMARY-BIOS @location 0/RP1 upgrade completed.

0/RP1/ADMIN0:Aug  2 05:36:56.018 UTC: shelf_mgr[4032]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP1 software state going to Operational

0/RP1/ADMIN0:Aug  2 05:36:56.018 UTC: shelf_mgr[4032]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP1 hardware state going to Operational

0/RP0/ADMIN0:Aug  2 05:36:56.582 UTC: control_driver[3920]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD PRIMARY-BIOS@0/RP0 image programming completed
 with UPGRADE DONE state Info: [  Upgrade Complete ]
0/RP0/ADMIN0:Aug  2 05:36:56.869 UTC: control_driver[3920]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD PRIMARY-BIOS @location 0/RP0 upgrade completed.

0/RP1/ADMIN0:Aug  2 05:36:56.871 UTC: shelf_mgr[4032]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP0 software state going to Operational

0/RP1/ADMIN0:Aug  2 05:36:56.872 UTC: shelf_mgr[4032]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP0 hardware state going to Operational

RP/0/RP0/CPU0:IOS#admin
Mon Aug  2 05:49:27.392 UTC

cafyauto connected from 192.0.0.4 using ssh on sysadmin-vm:0_RP1
sysadmin-vm:0_RP1# install commit
Mon Aug  2  05:49:40.694 UTC+00:00
result Mon Aug  2 05:49:41 2021 Install operation 4 (install commit) started by user
'cafyauto' will continue asynchronously.
sysadmin-vm:0_RP1# Mon Aug  2 05:49:44 2021 Install operation 4 completed successfully.
sysadmin-vm:0_RP1# 0/RP1/ADMIN0:Aug  2 05:49:44.733 UTC: inst_mgr[6351]:
%INFRA-INSTMGR-2-OPERATION_SUCCESS : Install operation 4 completed successfully
0/RP1/ADMIN0:Aug  2 05:49:46.936 UTC: inst_mgr[6351]: %PKT_INFRA-FM-6-FAULT_INFO :
INSTALL-IN-PROGRESS :CLEAR :0/RP1: Calvados INSTALL_IN_PROGRESS Alarm : being CLEARED
 for the system
sysadmin-vm:0_RP1#
```

5. Check the FPD Versions

6. Disable FPD auto-upgrade in XR VM

```
RP/0/RP1/CPU0:PP-Router#conf
RP/0/RP1/CPU0:PP-Router(config)#fpd auto-upgrade disable
RP/0/RP1/CPU0:PP-Router(config)#commit
```

7. Perform ISSU Upgrade in XR VM

```
RP/0/RP0/CPU0:IOS#install extract ncs560-mini-x-7.3.2
Mon Aug  2 05:55:19.880 UTC
2021-08-02 05:55:22 Install operation 100 started by cafyauto:
  install extract ncs560-mini-x-7.3.2
2021-08-02 05:55:22 Package list:
2021-08-02 05:55:22     ncs560-mini-x-7.3.2
2021-08-02 05:55:23 Install operation will continue in the background
RP/0/RP0/CPU0:IOS#2021-08-02 05:59:42 Install operation 100 finished successfully
RP/0/RP0/CPU0:Aug  2 05:59:42.840 UTC: sdr_instmgr[1213]:
%INSTALL-INSTMGR-2-OPERATION_SUCCESS : Install operation 100 finished successfully
RP/0/RP0/CPU0:IOS#install activate issu  ncs560-xr-7.3.2
Mon Aug  2 06:02:06.097 UTC
2021-08-02 06:02:08 Install operation 101 started by cafyauto:
  install activate issu ncs560-xr-7.3.2
2021-08-02 06:02:08 Package list:
2021-08-02 06:02:08     ncs560-xr-7.3.2
This install operation will start the issu, continue?
 [yes/no]:[yes] yes
2021-08-02 06:04:03 Install operation will continue in the background
RP/0/RP0/CPU0:IOS#RP/0/RP0/CPU0:Aug  2 06:04:11.315 UTC: issudir[342]:
%PKT_INFRA-FM-6-FAULT_INFO : ISSU-IN-PROGRESS :DECLARE :0/RP0/CPU0: ISSU_IN_PROGRESS
Alarm : being DECLARED for the system
…
RP/0/RP0/CPU0:IOS# RP/0/RP1/CPU0:Aug  2 06:18:13.640 UTC: imfpga[345]: Change ISSU
Node State from [Secondary] to [Primary]
RP/0/RP1/CPU0:Aug  2 06:18:13.659 UTC: tmgctrl[444]: ISSU Node Role Change Notification
 [Primary]
RP/0/RP1/CPU0:Aug  2 06:18:13.725 UTC: issudir[139]:
%INSTALL-ISSU_INFRA-1-OPERATION_ISSU_RUN_DONE : ISSU Run has completed for install
operation '101'. Issue the command "install activate issu cleanup" to continue the
operation.
RP/0/RP1/CPU0:Aug  2 06:18:13.729 UTC: issudir[139]: %PKT_INFRA-FM-6-FAULT_INFO :
ISSU-IN-PROGRESS :DECLARE :0/RP1/CPU0:
RP/0/RP1/CPU0:Aug  2 06:19:13.695 UTC: fpd-serv[216]: %PKT_INFRA-FM-3-FAULT_MAJOR :
ALARM_MAJOR :FPD-NEED-UPGRADE :DECLARE :0/3:
RP/0/RP1/CPU0:Aug  2 06:19:13.695 UTC: fpd-serv[216]: %PKT_INFRA-FM-3-FAULT_MAJOR :
ALARM_MAJOR :FPD-NEED-UPGRADE :DECLARE :0/7:
RP/0/RP1/CPU0:Aug  2 06:19:53.982 UTC: fpd-serv[216]: %PKT_INFRA-FM-3-FAULT_MAJOR :
ALARM_MAJOR :FPD-NEED-UPGRADE :DECLARE :0/1:
RP/0/RP1/CPU0:Aug  2 06:19:13.764 UTC: imfpga[343]: ISSU Phase Change Notification
[Phase Cleanup]
RP/0/RP1/CPU0:Aug  2 06:19:19.442 UTC: tmgctrl[444]: ISSU Phase Change Notification
[Phase Completed], Becoming Timing Primary now
RP/0/RP1/CPU0:Aug  2 06:19:19.452 UTC: sdr_instmgr[1213]: %PKT_INFRA-FM-6-FAULT_INFO
: INSTALL-IN-PROGRESS :DECLARE :0/RP1/CPU0: INSTALL_IN_PROGRESS Alarm : being DECLARED
 for the system
RP/0/RP1/CPU0:Aug  2 06:19:19.519 UTC: issudir[139]: %PKT_INFRA-FM-6-FAULT_INFO :
ISSU-IN-PROGRESS :CLEAR :0/RP1/CPU0:
RP/0/RP1/CPU0:Aug  2 06:19:19.538 UTC: tmgctrl[444]: ISSU Phase Change Notification
[Phase Completed] Processing done
RP/0/RP1/CPU0:Aug  2 06:19:20.480 UTC: sdr_instmgr[1213]:
%INSTALL-INSTMGR-2-OPERATION_SUCCESS : Install operation 101 finished successfully

RP/0/RP1/CPU0:IOS# install commit
Mon Aug  2 06:44:07.572 UTC
2021-08-02 06:44:10 Install operation 103 started by root123:
  install commit
```

```
2021-08-02  06:44:11 Install operation will continue in the background
RP/0/RP1/CPU0:ISO#0/RP1/ADMIN0:Aug  2 06:44:20.839 UTC: inst_mgr[6353]:
%PKT_INFRA-FM-6-FAULT_INFO : INSTALL-IN-PROGRESS :CLEAR :0/RP1: Calvados
INSTALL_IN_PROGRESS Alarm : being CLEARED for the system
RP/0/RP1/CPU0:Aug  2 16:44:20.579 UTC: sdr_instmgr[1213]: %PKT_INFRA-FM-6-FAULT_INFO
: INSTALL-IN-PROGRESS :CLEAR :0/RP1/CPU0: INSTALL_IN_PROGRESS Alarm : being CLEARED
for the system
2021-08-02 06:44:23 Install operation 103 finished successfully
RP/0/RP1/CPU0:Aug  2 06:44:23.201 UTC: sdr_instmgr[1213]:
%INSTALL-INSTMGR-2-OPERATION_SUCCESS : Install operation 103 finished successfully
sysadmin-vm:0_RP1# show version
Mon Aug  2  07:24:58.414 UTC+00:00
Cisco IOS XR Admin Software, Version 7.3.2
Copyright (c) 2013-2021 by Cisco Systems, Inc.

