



System Management Configuration Guide for Cisco NCS 560 Series Routers, IOS XR Release 7.4.x

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CHAPTER 1

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 1](#)
- [Flexible Configuration Restrictions, on page 1](#)
- [Configuring a Configuration Group, on page 3](#)
- [Verifying the Configuration of Configuration Groups, on page 5](#)
- [Regular Expressions in Configuration Groups, on page 6](#)

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:
<pre>RP/0/RP0/CPU0:router# configure</pre> Enters mode. |
| Step 2 | group <i>group-name</i>
Example:
<pre>RP/0/RP0/CPU0:router(config)# group g-interf</pre> Specifies a name for a configuration group and enters group configuration mode to define the group. The <i>group-name</i> 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 15](#). 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 TenGigE0/11/0/0. 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 <i>[group-name]</i> 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
	<pre>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</pre>	<p>applied to interface GigabitEthernet0/0/0/1, the configured MTU value is 2000 and not 1500. This happens if the command <code>mtu 2000</code> is configured directly on the interface. An actual configuration overrides a configuration group configuration if they are the same.</p>
Step 3	<p>show running-config inheritance</p> <p>Example:</p> <pre>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 ! . .</pre>	<p>Displays the inherited configuration wherever a configuration group has been applied.</p>
Step 4	<p>show running-config interface x/y/z inheritance detail</p> <p>Example:</p> <pre>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</pre>	<p>Displays the inherited configuration for a specific configuration command.</p>

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 OSPF 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 TenGigE0/11/0/0
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 TenGigE0/11/0/0`- 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 TenGigE0/11/0/0
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
  metric 10
!
```

```

interface TenGigE0/11/0/1
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
    metric 10
  !
!
interface TenGigE0/11/0/2
  lsp-interval 20
  hello-interval 40
  address-family ipv4 unicast
    metric 10
  !
!
interface TenGigE0/11/0/3
  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 TenGigE0/11/0/0
    apply-group g-isis-gige
  !
!
  interface TenGigE0/11/0/1
    apply-group g-isis-gige
  !
!
  interface TenGigE0/11/0/2
    apply-group g-isis-gige
  !
!
  interface TenGigE0/11/0/3
    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 TenGigE0/11/0/0
  !
  interface TenGigE0/11/0/1
  !
  interface TenGigE0/11/0/2
  !
  interface TenGigE0/11/0/3
  !

```

!

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 TenGigE0/11/0/0
 !
 interface TenGigE0/11/0/1
 !
 interface TenGigE0/11/0/2
 !
 interface TenGigE0/11/0/3
 !
!
```

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 0/11/0/0.1 inherits the 1514 MTU value. This is the output displayed from the **show running-config inheritance** command for the Ten Gigabit Ethernet interface:

```
interface TenGigE0/11/0/0.1 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
```