Build Information:
 Built By     : ingunawa
 Built On     : Thu Jul 29 01:27:41 PDT 2021
 Built Host   : iox-ucs-003
 Workspace    : /auto/iox-ucs-003-san2/prod/7.3.2.DT_IMAGE/ncs560/ws
 Version      : 7.3.2
 Location     : /opt/cisco/calvados/packages/
 Label        : 7.3.2
System uptime is 1 hour, 53 minutes

sysadmin-vm:0_RP1# exit
Mon Aug  2  07:25:02.260 UTC+00:00
RP/0/RP1/CPU0:IOS#show version
Mon Aug  2 07:25:04.063 UTC
Cisco IOS XR Software, Version 7.3.2
Copyright (c) 2013-2021 by Cisco Systems, Inc.

Build Information:
 Built By     : ingunawa
 Built On     : Thu Jul 29 03:34:42 PDT 2021
 Built Host   : iox-ucs-003
 Workspace    : /auto/iox-ucs-003-san2/prod/7.3.2.DT_IMAGE/ncs560/ws
 Version      : 7.3.2
 Location     : /opt/cisco/XR/packages/
 Label        : 7.3.2

cisco NCS-560 () processor
System uptime is 1 hour 13 minutes

RP/0/RP1/CPU0:IOS #
```

8. Check the IMFPGA FPD Versions

Note IMFPGA FPDs are not upgraded as part of ISSU, as auto-upgrade is disabled. Based on your network design, you must enable and upgrade the IM FPDs as well as reload the IMs at a time when it has the least impact on traffic.

```
RP/0/RP1/CPU0:IOS#show hw-module fpd
Mon Aug  2 06:38:52.253 UTC

Auto-upgrade:Disabled
                                                                    FPD Versions
                                                                   ==============
Location   Card type            HWver FPD device      ATR Status    Running   Programd
```

```
--------------------------------------------------------------------------------
0/1         NCS4200-1T16G-PS      0.0   IMFPGA              NEED UPGD   1.95      1.95
0/3         NCS4200-1T16G-PS      0.0   IMFPGA              NEED UPGD   1.95      1.95
0/4         A900-IMA8Z            0.0   IMFPGA              CURRENT    17.05     17.05
0/7         N560-IMA2C            0.0   IMFPGA              NEED UPGD   4.96      4.96
0/9         A900-IMA8Z            0.0   IMFPGA              CURRENT    17.05     17.05
0/RP0       N560-RSP4-E           0.0   ADM                 CURRENT     1.06      1.06
0/RP0       N560-RSP4-E           0.0   IOFPGA              CURRENT     0.67      0.67
0/RP0       N560-RSP4-E           0.0   PRIMARY-BIOS        RLOAD REQ   0.16      0.19
0/RP0       N560-RSP4-E           0.0   SATA                CURRENT     2.10      2.10
0/RP1       N560-RSP4-E           0.0   ADM                 CURRENT     1.06      1.06
0/RP1       N560-RSP4-E           0.0   IOFPGA              CURRENT     0.67      0.67
0/RP1       N560-RSP4-E           0.0   PRIMARY-BIOS        RLOAD REQ   0.16      0.19
0/RP1       N560-RSP4-E           0.0   SATA                CURRENT     2.10      2.10
0/FT0       N560-FAN-H            1.0   PSOC                CURRENT     2.02      2.02

RP/0/RP1/CPU0:IOS#
```

9. Verify Standby is Node and NSR ready

```
RP/0/RP1/CPU0:IOS#show redundancy
Mon Aug  2 06:39:44.953 UTC
Redundancy information for node 0/RP1/CPU0:
==========================================
Node 0/RP1/CPU0 is in ACTIVE role
Partner node (0/RP0/CPU0) is in STANDBY role
Standby node in 0/RP0/CPU0 is ready
Standby node in 0/RP0/CPU0 is NSR-ready

Reload and boot info
----------------------
RP reloaded Mon Aug  2 06:11:55 2021: 27 minutes ago
Active node booted Mon Aug  2 06:11:55 2021: 27 minutes ago
Standby node boot Mon Aug  2 06:20:02 2021: 19 minutes ago
Standby node last went not ready Mon Aug  2 06:22:46 2021: 16 minutes ago
Standby node last went ready Mon Aug  2 06:26:47 2021: 12 minutes ago
Standby node last went not NSR-ready Mon Aug  2 06:15:01 2021: 24 minutes ago
Standby node last went NSR-ready Mon Aug  2 06:24:52 2021: 14 minutes ago
There have been 0 switch-overs since reload

Active node reload "CARD_SHUTDOWN"
Standby node reload "CARD_SHUTDOWN "

RP/0/RP1/CPU0:IOS#
```

10. IM FPD auto-upgrade: After ISSU

a. Configure the **fpd auto-upgrade enable** command to auto upgrade FPDs for all IMs

Note After ISSU is complete for RPs, configure FPD auto upgrade and FPD auto reload.

Note FPD auto reload affects network traffic. Ensure you schedule the reload of IMs at a time when it has the least impact on traffic.

Note Do not exit configure exclusive mode until all IM FPGA upgrades are automatically completed. Use a separate VTY session to monitor and check status.

```
RP/0/RP1/CPU0:IOS# configure exclusive
Mon Aug  2 06:45:11.297 UTC
RP/0/RP1/CPU0:IOS(config)# fpd auto-upgrade enable
RP/0/RP0/CPU0:IOS(config)# fpd auto-reload enable
RP/0/RP0/CPU0:IOS# commit
```

Note During this step, all IMs that need FPD upgrades, are upgraded simultaneously. IMs are reloaded automatically for the versions to reflect.

b. Exit **configure exclusive** mode when IMFPGA upgrades are completed on all IMs.

```
RP/0/RP1/CPU0:ROUTER#RP/0/RP1/CPU0:Jun 29 06:44:28.808 UTC: fpd_imfpga[430]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : Auto fpd triggered for FPD IMFPGA upgrade @
location 0/5/CPU0 please wait until all fpd upgrades are done
RP/0/RP1/CPU0:Jun 29 06:45:25.105 UTC: fpd-serv[125]: %PKT_INFRA-FM-3-FAULT_MAJOR
: ALARM_MAJOR :FPD-NEED-UPGRADE :DECLARE :0/5:
RP/0/RP1/CPU0:Jun 29 06:48:02.020 UTC: fpd_imfpga[430]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD IMFPGA@0/5 image programming completed with
 UPGRADE DONE state Info: [DONE ]
RP/0/RP1/CPU0:Jun 29 06:48:02.032 UTC: fpd_imfpga[430]:
%INFRA-FPD_Driver-1-UPGRADE_ALERT : FPD IMFPGA @location 0/5 upgrade completed.
0/RP1/ADMIN0:Jun 29 06:48:02.473 UTC: shelf_mgr[3695]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/5 hardware state going to
Operational
0/RP1/ADMIN0:Jun 29 06:48:02.473 UTC: shelf_mgr[3695]:
%INFRA-SHELF_MGR-6-CARD_SW_OPERATIONAL : Card: 0/RP1 software state going to
Operational
0/RP1/ADMIN0:Jun 29 06:48:02.474 UTC: shelf_mgr[3695]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/RP1 hardware state going to
Operational
RP/0/RP1/CPU0:Jun 29 06:48:08.741 UTC: fpd-serv[125]:
%INFRA-FPD_SERVER-1-UPGRADE_ALERT : fpd auto-reload configured on this box.  Going
 to reload node 0/5/CPU0 to activate newly upgraded FPD(s).
0/RP1/ADMIN0:Jun 29 06:48:19.182 UTC: shelf_mgr[3695]: %INFRA-SHELF_MGR-4-CARD_RELOAD
 : Reloading card 0/5
0/RP1/ADMIN0:Jun 29 06:48:19.186 UTC: shelf_mgr[3695]: %INFRA-SHELF_MGR-6-HW_EVENT
 : Rcvd HW event HW_EVENT_RESET, event_reason_str '' for card 0/5
0/RP1/ADMIN0:Jun 29 06:48:21.581 UTC: shelf_mgr[3695]: %INFRA-SHELF_MGR-6-HW_EVENT
 : Rcvd HW event HW_EVENT_POWERED_OFF, event_reason_str 'reset requested by user'
for card 0/5
RP/0/RP1/CPU0:Jun 29 06:48:58.746 UTC: fpd-serv[125]: %PKT_INFRA-FM-3-FAULT_MAJOR
: ALARM_MAJOR :FPD-NEED-UPGRADE :CLEAR :0/5:
```

```
0/RP1/ADMIN0:Jun 29 06:49:52.266 UTC: shelf_mgr[3695]: %INFRA-SHELF_MGR-6-HW_EVENT
 : Rcvd HW event HW_EVENT_POWERED_OFF, event_reason_str '' for card 0/5
0/RP1/ADMIN0:Jun 29 06:49:57.586 UTC: shelf_mgr[3695]: %INFRA-SHELF_MGR-6-HW_EVENT
 : Rcvd HW event HW_EVENT_POWERED_ON, event_reason_str '' for card 0/5
0/RP1/ADMIN0:Jun 29 06:50:23.999 UTC: shelf_mgr[3695]: %INFRA-SHELF_MGR-6-HW_EVENT
 : Rcvd HW event HW_EVENT_OK, event_reason_str '' for card 0/5
0/RP1/ADMIN0:Jun 29 06:50:23.999 UTC: shelf_mgr[3695]:
%INFRA-SHELF_MGR-6-CARD_HW_OPERATIONAL : Card: 0/5 hardware state going to
Operational
```

11. Break Reload Actions in Multiple Steps to Avoid Traffic Loss

a. Reload Standby RP

In the following example, RP1 is the active and RP0 is the standby route processor. After the standby RP reloads and boots up, the RP FPDs come to node ready and NSR ready state.

Note It is expected behavior to see different versions of the RPs in System Admin VM and XR VM.

```
RP/0/RP1/CPU0:IOS# admin
Mon Aug  2 07:34:26.615 UTC
Last login: Mon Aug  2 07:20:24 2021 from 192.0.4.4

cafyauto connected from 192.0.4.4 using ssh on sysadmin-vm:0_RP1
sysadmin-vm:0_RP1# hw-module location 0/RP0 reload
Mon Aug  2  07:34:47.432 UTC+00:00
Reload hardware module ? [no,yes] yes
0/RP1/ADMIN0:Aug  2 07:34:48.728 UTC: shelf_mgr[4032]: %INFRA-SHELF_MGR-6-USER_ACTION
 : User cafyauto(192.0.4.4) requested CLI action 'graceful card reload' for location
 0/RP0
result Card graceful reload request on 0/RP0 succeeded.
0/RP1/ADMIN0:Aug  2 07:35:01.151 UTC: shelf_mgr[4032]: %INFRA-SHELF_MGR-4-CARD_RELOAD
 : Reloading card 0/RP0
RP/0/RP1/CPU0:Aug  2 07:35:01.263 UTC: fpd-serv[216]: %PKT_INFRA-FM-3-FAULT_MAJOR
: ALARM_MAJOR :FPD-NEED-UPGRADE :CLEAR :0/RP0:
RP/0/RP1/CPU0:IOS#show hw-module fpd

Auto-upgrade:Enabled
                                                                        FPD Versions


==============
Location   Card type             HWver FPD device       ATR Status    Running
Programd
-----------------------------------------------------------------------------------
0/1        NCS4200-1T16G-PS      0.0   IMFPGA               CURRENT     1.102
1.10
0/3        NCS4200-1T16G-PS      0.0   IMFPGA               RLOAD REQ   1.95
1.10
0/4        A900-IMA8Z            0.0   IMFPGA               CURRENT    17.05
17.05
0/7        N560-IMA2C            0.0   IMFPGA               RLOAD REQ   4.96
5.01
0/9        A900-IMA8Z            0.0   IMFPGA               CURRENT    17.05
17.05
0/RP0      N560-RSP4-E           0.0   ADM                  CURRENT     1.06
1.06
0/RP0      N560-RSP4-E           0.0   IOFPGA               CURRENT     0.67
0.67
0/RP0      N560-RSP4-E           0.0   PRIMARY-BIOS         CURRENT     0.19
```

```
0.19
0/RP0      N560-RSP4-E           0.0   SATA                CURRENT     2.10
2.10
0/RP1      N560-RSP4-E           0.0   ADM                 CURRENT     1.06
1.06
0/RP1      N560-RSP4-E           0.0   IOFPGA              CURRENT     0.67
0.67
0/RP1      N560-RSP4-E           0.0   PRIMARY-BIOS        RLOAD REQ   0.16
0.19
0/RP1      N560-RSP4-E           0.0   SATA                CURRENT     2.10
2.10
0/FT0      N560-FAN-H            1.0   PSOC                CURRENT     2.02
2.02
RP/0/RP1/CPU0:IOS#
```

b. Redundancy Switchover—Swap to the Updated RP as Active RP

After the standby RP is reloaded and booted up, perform the redundancy switchover to this RP with upgraded FPD, as active RP.

Note Follow Step 11a to upgrade and reload the new standby RP.

```
RP/0/RP1/CPU0:IOS#redundancy switchover
Mon Jun 28 17:16:44.914 UTC
Proceed with switchover 0/RP0/CPU0 -> 0/RP1/CPU0? [confirm]

RP/0/RP1/CPU0:Jun 28 17:16:46.157 UTC: rmf_svr[234]: %HA-REDCON-4-FAILOVER_REQUESTED
 : failover has been requested by operator, waiting to initiate
Initiating switch-over.
```

c.

Note You can either perform steps 11a and 11b, *or* you can perform step 11c.

Reload the Router to Reflect the Latest FPD Versions

Note Reloading the router impacts network traffic.

```
RP/0/RP1/CPU0:IOS#admin
Wed Sep  8 06:10:48.761 UTC
Last login: Wed Sep  8 06:05:30 2021 from 192.0.4.6

root connected from 192.0.4.6 using ssh on sysadmin-vm:0_RP1
sysadmin-vm:0_RP1# hw-module location all reload
Wed Sep  8  06:10:56.203 UTC+00:00
Reloading the module will be traffic impacting if not properly drained. Continue
to Reload hardware module ? [no,yes] yes
result Card graceful reload request on all acknowledged.
sysadmin-vm:0_RP1#
```

Automatic FPD Upgrade for PSU

During the Power Supply Unit (PSU) insertion and installation process, the routers can now automatically upgrade the Field-Programmable Devices (FPD) associated with the PSUs.

Starting with Cisco IOS-XR Release 7.5.2, the automatic FPD upgrade includes the FPDs associated with the PSUs by default. This means that when automatic FPD upgrade is enabled, the FPDs associated with the PSUs will also be upgraded. The upgrades for the PSUs will occur sequentially, so the FPD upgrades for the PSUs will take longer than for other components.

You can choose to exclude PSUs from the automatic upgrade process to reduce the time taken for FPD automatic upgrade by preventing them from being upgraded upon insertion or during a system upgrade using the **fpd auto-upgrade exclude pm** command.

Configuration example for excluding PSUs from automatic FPD upgrade:

Configuration