Changes to Configuration Group are Automatically Inherited: Example

```
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.



CHAPTER 2

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 19](#)
- [How to Configure Manageability, on page 19](#)
- [Configuration Examples for Manageability, on page 20](#)

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. <ul style="list-style-type: none"> 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 3

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 23](#)
- [Prerequisites for Implementing Object Tracking, on page 23](#)
- [Information about Object Tracking, on page 24](#)
- [How to Implement Object Tracking, on page 24](#)
- [Configuration Examples for Configuring Object Tracking, on page 33](#)
- [Additional References, on page 36](#)

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. <ul style="list-style-type: none"> • <i>track-name</i>—Specifies a name for the object to be tracked.
Step 3	type line-protocol state Example:	Creates a track based on the line protocol of an interface.

	Command or Action	Purpose
	RP/0/RP0/CPU0:router(config-track)# type line-protocol state	
Step 4	interface <i>type</i> <i>interface-path-id</i> 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. <ul style="list-style-type: none"> • <i>type</i>—Specifies the interface type. For more information, use the question mark (?) online help function. • <i>interface-path-id</i>—Identifies a physical interface or a virtual interface. <p>Note Use the show interfaces command to see a list of all possible interfaces currently configured on the router.</p> <p>Note The loopback and null interfaces are always in the up state and, therefore, cannot be tracked.</p>
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 <i>seconds</i> down <i>seconds</i> } 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: <ul style="list-style-type: none"> • end • commit Example: RP/0/RP0/CPU0:router(config-track)# end or RP/0/RP0/CPU0:router(config-track)# commit	Saves configuration changes. <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: <pre>Uncommitted changes found, commit them before exiting (yes/no/cancel)? [cancel]:</pre> <ul style="list-style-type: none"> • Entering yes saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering no exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

	Command or Action	Purpose
		<ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • <i>track-name</i>—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: <ul style="list-style-type: none"> • vrf vrf-table-name • route ipv4 IP-prefix/mask Example: RP/0/RP0/CPU0:router(config-track-route)# vrf vrf-table-4 OR	Configures the type of IP route to be tracked, which can consist of either of the following, depending on your router type: <ul style="list-style-type: none"> • <i>vrf-table-name</i>—A VRF table name. • <i>IP-prefix/mask</i>—An IP prefix consisting of the network and subnet mask (for example, 10.56.8.10/16).

	Command or Action	Purpose
	RP/0/RP0/CPU0:router(config-track-route)# route ipv4 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 <i>seconds</i> down <i>seconds</i> } 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: <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • <i>track-name</i>—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. <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> • <i>object-name</i>—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.
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.

	Command or Action	Purpose
Step 7	<p>Use one of the following commands:</p> <ul style="list-style-type: none"> • end • commit <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config-track)# end</pre> <p>or</p> <pre>RP/0/RP0/CPU0:router(config-track)# commit</pre>	<p>Saves configuration changes.</p> <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: <pre>Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:</pre> <ul style="list-style-type: none"> • 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	<p>configure</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router# configure</pre>	Enters mode.
Step 2	<p>track track-name</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)# track track1</pre>	<p>Enters track configuration mode.</p> <ul style="list-style-type: none"> • <i>track-name</i>—Specifies a name for the object to be tracked.

	Command or Action	Purpose
Step 3	type list threshold percentage Example: <pre>RP/0/RP0/CPU0:router(config-track)# type list threshold percentage</pre>	Configures a track of type threshold percentage list.
Step 4	object object-name Example: <pre>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</pre>	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: <pre>RP/0/RP0/CPU0:router(config-track-list-threshold)# threshold percentage up 50 down 33</pre>	<p>Configures the percentage of objects that need to be UP or DOWN for the list to be considered UP or Down respectively.</p> <p>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.</p>
Step 6	<p>Use one of the following commands:</p> <ul style="list-style-type: none"> • end • commit Example: <pre>RP/0/RP0/CPU0:router(config-track)# end</pre> <p>or</p> <pre>RP/0/RP0/CPU0:router(config-track)# commit</pre>	<p>Saves configuration changes.</p> <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: <pre>Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:</pre> <ul style="list-style-type: none"> • 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.

	Command or Action	Purpose
		<ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> <i>track-name</i>—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 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.
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).

	Command or Action	Purpose
Step 6	<p>Use one of the following commands:</p> <ul style="list-style-type: none"> • end • commit <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config-track)# end</pre> <p>or</p> <pre>RP/0/RP0/CPU0:router(config-track)# commit</pre>	<p>Saves configuration changes.</p> <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: <pre>Uncommitted changes found, commit them before exiting (yes/no/cancel)? [cancel]:</pre> <ul style="list-style-type: none"> • 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	<p>configure</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router# configure</pre>	Enters global configuration mode.
Step 2	<p>track track-name</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)# track t1</pre>	<p>Enters track configuration mode.</p> <p>Note Special characters are not allowed in a <i>track-name</i>.</p>

	Command or Action	Purpose
Step 3	type rtr <i>ipsla-no</i> 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 <i>ipsla-no</i> can range from 1 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: <ul style="list-style-type: none"> • 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 TenGigE0/11/0/3:

```
track IPSec1
  type line-protocol state
  interface TenGigE0/11/0/3
  !
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 TenGigE0/11/0/3 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	<i>Implementing IP Service Level Agreements on System Monitoring Configuration Guide for Cisco NCS 560 Series Routers</i>
IP SLA commands	<i>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</i>

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	<i>Security Architecture for the Internet Protocol</i>