```
Router# config
Router(config)# fpd auto-upgrade enable
Router(config)# fpd auto-upgrade exclude pm
Router(config)# commit
```

Show Running Configuration

```
Router# show running-config fpd auto-upgrade
fpd auto-upgrade enable
fpd auto-upgrade include pm
```

Upgrade Failure

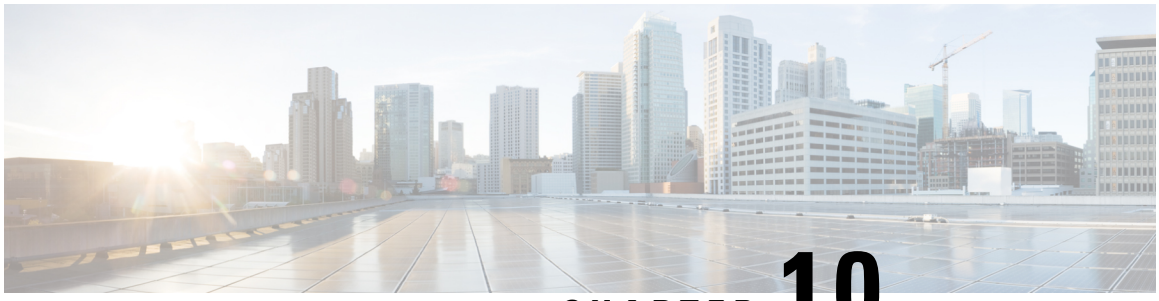
On failure of an FPD upgrade, you get a warning with the following syslog message:

```
LC/0/5/CPU0:Jun 27 05:02:25.742 UTC: optics_driver[216]: %INFRA-FPD_Driver-1-UPGRADE_ALERT
 : FPD MIFPGA@0/5 image programming completed with UPGD FAIL state Info: [Image verification
 failed at offset 0x5c8, flash value = 0x0, image value = 0x40, image size = 4194304]
LC/0/5/CPU0:Jun 27 05:02:26.570 UTC: optics_driver[216]: %INFRA-FPD_Driver-1-UPGRADE_ALERT
 : FPD MIFPGA@0/5 image programming completed with UPGD FAIL state Info: [Image verification
 failed at offset 0x1e, flash value = 0x56, image value = 0xff, image size = 4194304]
```

When you use the **show hw-module fpd**command, the status column displays **UPGD FAIL** to indicate failure of the FPD upgrade.

Note

- Do not reload the line card with a failed FPD upgrade image.
- Upgrade failed FPDs will be fixed with a manual upgrade.
- Contact Cisco TAC or your account representative if the FPD upgrade failure is not repaired.



CHAPTER 10

Y.1564 - Ethernet Service Activation Test

With the deployment of Ethernet in service provider networks, ethernet services have evolved significantly. Not only is ethernet found at the User Network Interface (UNI) but can also be deployed anywhere in the network, creating a Network-to-Network Interface (NNI). With the capability to prioritize traffic, high availability, and its built-in resiliency, service providers are now using this technology to deliver advanced services. In the absence of any standardized test methodologies that can measure delay, jitter, loss, and throughput at a port, the ITU-T recommendation Y.1564 addresses the gap

Y.1564 - Ethernet Service Activation Test (or performance test methodology) is a testing procedure which tests service turn-up, installation, and troubleshooting of Ethernet-based services. This test methodology was created to have a standard way of measuring Ethernet-based services in the industry.

Cisco implementation of ITU-T Y.1564 has three key objectives:

- To serve as a network SLA validation tool, ensuring that a service meets its guaranteed performance settings in a controlled test time.
- To ensure that all services carried by the network meet their SLA objectives at their maximum committed rate, thus proving that under maximum load, network devices and paths can support all traffic as designed.
- To perform medium-term and long-term service testing, confirming that network elements can properly carry all services while under stress during a soaking period.

The following Key Performance Indicators (KPI) metrics are collected to ensure that the configured SLAs are met for the service or stream.

- Frame Transfer Delay (FTD) or latency—Measures the round-trip time (RTT) taken by a test frame to travel through a network device, or across the network and back to the test port.
- Frame Loss Ratio (FLR)—Measures the number of packets lost from the total number of packets sent. Frame loss can be due to a number of issues such as network congestion or errors during transmissions.

Supported Modes

The mode of operation that is supported for Y.1564 is the Two-way statistics collection mode. In the two-way mode, the sender generates the test traffic used to perform the test, which is then looped back by the remote node. The statistics are measured and collected locally on the sender

The following encapsulations are supported by Y.1564 SADT feature:

- dot1q
- dot1q + second dot1q

- dot1ad
- dot1ad + second dot1q
- priority tagged
- untagged
- default

Usage Guideline and Limitations

- Rewrite with POP option is supported with Color Blind mode with Outer-Cos value of 0.
- Rewrite Push and Translate on Encapsulation Untagged is not supported.
- Y.1564 doesn’t support L1 loopback.
- Y.1564 doesn’t support measuring and analyzing jitter.
- When utilizing the SAT engine received bytes statistics feature, there can be potential inaccuracies in the following conditions:
  - During tests incorporating EMIX sequences that encounter packet drops.
  - When handling LMM packets originating from TGEN, Y.1731 protocols, or any unidentified sources.
- SAT supports a scale of four parallel sessions per system. However, all four sessions can not operate as color aware sessions simultaneously due to limitations in Class of Service (CoS) combinations.

Note The CIR and EIR cos values must be unique for each parallel test.

- SAT over bundle interface functions by selecting one of its members for transmission. Therefore, at least one member must be in the 'UP' state to initiate an SAT session. For modular chasis, bundle member from the different LCs is not supported.
- For optimal performance, it's recommended to use the Ethernet Data Plane Loopback functionality (EDPL) on the peer side for SAT. EDPL loops back and swaps the MAC addresses of Layer 2 packets generated. If the peer node doesn't support EDPL functionality, you can configure SAT to generate Layer 2 packets with the destination MAC address equal to the source MAC address. In such cases, the peer can perform an L1 loopback.
- Packets generated by SAT with PRBS payload at certain packet sizes may have PRBS errors. When configuring GTF packet using bcm_sat_gtf_packet_config_set, this is verified. If the payload_type is bcmSatPayloadPRBS and packets generated at the configured packet_length have PRBS error, this API now returns BCM_E_PARAM to the caller. The user is informed about the PRBS error through the test abort reason.
  - On BCM8869X, packets have PRBS errors, if (packet_length + 63) / 64 is one of [4, 6, 10, 12, 13, 14] or > = 18.
  - On BCM8880X, packets have PRBS errors, if (packet_length + 63) / 64 equals to 6 or > = 33.

SAT Generation Rate

The following table includes the SAT generation rate for different platforms.

Platform (PID)	SAT Generation Rate
NCS540	19.2 Gbps
NCS560	19.2 Gbps
NCS540L	19.2 Gbps
NCS4K	23 Gbps
NCS5501	19.2 Gbps
NCS-5501-SE	19.2 Gbps
NCS55A1-48Q6H	23 Gbps
NCS55A2_MOD_S_SE	23 Gbps
NCS-55A1-36H-SE-S	23 Gbps
NCS-55A1-36H-S	23 Gbps
NCS-55A1-24Q6H-S	23 Gbps
NCS-55A1-24Q6H-SS	23 Gbps
NCS-55A1-24H	23 Gbps
NCS-5502-SE	23 Gbps
N540X-6Z18G-SYS-A	8 Gbps
N540X-4Z14G2Q-D	8 Gbps
N540X-8Z16G-SYS-D	8 Gbps
N540-6Z14S-SYS-D	8 Gbps
NCS-57C1-48Q6-SYS	300 or 400 Gbps
NCS-57C3-MODS-SYS	400 Gbps
NCS-57B1-5DSE-SYS	400 Gbps
N540-24Q8L2DD-SYS	300 Gbps
NCS-57D2-18DD-SYS	400 Gbps

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- Optional Source MAC Address for Y.1564 Service Activation Test , on page 137
- Loopback Frames for Y.1564 Service Activation Test , on page 139
- Combined Frame Delay and Frame Loss Measurement for Y.1564 Service Activation Test, on page 141

CoS DEI Support Matrix

Table 7: Class of Service (CoS) and Discard Eligibility Identifier (DEI) Matrix

		CoS							
		0	1	2	3	4	5	6	7
DEI	0	Ö	Ö	Ö	Ö	Ö	X	Ö	X
	1	Ö	Ö	X	X	X	X	X	X

Ö - Supported

X- Not Supported

Supported Bandwidth Parameters

Bandwidth Parameters	Internal Direction	External Direction
Commited Information Rate	Y	Y
Exceeded Information Rate	Y	Y

Service Activation Test Target Matrix

Target	Internal Direction	External Direction
L2 Interface over physical main/sub interfaces	Y	Y
L2 Interface over bundle main/sub interfaces	Y	Y
L2 PW VPWS over physical main/sub interfaces	Y	Y
L2 PW VPWS over bundle main/sub interfaces	Y	Y
L2 EVPN/XConnect over physical main/sub interfaces	Y	Y
L2 EVPN/XConnect over bundle main/sub interfaces	Y	Y
L2 VPLS PW	N	N
L2 EVPN Bridge-Domain	N	N

Target	Internal Direction	External Direction
L3 Interfaces	N	N

Configuration Examples

The following example shows how to start service-activation test on an interface with external direction:

```
RP/0/RP0/CPU0:router ethernet  service-activation-test start interface TenGigE 10/0/0/1
profile test destination 00ab.6009.9c3c direction external
```

The following example shows how to start service-activation test on an interface with internal direction:

```
RP/0/RP0/CPU0:routerethernet  service-activation-test start interface TenGigE 10/0/0/1
profile test destination 00ab.6009.9c3c direction internal
```

The following example shows how to stop service-activation-test on an interface:

```
RP/0/RP0/CPU0:routerethernet service-activation-test stop interface TenGigE 10/0/0/1
```

The following example shows how to stop all service-activation-tests:

```
RP/0/RP0/CPU0:routerethernet service-activation-test stop all
```

Configuring Ethernet Service Activation Test Color Profile

The following example shows how to configure a color-blind profile for ethernet service activation test:

```
RP/0/RP0/CPU0:router#configure
RP/0/RP0/CPU0:router(config)# ethernet service-activation-test
RP/0/RP0/CPU0:router(config-ethsat)#profile sattest1
RP/0/RP0/CPU0:router(config-ethsat-prf)#outer-cos 4
RP/0/RP0/CPU0:router(config-ethsat-prf)#duration 8 minutes
RP/0/RP0/CPU0:router(config-ethsat-prf)#information-rate 11800 mbps
RP/0/RP0/CPU0:router(config-ethsat-prf)#packet-size 1000
```

The following example shows how to configure a color-aware profile for ethernet service activation test:

```
RP/0/RP0/CPU0:router#configure
RP/0/RP0/CPU0:router(config)# ethernet service-activation-test
RP/0/RP0/CPU0:router(config-ethsat)#profile sattest3
RP/0/RP0/CPU0:router(config-ethsat-prf)#outer-cos 4
RP/0/RP0/CPU0:router(config-ethsat-prf)#duration 1 minutes
RP/0/RP0/CPU0:router(config-ethsat-prf)#color-aware cir 7 gbps eir-color cos 1
RP/0/RP0/CPU0:router(config-ethsat-prf)#information-rate 8 gbps
RP/0/RP0/CPU0:router(config-ethsat-prf)#packet-size 1000
```

Verification

To verify the interfaces on which Y.1564 (ethernet service activation test) is enabled, use the **show ethernet service-activation-test brief** command. The following is a sample output of an enabled device:

```
RP/0/RP0/CPU0:router#show ethernet service-activation-test brief
Interface TenGigE0/0/0/14.1
  Service activation tests permitted (external only)
  Test completed:
    Duration 1 minute(s)
```

```
  Information rate 1 Gbps
  Color-aware, CIR: 900 Mbps, EIR: DEI set, CoS 1
  External, Two-way, Destination 00:11:00:22:00:33
  Packet size EMIX, Sequence 'abceg', Pattern hex 0x00
  Packet format: SAT MEF-49
  Outer CoS 2

Results:
  Step 1, Information Rate 1 Gbps
    CIR packets:
      Tx packets: 11276845, bytes: 6743553310
      Rx packets: 11276845, bytes: 6743553310
      FL: 0, FLR: 0%
      FD: Min 5.144us, Mean 6.681us, Max 9.576us
      IFDV: Not supported
      Out of order packets: 0 (0%)
      Error packets: 0 (0%)

    EIR packets:
      Tx packets: 1252895, bytes: 749231210
      Rx packets: 1252895, bytes: 749231210
      FL: 0, FLR: 0%
      FD: Min 5.160us, Mean 6.679us, Max 8.800us
      IFDV: Not supported
      Out of order packets: 0 (0%)
      Error packets: 0 (0%)
```

Optional Source MAC Address for Y.1564 Service Activation Test

Table 8: Feature History Table

Feature Name	Release Information	Feature Description
Optional Source MAC Address for Y.1564 Service Activation Test	Release 24.1.1	By specifying the source MAC address to the ITU-T Y.1564 SAT, you can ensure that the test results are relevant and applicable to the specific service configuration for use in production and before deployment for your customers. This feature introduces the following change: **Modified CLI:** The **source** keyword is added to the **ethernet service-activation-test** command. **YANG DATA Model**: • New XPaths for Cisco-IOS-XR-ethernet-sat-act.yang (see Github, YANG Data Models Navigator)

Prior to Cisco IOS XR Software Release 24.1.1, the default local interface MAC address was automatically employed as the source MAC address for the test traffic. This approach lacked flexibility and customization options, as you were restricted to the default address. With the optional source MAC address extension, you can specify the exact source MAC address you wish to use in the test traffic. This functionality empowers you to tailor the test sessions according to your specific requirements and network configurations.

Add Source MAC Address for a Y.1564 Service Activation Test

Use the **source** keyword in the **ethernet service-activation-test** command to specify a source MAC address for a Y.1564 Service Activation Test.

Procedure

Step 1 Use the **ethernet service-activation-test** command to configure a profile.

```
Router(config)#ethernet service-activation-test
Router(config-ethsat)#profile prof1
Router(config-ethsat-prf)#duration 1 minutes
```

```
Router(config-ethsat-prf)#information-rate 1 mbps
Router(config-ethsat-prf)#root
Router(config)#interface TenGigE0/0/0/1
Router(config-if)#ethernet service-activation-test
Router(config-if-ethsat)#permit all
Router(config-if-ethsat)#commit
```

Step 2 Run the **ethernet service-activation-test** command in exec mode to specify source MAC address for an SAT:

```
Router#ethernet service-activation-test start interface TenGigE0/0/0/1 profile prof1
destination 00ab.6009.9c3c source 0000.1000.001d direction external
```

Step 3 The **show ethernet service-activation-test in-progress** command displays the source MAC address.

```
Router#show ethernet service-activation-test in-progress
Fri Oct 21 03:50:55.658 PDT
Interface TenGigE0/0/0/1
  Service activation tests permitted
  Test in progress, 1 minute(s) remaining:
    Duration 1 minute(s)
    Information rate 1 Mbps
    External, Two-way, Destination 00ab.6009.9c3c, Source 0000.1000.001d
```

Loopback Frames for Y.1564 Service Activation Test

Table 9: Feature History Table

Feature Name	Release Information	Feature Description
Loopback Frames for Y.1564 Service Activation Test	Release 24.1.1	This feature enables the redirection of test traffic from the destination router to the source router in loopback message (LBM) format. Loopback message enables the measurement of various parameters and performance metrics, such as frame delay, frame loss rates, and QoS settings, after the traffic has completed its round trip. Such comprehensive measurement helps identify issues within the network setup. You can also use it to ensure the service is running and meets the SLA. This feature introduces the following change: **CLI:** The **packet-format lbm** keyword is added to the **ethernet service-activation-test profile** command. **YANG DATA Model**: New XPaths for Cisco-IOS-XR-ethernet-sat-cfg.yang (see Github, YANG Data Models Navigator)

In a typical Y.1564 Service Activation Test scenario, traffic flows from a source router to a destination router. However, with the inclusion of the loopback-message packet-format configuration, the traffic that reaches the destination router can be redirected back to the source router through a loopback interface. Now, the data packets are used in LBM format.

The collection of statistics start once the source router receives the test traffic from the destination.

Prior to Cisco IOS XR Software Release 24.1.1, tests were conducted independently in each direction, with traffic flowing from the source to the destination router. The data packets were used in Loss Measurement Message (LMM) format for Frame Loss (FL).

To enable this functionality, use the **packet-format lbm** keyword in the **ethernet service-activation-test profile** command. Once **packet-format lbm** is configured, data packets are used as per MEF-49.

Configure Loopback for Test Traffic in a Y.1564 Service Activation Test

The following configuration example shows how to configure loopback frames for Y.1564 Service Activation Test.

Procedure

Step 1 Use the **ethernet service-activation-test profile** command to configure loopbback for a test traffic.

```
Router(config)#ethernet service-activation-test
Router(config-ethsat)#profile p1
Router(config-ethsat-prf)#duration 2 minutes
Router(config-ethsat-prf)#information-rate 5 gbps
Router(config-ethsat-prf)#packet-format lbm
Router(config-ethsat-prf)#root
Router(config)#interface TenGigE0/0/0/12
Router(config-if)#ethernet service-activation-test
Router(config-if-ethsat)#permit all
Router(config-if-ethsat)#commit
```

Example of SAT results:

```
 Results:
    Step 1, Information Rate 5 Gbps
      CIR packets:
        Tx packets: 313509436, bytes: 160516831232
        Rx packets: 313464074, bytes: 160493605888
        FL: 45362, FLR: 0%
        FD: Min 5.244us, Mean 6.122us, Max 8.188us
        IFDV: Not supported
        Out of order packets: 0 (0%)
        Error packets: 0 (0%)

      EIR packets:
        Tx packets: 0, bytes: 0
        Rx packets: 0, bytes: 0
        FL: 0, FLR: 0%
        FD: Min 0.000us, Mean 0.000us, Max 0.000us
        IFDV: Min 0.000us, Mean 0.000us, Max 0.000us
        Out of order packets: 0 (0%)
        Error packets: 0 (0%)
```

Step 2 Use the **show running-config** command for the running configuration

```
Router#show running-config
Wed Feb 14 14:37:59.418 UTC
!
ethernet service-activation-test
 profile p1
  duration 2 minutes
  information-rate 5 gbps
  packet-format lbm
 !
!
interface TenGigE0/0/0/12
 ethernet service-activation-test
  permit all
 !
```

Step 3 The **show ethernet service-activation-test** command shows that **packet-format lbm** is configured.

```
Router#show ethernet service-activation-test
Thu Feb 29 06:38:33.435 UTC
Interface TenGigE0/0/0/19
Service activation tests permitted
Test in progress, 179 minute(s) remaining:
Duration 2 minute(s)
Information rate 5 Gbps
Color-blind
External, Two-way, Destination 0A:AA:0B:BB:0C:CC
Packet size 512, Pattern hex 0x00
Packet format: Y.1731 LBM
CoS not set
```

Combined Frame Delay and Frame Loss Measurement for Y.1564 Service Activation Test

Table 10: Feature History Table

Feature Name	Release Information	Feature Description
Combined Frame Delay and Frame Loss Measurement for Y.1564 Service Activation Test	Release 24.1.1	We have enhanced the ITU-T Y.1564 Service Activation Testing (SAT) capabilities by enabling a comprehensive service quality measurement that includes network responsiveness, congestion, and other issues degrading network performance. This feature also allows a holistic testing of the QoS SLAs, which helps identify potential issues faster and troubleshoot effectively. This feature introduces the following change: **CLI:** The **measurement combined** keyword is added to the **ethernet service-activation-test profile** command. **YANG DATA Model**: • New XPaths for Cisco-IOS-XR-ethernet-sat-cfg.yang (see Github, YANG Data Models Navigator)

You can configure the SAT test to measure both delay and loss simultaneously for each frame transmitted and received. This configuration allows for the consolidated calculation of both delay and loss using Frame Delay (FD) packets . By setting the Frame Loss (FL) rate to 0% in the generator function, the test focuses solely on calculating delay and loss metrics using Delay Measurement Message (DMM) frames. This means that every frame sent and received is analyzed for delay and loss characteristics.

Prior to Cisco IOS XR Software Release 24.1.1 release, either FD or FL could be measured at a time

Furthermore, the configuration treats out-of-order packets in the same manner as the transmitted packets since there is no sequence numbering on the DMM packets. This approach ensures that all frames, regardless of their order of arrival, are accounted for in the measurement of delay and loss.

Configure Measurement Combined for a Y.1564 Service Activation Test

The following configuration example shows how to configure combined frame delay and frame loss measurements for Y.1564 Service Activation Test.

Procedure

Step 1 Use the **ethernet service-activation-test profile** command to configure **measurement combined** for a test traffic.

```
Router(config)#ethernet service-activation-test
Router(config-ethsat)#profile p1
Router(config-ethsat-prf)#duration 10 minutes
Router(config-ethsat-prf)#information-rate 1 gbps
Router(config-ethsat-prf)#measurement combined
Router(config-ethsat-prf)#root
Router(config)#interface TenGigE0/0/0/12
Router(config-if)#ethernet service-activation-test
Router(config-if-ethsat)#permit all
Router(config-if-ethsat)#commit
```

Example of SAT results:

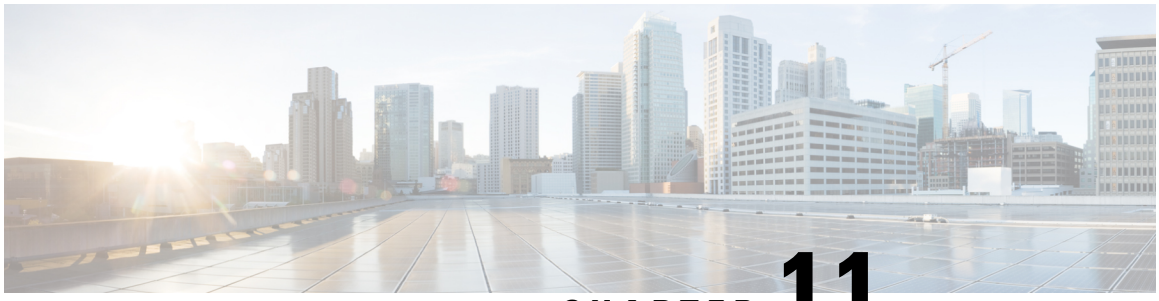
```
 Results:
    Step 1, Information Rate 1 Gbps
      CIR packets:
        Tx packets: 2929519174, bytes: 1499913817088
        Rx packets: 20696794, bytes: 10596758528
        FL: 2908822380, FLR: 99%
        FD: Min 5.232us, Mean 18.642us, Max 63.032us
        IFDV: Not supported
        Out of order packets: 0 (0%)
        Error packets: 0 (0%)

      EIR packets:
        Tx packets: 0, bytes: 0
        Rx packets: 0, bytes: 0
        FL: 0, FLR: 0%
        FD: Min 0.000us, Mean 0.000us, Max 0.000us
        IFDV: Min 0.000us, Mean 0.000us, Max 0.000us
        Out of order packets: 0 (0%)
        Error packets: 0 (0%)
```

Step 2 Use the **show running-configuration** command for the running configuration

```
Router#show running-config
Wed Feb 14 14:37:59.418 UTC
!
ethernet service-activation-test
 profile p1
  duration 10 minutes
  information-rate 1 gbps
  measurement combined
 !
!
interface TenGigE0/0/0/12
 ethernet service-activation-test
  permit all
 !
```

Step 3 The **show ethernet service-activation-test** command shows frame loss and frame delay are measured on every frame.