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 4

Configuring Physical and Virtual Terminals

Line templates define standard attribute settings for incoming and outgoing transport over physical and virtual terminal lines (vty). 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 39](#)
- [Information About Implementing Physical and Virtual Terminals, on page 39](#)
- [How to Implement Physical and Virtual Terminals on Cisco IOS XR Software, on page 42](#)
- [Configuration Examples for Implementing Physical and Virtual Terminals, on page 46](#)

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. <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • end • commit Example: RP/0/RP0/CPU0:router(config-line)# end or RP/0/RP0/CPU0:router(config-line)# commit	Saves configuration changes. <ul style="list-style-type: none"> • When you issue the end command, the system prompts you to commit changes: Uncommitted changes found, commit them before exiting (yes/no/cancel)? [cancel]: <ul style="list-style-type: none"> • Entering yes saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode. • Entering no exits the configuration session and returns the router to EXEC mode without committing the configuration changes.

	Command or Action	Purpose
		<ul style="list-style-type: none"> • 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: RP/0/RP0/CPU0:router(config-line)# exit	Exits line template configuration mode and returns the router to global configuration mode.

	Command or Action	Purpose
Step 6	<p>vtty-pool {default <i>pool-name</i> eem} <i>first-vty</i> <i>last-vty</i> [line-template {default <i>template-name</i>}]</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)#vty-pool default 0 5 line-template default</pre> <p>or</p> <pre>RP/0/RP0/CPU0:router(config)#vty-pool pool1 5 50 line-template template1</pre> <p>or</p> <pre>RP/0/RP0/CPU0:router(config)#vty-pool eem 100 105 line-template template1</pre> <pre>RP/0/RP0/CPU0:router(config)#vty-pool default 0 5 line-template template1</pre>	<p>Creates or modifies vty pools.</p> <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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. <i>pool-name</i> —Creates a user-defined vty pool. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> 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 <i>template-name</i> —Configures the vty pool to reference a user-defined template.
Step 7	Use the commit or end command.	<p>commit —Saves the configuration changes and remains within the configuration session.</p> <p>end —Prompts user to take one of these actions:</p> <ul style="list-style-type: none"> Yes — Saves configuration changes and exits the configuration session.

	Command or Action	Purpose
		<ul style="list-style-type: none"> • 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 <i>node-id</i> console location <i>node-id</i> vty number] Example: RP/0/RP0/CPU0:router# show line	Displays the terminal parameters of terminal lines. <ul style="list-style-type: none"> • Specifying the show line aux location <i>node-id</i> EXEC command displays the terminal parameters of the auxiliary line. • Specifying the show line console location <i>node-id</i> EXEC command displays the terminal parameters of the console. <ul style="list-style-type: none"> • For the location <i>node-id</i> keyword and argument, enter the location of the Route Processor (RP) on which the respective auxiliary or console port resides. • The <i>node-id</i> argument is expressed in the format of <i>rack/slot/module</i>. • Specifying the show line vty number EXEC command displays the terminal parameters for the specified vty.
Step 2	(Optional) show terminal Example: RP/0/RP0/CPU0:router# show terminal	Displays the terminal attribute settings for the current terminal line.

	Command or Action	Purpose
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/RP0/CPU0
Tue Nov 24 03:10:24.656 UTC
Tty          Speed      Overruns      Acc I/O
*con0/RP0/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 5

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 49](#)
- [Restrictions for SNMP use on Cisco IOS XR Software, on page 49](#)
- [Information about Implementing SNMP, on page 50](#)
- [Session MIB support on subscriber sessions , on page 55](#)
- [How to Implement SNMP on Cisco IOS XR Software, on page 57](#)

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.

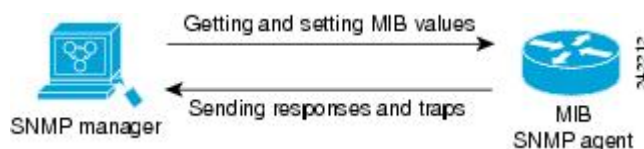
MIB

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 52](#) 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

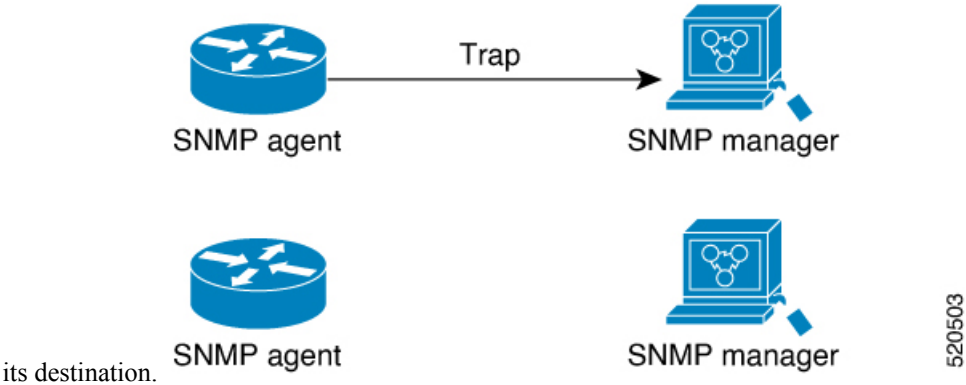
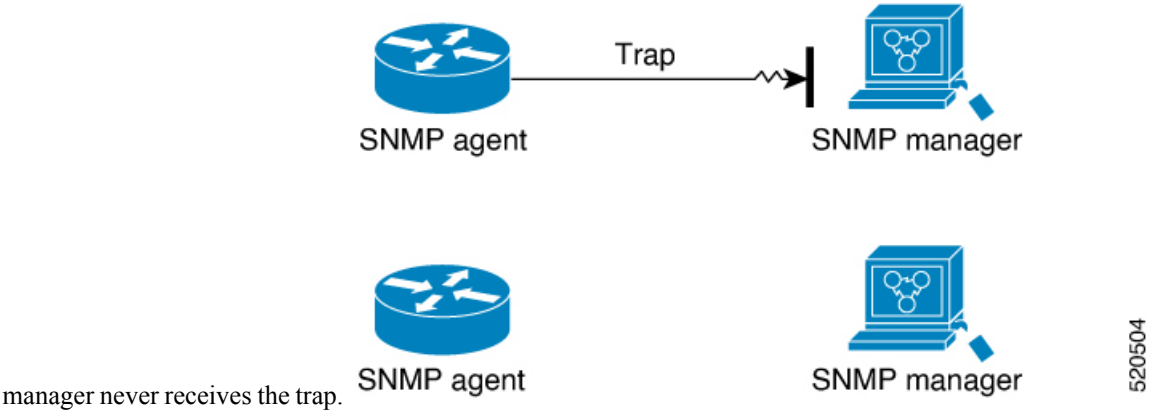


Figure 3: Trap Not Received by the SNMP Manager

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



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. .

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	(Optional) snmp-server vrf vrf-name Example: RP/0/RP0/CPU0:router(config)# snmp-server vrf vrfa	Configures VRF properties of SNMP.

	Command or Action	Purpose
Step 4	snmp-server view <i>view-name oid-tree</i> { included excluded } Example: RP/0/RP0/CPU0:router(config) # snmp-server view view_name 1.3.6.1.2.1.1.5 included	Creates or modifies a view record.
Step 5	snmp-server group <i>name</i> { v1 v2c v3 { auth noauth priv }} [read view] [write view] [notify view] [<i>access-list-name</i>] 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 6	snmp-server user <i>username groupname</i> { v1 v2c v3 [auth { md5 sha } { clear encrypted } <i>auth-password</i> [priv des56 { clear encrypted } <i>priv-password</i>]]} [<i>access-list-name</i>] Example: RP/0/RP0/CPU0:router(config) # snmp-server user noauthuser group_name v3	Configures a new user to an SNMP group.
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: <ul style="list-style-type: none"> • 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 8	(Optional) show snmp Example: RP/0/RP0/CPU0:router# show snmp	Displays information about the status of SNMP.

	Command or Action	Purpose
Step 9	(Optional) show snmp engineid Example: RP/0/RP0/CPU0:router# show snmp engineid	Displays information about the local SNMP engine.
Step 10	(Optional) show snmp group Example: RP/0/RP0/CPU0:router# show snmp group	Displays information about each SNMP group on the network.
Step 11	(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 12	(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_70](#) if you have already completed the steps documented under the [#unique_70](#) task.