```
Router#show ethernet service-activation-test in-progress
Tue Dec 14 08:18:22.981 PST
Interface TenGigE0/0/0/12
  Service activation tests permitted
  Test in progress, 10 minute(s) remaining:
    Duration 10 minute(s)
    Information rate 1 gbps
    Color-blind
    External, Two-way, Destination Source 2001:DB8:0:ABCD::1
    Packet size 1024, Pattern hex 0x00
    Packet format: SAT MEF-48
    Delay and loss measured on every frame
    CoS not set
```



CHAPTER 11

Configuration and File System Management

This module describes methods for configuration management and file transfer enhancements.

- Secure file transfer from the Router, on page 145
- Auto-Save Configuration, on page 147
- Auto-Save and Copy Router Configuration Using Public Key Authentication, on page 148
- Increasing Commit Limit, on page 149

Secure file transfer from the Router

Table 11: Feature History Table

Feature Name	Release Information	Feature Description
Secure file transfer from the Router	Release 7.9.1	Your routers are now enabled to transfer files securely to an archive server. It's made possible because the copy command now supports SFTP (Secure File Transfer Protocol) and SCP (Secure Copy Protocol using the underlying SSH protocol implementation. Secure transfer of files from the router maintains the integrity, confidentiality, and availability of network configurations. This feature modifies the **copy** command.

You can duplicate files or data in the router from one location to another using the **copy** command. This functionality helps to create a copy of a file, folder, or data set and place it in a specific destination. You can use the copy functionality to back up files, move data between directories, create duplicates of the files for editing or distribution without modifying the original content. It also allows you to retain the original data while making a duplicate that you can further manipulate independently.

Starting with Cisco IOS XR Release 7.9.1, we've enhanced the functionality of the copy command to support secure file transfer from the router. Secure file transfer protects data during transit using the SFTP (Secure

File Transfer Protocol) and SCP (Secure Copy Protocol) when sharing files within or across networks. The SFTP and SCP functionalities in the copy feature use the SSH protocol implementation in the router to secure transfer the files to a remote server.

You can use the following options in the **copy** command for secure file transfer:

- **sftp:** You can transfer the files to a remote location using the **SFTP** file transfer protocol. SFTP is a secure file transfer protocol for transferring large files.
- **scp:** You can transfer the files to a remote location using the **SCP** file transfer protocol. SCP is a secure copy protocol to transfer files between servers.

Prerequisites:

Enable the SSH Server in the router as follows:

```
Router# config
Router(config)# ssh server v2
Router(config)# ssh server vrf default
Router(config)# ssh server netconf vrf default
Router(config)# commit
```

Configuration Example for Secure File Transfer Protocol

You can copy the running configuration file from the router to a remote server using SFTP:

Configuration in the Router

```
Router# copy running-config sftp://root:testpassword@192.0.2.1//var/opt/run_conf_sftp.txt

Destination file name (control-c to cancel): [/var/opt/run_conf_sftp.txt]?

.
215 lines built in 1 second
[OK]Connecting to 192.0.2.1...22
Password:
sftp> put /tmp/tmpsymlink/nvgen-34606-_proc_34606_fd_75 /var/opt/run_conf_sftp.txt


/tmp/tmpsymlink/nvgen-34606-_proc_34606_fd_75

  Transferred 3271 Bytes
  3271 bytes copied in 0 sec (3271000)bytes/sec
sftp> exit
```

Verification in the SFTP Server

```
[root@sftp_server ~]# ls -ltr /var/opt/run_conf_sftp.txt
-rw-r--r-- 1 root root 3271 Mar 21 18:07 /var/opt/run_conf_sftp.txt
```

Configuration Example for Secure Copy Protocol

You can copy the running configuration file from the router to a remote server using SCP:

Configuration in the Router

```
Router# copy running-config scp://root:testpassword@192.0.4.2//var/opt/run_conf_scp.txt

Destination file name (control-c to cancel): [/var/opt/run_conf_scp.txt]?

.
215 lines built in 1 second
```

```
[OK]Connecting to 192.0.4.2...22
Password:

  Transferred 3271 Bytes
  3271 bytes copied in 0 sec (0)bytes/sec
```

Verification in the SCP Server

```
[root@scp_server ~]# ls -ltr /var/opt/run_conf_scp.txt
-rw-r--r-- 1 root root 3271 Mar 21 18:07 /var/opt/run_conf_scp.txt
```

Auto-Save Configuration

You can configure the router to automatically take the backup of the running configuration by using **configuration commit auto-save** command. This auto-save feature saves the configuration to the specified location on the router after every **commit** is made. These auto-save files are stored in the form of Linux files.

Configure Auto-Save

Use the **configuration commit auto-save** command to auto save the configuration.

```
Router#configure
Router(config)#configuration commit auto-save
Router(config-cfg-autosave)#commit
```

You can also configure options such as **password**, **timestamp**, **maximum**, and **wait-time** with the **configuration commit auto-save** command. The location to save the file-name must be specified in <protocol>://<user>@<host>:<port>/<url-path>/<file-name> format.

When filename is accessed through VRF, you can specify filename in **filename** <protocol>://<user>@<host>:<port>;<vrf name>/<url-path>/<file-name> format.

When you are using public key authentication, you don't need to mention **password**.

```
Router(config-cfg-autosave)#configuration commit auto-save filename
sftp://user1@server1://test-folder/test_123
Router(config-cfg-autosave)#password clear encryption-default cisco
Router(config-cfg-autosave)#timestamp
Router(config-cfg-autosave)#maximum 10
Router(config-cfg-autosave)#wait-time days 0 hours 0 minutes 0 seconds 5
Router(config-cfg-autosave)#commit
```

Running Configuration