Procedure

	Command or Action	Purpose
Step 1	configure Example: RP/0/RP0/CPU0:router# configure	Enters mode.
Step 2	snmp-server group <i>name</i> { v1 v2 v3 { auth noauth priv }} [read <i>view</i>] write <i>view</i>] [notify <i>view</i>] [<i>access-list-name</i>] 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 <i>username</i> <i>groupname</i> { v1 v2c v3 { auth md5 sha } { clear encrypted } <i>auth-password</i>] [priv des56 { clear <i>access-list-name</i>] 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 <i>address</i> [traps] [version { 1 2c 3 { auth priv }}] <i>community-string</i> [udp-port <i>port</i>] [<i>notification-type</i>] 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 [<i>notification-type</i>] 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. <ul style="list-style-type: none"> • If a trap is not specified with the <i>notification-type</i> 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: <ul style="list-style-type: none"> • 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 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** command 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 <i>system-contact-string</i> Example: <pre>RP/0/RP0/CPU0:router(config)# snmp-server contact Dial System Operator at beeper # 27345</pre>	Sets the system contact string.
Step 3	(Optional) snmp-server location <i>system-location</i> Example: <pre>RP/0/RP0/CPU0:router(config)# snmp-server location Building 3/Room 214</pre>	Sets the system location string.
Step 4	(Optional) snmp-server chassis-id <i>serial-number</i> Example: <pre>RP/0/RP0/CPU0:router(config)# snmp-server chassis-id 1234456</pre>	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: <ul style="list-style-type: none"> • 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 <i>byte-count</i> 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: <ul style="list-style-type: none"> • 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: RP/0/RP0/CPU0:router# configure	Enters mode.

	Command or Action	Purpose
Step 2	(Optional) snmp-server trap-source <i>type interface-path-id</i> Example: <pre>RP/0/RP0/CPU0:router(config)# snmp-server trap-source POS 0/0/1/0</pre>	Specifies a source interface for trap notifications.
Step 3	(Optional) snmp-server queue-length <i>length</i> Example: <pre>RP/0/RP0/CPU0:router(config)# snmp-server queue-length 20</pre>	Establishes the message queue length for each notification.
Step 4	(Optional) snmp-server trap-timeout <i>seconds</i> Example: <pre>RP/0/RP0/CPU0:router(config)# snmp-server trap-timeout 20</pre>	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: <ul style="list-style-type: none"> • 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:	Enters mode.

	Command or Action	Purpose
	RP/0/RP0/CPU0:router# configure	
Step 2	<p>Use one of the following commands:</p> <ul style="list-style-type: none"> • snmp-server ipv4 precedence <i>value</i> • snmp-server ipv4 dscp <i>value</i> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)# snmp-server dscp 24</pre>	Configures an IP precedence or IP DSCP value for SNMP traffic.
Step 3	Use the commit or end command.	<p>commit —Saves the configuration changes and remains within the configuration session.</p> <p>end —Prompts user to take one of these actions:</p> <ul style="list-style-type: none"> • 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: RP/0/RP0/CPU0:router(config)# snmp-server mibs eventmib packet-loss TenGigE0/0/0/0 falling 1 interval 5 rising 2	Generates SNMP EVENT-MIB traps for the interface when the packet loss exceeds the specified thresholds. Up to 100 interfaces can be monitored. 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.

	Command or Action	Purpose
		<p>interval <i>sampling-interval</i> —Specifies how often packet loss statistics are polled. This is a value between 5 and 1440 minutes, in multiples of 5.</p> <p>rising <i>upper-threshold</i> —Specifies the upper threshold. When packet loss between two intervals increases above this threshold, an SNMP mteTrigggeRising trap is generated. This trap is not generated until the packet loss drops below the lower threshold and then rises above the upper threshold.</p>

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	<p>(Optional) snmp-server mibs cbqosmib persist</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)# snmp-server mibs cbqosmib persist</pre>	Enables persistent storage of the CISCO-CLASS-BASED-QOS-MIB data.
Step 2	<p>snmp-server ifindex persist</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)# snmp-server ifindex persist</pre>	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 <i>subset-number</i> regular-expression <i>expression</i> 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 <i>subset-number</i> 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 <i>expression</i> argument must be entered surrounded by double quotes. Refer to the <i>Understanding Regular Expressions, Special Characters, and Patterns</i> 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.
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: <ul style="list-style-type: none"> • Yes — Saves configuration changes and exits the configuration session. • No —Exits the configuration session without committing the configuration changes.

	Command or Action	Purpose
		<ul style="list-style-type: none"> • Cancel —Remains in the configuration mode, without committing the configuration changes.
Step 5	(Optional) show snmp interface notification subset <i>subset-number</i> Example: <pre>RP/0/RP0/CPU0:router# show snmp interface notification subset 10</pre>	Displays the linkUp and linkDown notification status for all interfaces identified by the subset priority.
Step 6	(Optional) show snmp interface notification regular-expression <i>expression</i> Example: <pre>RP/0/RP0/CPU0:router# show snmp interface notification regular-expression "^Gig[a-zA-Z]+[0-9/]+\."</pre>	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: <pre>RP/0/RP0/CPU0:router# show snmp interface notification tengige 0/11/0/0.10</pre>	Displays the linkUp and linkDown notification status for the specified interface.



CHAPTER 6

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 75](#)
- [Information About Periodic MIB Data Collection and Transfer, on page 75](#)
- [How to Configure Periodic MIB Data Collection and Transfer, on page 77](#)
- [Periodic MIB Data Collection and Transfer: Example, on page 83](#)

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 <i>list-name</i> 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 <i>object-name</i>} 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: <ul style="list-style-type: none"> • Yes — Saves configuration changes and exits the configuration session.

	Command or Action	Purpose
		<ul style="list-style-type: none"> • 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 <i>schema-name</i> 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 <i>list-name</i> 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: <ul style="list-style-type: none"> • instance exact {interface <i>interface-id</i> [sub-if] oid <i>oid</i>} • instance wild {interface <i>interface-id</i> [sub-if] oid <i>oid</i>} • instance range start <i>oid</i> end <i>oid</i> 	Specifies the instance information for objects in this schema: <ul style="list-style-type: none"> • The instance exact command indicates that the specified instance, when appended to the object list, represents the complete OID.

	Command or Action	Purpose
	<ul style="list-style-type: none"> • instance repetition oid max repeat-number <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config-bulk-sc)# instance wild oid 1</pre> <p>or</p> <pre>RP/0/RP0/CPU0:router(config-bulk-sc)# instance exact interface TenGigE 0/1.25</pre> <p>or</p> <pre>RP/0/RP0/CPU0:router(config-bulk-sc)# instance range start 1 end 2</pre> <p>or</p> <pre>RP/0/RP0/CPU0:router(config-bulk-sc)# instance repetition 1 max 4</pre>	<ul style="list-style-type: none"> • 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. <p>Note Only one instance command can be configured per schema. If multiple instance commands are executed, the earlier ones are overwritten by new commands.</p>
Step 5	<p>poll-interval minutes</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config-bulk-sc)# poll-interval 10</pre>	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.	<p>commit —Saves the configuration changes and remains within the configuration session.</p> <p>end —Prompts user to take one of these actions:</p> <ul style="list-style-type: none"> • 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 <i>transfer-id</i> Example: RP/0/RP0/CPU0:router(config)# snmp-server mib bulkstat transfer bulkstat1	Identifies the transfer configuration with a name (<i>transfer-id</i> argument) and enters bulk statistics transfer configuration mode.
Step 3	buffer-size <i>bytes</i> 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 <i>schema-name</i> Example: RP/0/RP0/CPU0:router(config-bulk-tr)# schema TenGigE 0_11_0_0 RP/0/RP0/CPU0:router(config-bulk-tr)# schema TenGigE/0-CAR RP/0/RP0/CPU0:router(config-bulk-tr)#	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
	<code>schema TenGigE 0_10_0_1</code>	
Step 6	transfer-interval <i>minutes</i> Example: <code>RP/0/RP0/CPU0:router(config-bulk-tr)# transfer-interval 20</code>	(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 <i>primary url</i> Example: <code>RP/0/RP0/CPU0:router(config-bulk-tr)# url primary ftp://user:password@host/folder/bulkstat1</code>	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 <i>secondary url</i> Example: <code>RP/0/RP0/CPU0:router(config-bulk-tr)# url secondary tftp://10.1.0.1/tftpboot/user/bulkstat1</code>	(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 <i>number</i> Example: <code>RP/0/RP0/CPU0:router(config-bulk-tr)# retry 1</code>	<p>(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.</p> <p>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.</p> <p>If all retries fail, the next normal transfer occurs after the configured transfer-interval time.</p>
Step 10	retain <i>minutes</i> Example: <code>RP/0/RP0/CPU0:router(config-bulk-tr)# retain 60</code>	(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
		<p>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.</p>
Step 11	<p>enable</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config-bulk-tr)# enable</pre>	<p>Begins the bulk statistics data collection and transfer process for this configuration.</p> <ul style="list-style-type: none"> 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	<p>commit <i>minutes</i></p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config-bulk-tr)# retain 60</pre>	<p>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.</p> <p>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.</p>