```
Router#show running-config configuration commit auto-save
configuration commit auto-save
 filename sftp://user1@server1://test-folder/test_123
 password encrypted encryption-default <password for above user>
 timestamp
 maximum 10
 wait-time days 0 hours 0 minutes 0 seconds 5
!
```

Auto-Save and Copy Router Configuration Using Public Key Authentication

Table 12: Feature History Table

Feature Name	Release Information	Feature Description
Auto-Save and Copy Router Configuration Using Public Key Authentication	Release 7.10.1	You can now experience passwordless authentication while automatically saving running configurations and securely copying them on the router. The feature uses public key-based authentication, a secure logging method using a secure shell (SSH), which provides increased data security. This feature offers automatic authentication and single sign-on benefits, which also aids in a secure automation process. This feature modifies **configuration commit auto-save** and **copy** command to support password-less authentication.

From Cisco IOS XR Software Release 7.10.1, you don't need to remember and enter the **password** as you can use public key-based authentication while doing the following:

- Automatically saving your running configuration
- Copying the configuration from a source (such as a network server) to a destination (such as a flash disk)

Password is automatically verified when you have enabled SSH connection using public key-based authentication. Using public key-based authentication avoids several problems such as password disclosure and password leakage.

Public key is mathematically related to private key. The private key is secret, whereas the public key is available on the servers. You can copy the public key to the SSH server from the SSH client. Then, when you try to secure the running configuration, the SSH server tries to authenticate by generating a challenge using the public key. Only the private key can answer this challenge. As the keys are related, log-in is successful.

Prerequisites for Auto-Save and Copy Router Configuration Using Public Key Authentication

Ensure you have enabled public key-based authentication of SSH clients, using the following steps:

- Generate RSA key pair on the router configured as the SSH client. Use the **cyrpto key generate authentication-ssh rsa** command to generate the RSA key pair.
- Use the **show crypto key mypubkey authentication-ssh rsa** command to view the details of the RSA key. The key value starts with *ssh-rsa* in this output.

- Copy the RSA public key from the SSH client to the SSH server.

For more detailed information on how to enable SSH connection using public-key based authentication, see *Public Key Based Authentication of SSH Clients* in System Security Configuration Guide for Cisco NCS 5500 Series Routers.

Increasing Commit Limit

The Cisco IOS XR Routers use a two-stage configuration model. The first stage is target configuration, where you build the configurations using the necessary commands in the command line interface. The second stage is the commit, where the configuration made in the target stage is added to the router configuration using the **commit** command. After each commit, the router generates a file for the newly configured changes and adds it to its running configuration, making it an integral part of the running configuration.

Note This target configuration doesn’t impact the router's running configuration.

The Cisco IOS XR routers perform rebase and ASCII backup operations to maintain the real time configuration in the backup copy. The rebase and ASCII backup operations block you from committing configurations to the router.

In rebase, the router automatically saves your changes to the backup binary configuration file after 20 commits, or 2 MB of configuration data. The router blocks the commit while saving the configuration to the backup file. The router takes a few seconds to complete the rebase operation, during which, if you terminate the CLI session, the router loses the target configurations in the blocked commit.

In ASCII backup, the router automatically saves a copy of its running configuration in the ASCII format. This backup process takes place if there has been a commit to the router configuration and when the ASCII backup timer completes a 55-minute window after the previous backup event. However, if there was no commit when the ASCII backup timer completes 55 minutes, the counter is reset without any backup. During the ASCII backup, the router blocks the configuration commits.

Starting with , we have made the following enhancements:

- You can use the **cfs check** command to increase the rebase limits in the router from 20 to 40 commits and the configuration data from 2 MB to 4 MB. When configuring the router, you can check the current commit count and configuration data size using the **show cfgmgr commitdb** command. If the commit count is 20 or higher, or the configuration data size is 2 MB or above, the router initiates a rebase within 10 seconds. By using the **cfs check** command to increase the commit count to 40 and the configuration data to 4 MB, you can commit without delay.
- You can use the **clear configuration ascii inconsistency** command to perform an ASCII backup and reset the ASCII backup timer to zero. Once the backup is complete, the router will automatically initiate the next periodic ASCII backup operation only after 55 minutes from the time the **clear configuration ascii inconsistency** command is executed.

Guidelines and Restrictions for Increasing the Commit Limit

- The **cfs check** command increases the rebase limits only for one instance. After executing the **cfs check** command, the router will perform a rebase operation after 40 commits or when the configuration data

reaches 4 MB. Once the router performs a rebase operation, the limits will reset to the default values of 20 commits and 2 MB configuration data. To enable 40 commits and 4 MB configuration data, you must perform the **cfs check** command again.

- After executing the **cfs check** command, if a router switches over to standby RP, the rebase limits are retained as 40 commits and configuration data of 4 MB. However, if the router reloads, the rebase limits are reset to 20 commits and 2 MB of configuration data. For example, after executing the **cfs check** command, if the router switches over to standby RP after 30 commits, it will still have ten more commits before a rebase. However, if the router reloads, the rebase limits are reset to default 20 commits and 2 MB of configuration data.
- The **clear configuration ascii inconsistency** command initiates an ASCII backup and resets the ASCII backup timer count to zero. Following this, the router will automatically initiate the next periodic ASCII backup operation only after 55 minutes from the time **clear configuration ascii inconsistency** command is executed. For example, if you execute a commit operation after executing a **clear configuration ascii inconsistency** command, the router will perform an ASCII backup operation 55 minutes after the**clear configuration ascii inconsistency** command was executed, and merge the new commit into ASCII backup. Hence, before the next 55 minutes, you must execute the **clear configuration ascii inconsistency** command again to reset the ASCII backup timer to zero.
- When the router enters standby mode or reloads, the ASCII timer does not reset to zero, and the router performs an ASCII backup operation 55 minutes after the first commit operation before the standby mode or reload.
- Cisco does not recommend executing **clear configuration inconsistency** and **clear configuration ascii inconsistency** commands regularly after each commit, as it causes hard disk wear and tear. You should execute these commands only before a commit or sequence of commits that must be done within a specific timeframe and without being delayed by rebase and ASCII backup operations. As these commands perform disk input and output operations in the background, frequent execution of these commands causes frequent access to the hard disk, which increases the wear and tear on the hard disk.

Increasing the Rebase Limits

You can increase the rebase limits as follows:

1. Use the **cfs check** command to increase the commit count to 40 and the configuration data to 4 MB.

```
Router# cfs check
Creating any missing directories in Configuration File system...OK
Initializing Configuration Version Manager...OK
Syncing commit database with running configuration...OK
```

2. Verify if the **cfs check** command is executed using the **show configuration history** command.

```
Router# show configuration history last 5
Sno.  Event      Info                          Time Stamp
~~~~  ~~~~~      ~~~~                          ~~~~~~~~~~
1     cfs check  completed                     Wed Jan 10 11:42:21 2024
2     commit     id 1000000001                 Wed Jan 10 11:39:26 2024
3     startup    configuration applied         Wed Jan 10 11:39:02 2024
```

Perform ASCII Backup and Rest ASCII Backup Timer

You can perform ASCII backup and rest ASCII backup timer as follows:

1. Use the **clear configuration ascii inconsistency** command to perform ASCII backup at that instance and reset the ASCII backup timer count to zero.

```
Router# clear configuration ascii inconsistency
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! Warning: !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! It is recommended to run this command only when all nodes in router      !!!!
!!!! are in IOS-XR RUN state. To determine node state, run following command: !!!!
!!!! 'show platform'.                                                         !!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! Warning: !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Proceed with the command ?[confirm] y
 Ascii configuration backup is in progress...
Configuration ascii backup complete
```

2. Verify if the **clear configuration ascii inconsistency** command is executed using the **show configuration history** command.

```
Router# show configuration history last 5
Sno.  Event      Info                          Time Stam
~~~~  ~~~~~      ~~~~                          ~~~~~~~~~~
1     backup     Periodic ASCII backup         Wed Jan 10 11:48:20 2024
2     cfs check  completed                     Wed Jan 10 11:42:21 2024
3     commit     id 1000000001                 Wed Jan 10 11:39:26 2024
4     startup    configuration applied         Wed Jan 10 11:39:02 2024
```

Concurrent Configuration Rebase during Commit

Table 13: Feature History Table

Feature Name	Release Information	Feature Description
Concurrent Configuration Rebase during Commit	Release 24.3.1	Introduced in this release on: The router performs the commit and rebase operations simultaneously, ensuring that the commit operation remains unblocked during the rebase operation. This removes the need to use the **cfs check** command to increase the commit count and the commit file diff size.

Cisco IOS XR routers use a two-stage configuration model. In the first stage, configurations are built using necessary commands in the command line interface, and in the second stage, the configurations are committed to the router.

During rebase and ASCII backup operations, the router blocks configuration commits. However, the "Concurrent Configuration Rebase during Commit" feature allows the router to perform commit and rebase operations simultaneously, ensuring that the commit operation remains unblocked during the rebase operation.

The Cisco IOS XR routers perform rebase and ASCII backup operations to maintain the real time configuration in the backup copy.

Before Release 24.3.1,

- The rebase and ASCII backup operations block you from committing configurations to the router.

- You can increase the maximum number of commits and reset the ASCII backup timer to allow the router to configure complex topology changes without interruptions caused by the default blocking of commit changes during rebase or ASCII backup operations. For more information, see the section Increasing Commit Limit, on page 149.

From Release 24.3.1,

- The router performs the commit and rebase operations simultaneously, ensuring that the commit operation remains unblocked during the rebase operation. This removes the need to use the **cfs check** command to increase the commit count and the commit file diff size.
- However, the ASCII backup operations still block the commit operation. You can reset the ASCII backup timer using the **clear configuration ascii inconsistency** command. This allows the router to perform an ASCII backup after 55 minutes and perform commit operations without being blocked by ASCII backup operations. For more information on ASCII backup, see the section Increasing Commit Limit, on page 149.