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/dumppdcm
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 7

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 85](#)
- [Information About Implementing CDP, on page 85](#)
- [How to Implement CDP on Cisco IOS XR Software, on page 87](#)
- [Configuration Examples for Implementing CDP, on page 90](#)

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 <i>type interface-path-id</i> Example: RP/0/RP0/CPU0:router(config)# int TenGigE 0/11/0/0	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: <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> 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. <ul style="list-style-type: none"> By default, when CDP is enabled, the receiving networking device holds a CDP packet for 180 seconds before discarding it. <p>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.</p> <ul style="list-style-type: none"> In this example, the value of hold-time for the <i>seconds</i> argument is set to 30.
Step 4	cdp timer seconds Example: RP/0/RP0/CPU0:router(config)# cdp timer 20	Specifies the frequency at which CDP update packets are sent. <ul style="list-style-type: none"> By default, when CDP is enabled, CDP update packets are sent at a frequency of once every 60 seconds.

	Command or Action	Purpose
		<p>Note A lower timer setting causes CDP updates to be sent more frequently.</p> <ul style="list-style-type: none"> • In this example, CDP update packets are configured to be sent at a frequency of once every 20 seconds.
Step 5	<p>Use the commit or end command.</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router(config)# commit OR RP/0/RP0/CPU0:router(config)# end</pre>	<p>commit —Saves the configuration changes and remains within the configuration session.</p> <p>end —Prompts user to take one of these actions:</p> <ul style="list-style-type: none"> • 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	<p>(Optional) show cdp</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router# show cdp</pre>	<p>Displays global CDP information.</p> <p>The output displays the CDP version running on the router, the hold time setting, and the timer setting.</p>

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	<p>show cdp entry [* <i>entry-name</i>] [protocol version]</p> <p>Example:</p> <pre>RP/0/RP0/CPU0:router# show cdp entry *</pre>	Displays information about a specific neighboring device or all neighboring devices discovered using CDP.

	Command or Action	Purpose
Step 2	show cdp interface [<i>type interface-path-id</i> 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 [<i>type interface-path-id</i> 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 0/11/0/0:

```
cdp
interface 0/11/0/0
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 8

What is Smart Licensing?

Smart Licensing is a cloud-based, flexible software licensing model that enables you to activate and manage Cisco software licenses across their organization. Smart Licensing solution allows you to easily track the status of your license and software usage trends. Cisco Smart Licensing establishes a pool of licenses or entitlements that can be used across the entire organization in a flexible and automated manner. Smart Licensing helps simplify four core functions:

- **Purchase**—Creates a Smart Account (and optionally, your Virtual Account). Licenses are added to your Smart Account and are immediately available for use.
 - **Install**—Register your product with your Smart Account using an account-based Registration Token. Thereafter, the entire process is automatic. Product Activation Keys (PAKs) and license files are no longer needed.
 - **Management**—Make changes to license consumption by updating your configuration; any license change is automatically reflected in your Smart Account. You can share licenses in your Virtual Account through the license pooling option. License pools (logical grouping of licenses) can reflect your organization structure. Smart Licensing solution also offers Cisco Smart Software Manager, a centralized portal that enables you to manage all your Cisco software licenses from one centralized website.
 - **Visibility and Asset Management**—Cisco Smart Software Manager (CSSM) portal offers an integrated view of the licenses you own and have deployed. You can use this data to make better purchase decisions, based on your consumption.
-
- [What is Flexible Consumption Model?, on page 94](#)
 - [Software Innovation Access, on page 96](#)
 - [How Does Smart Licensing Work?, on page 99](#)
 - [What is Cisco Smart Software Manager?, on page 101](#)
 - [YANG Data Models for Smart Licensing, on page 103](#)
 - [Configuring Smart Licensing, on page 104](#)
 - [Registering and Activating Your Router, on page 110](#)
 - [Verifying the Smart Licensing Configuration , on page 116](#)

What is Flexible Consumption Model?

Table 5: Feature History Table

Feature Name	Release Information	Feature Description
Support for Flexible Consumption Model on <ul style="list-style-type: none"> • N560-IMA8Q • N560-IMA2C-DD • A900-IMA8Z 	Release 7.4.1	Support for Flexible Consumption Model (FCM) is now extended to the following interface modules supported on the Cisco routers: <ul style="list-style-type: none"> • N560-IMA8Q • N560-IMA2C-DD • A900-IMA8Z
Essential and Advantage smart licenses in a combined entitlement	Release 7.4.1	<p>With this release, the Advanced licenses are now referred to as the Advantage licenses, without essential entitlement.</p> <p>Also, a new license model – Advantage with Essentials, has been introduced that contains both Essential and Advantage licenses as a combined entitlement in a single PID. This simplifies the license procurement and management effort by eliminating the need to procure separate PIDs for Essential and Advantage licenses.</p>

The Flexible Consumption Model (FCM) provides the capability and flexibility to purchase software capacity as needed. FCM delivers the following:

- Pay-as-you-grow—Enables you to lower initial costs and add more capacity over time.
- Simplify operations—FCM delivers the carrier-class IOS-XR software feature set with two software suites, Essentials and Advantage, that simplifies license management.
- Utilize capital efficiently—License pooling enables an efficient way to share licenses across the network.



Note FCM is enabled by default for Cisco IOS XR Release 7.1.2 and later.

The types of licenses in this model are:

- Essential Licenses are the base licenses that are required by every active port for its operation. An example of Essential License is ESS-AC-10G-RTU-1.

- Advantage (earlier known as Advanced licenses) without essential licenses, are the licenses that are required on top of Essential Licenses for ports that use advanced features like L3VPN. An example of an advantage license is ADV-AC-100G-RTU-1.
- Advantage with Essential combination licenses are the licenses that are packaged together as a combined entitlement. Example of an advantage license with essentials is ADN-AC-100G-RTU-1.
- Tracking licenses, for example .

To enable Flexible Consumption model licensing on routers running Cisco IOS XR Releases 7.1.1 and earlier:

```
Router(config)# license smart flexible-consumption enable
Router(config)# commit
```

To verify the Flexible Consumption Model configuration:

```
Device# show running-config license smart flexible-consumption enable
```

The following table provides information about FCM licenses for Cisco NCS 560 routers:

Table 6: Flexible Consumption Licensing Model Usage Pattern

Flexible Consumption Model Licenses	Consumption Pattern
Essential Licenses: <ul style="list-style-type: none"> • ESS-AC-100G-RTU-1 Advantage Licenses: <ul style="list-style-type: none"> • ADV-AC-100G-RTU-1 	If the router has a modular chassis, the license consumption checks are performed on the chassis.
Hardware Tracking Licenses that support the chassis: <ul style="list-style-type: none"> • N560-4-SYS-TRK • N560-4-SYS-E-TRK • N560-4-SYS-CC-TRK • N560-4-SYSE-CC-TRK 	Licensing consumption is checked on every chassis.
Hardware Tracking Licenses that support components in the chassis. <ul style="list-style-type: none"> • N560-IMA2C-TRK • A900-IMA8Z-TRK • A900-IMA8CS1ZM-TRK 	Licensing consumption is checked on every chassis. For example, the N560-IMA2C-TRK license is tracked on the chassis that has this line card.

Table 7: Advantage with Essential Licenses

License Product ID	License Entitlement	License Description
ADN-AC-100G-RTU-1	1 ESS RTU Tag + 1 ADV RTU Tag	Access Advantage with Essentials SW RTU v1.0 100G

License Product ID	License Entitlement	License Description
ESS-ADN-AC-100G-RT	1 ADV RTU Tag	Access Essentials to Advantage Upgrade RTU per 100G
ESS-ADN-AC100G-SST	1 ADV SIA 3 Tag	Access Essentials to Advantage Upgrade SIA 100G 1-35 month term
ESS-ADN-AC100G-S3	1 ADV SIA 3 Tag	Access Essentials to Advantage Upgrade SIA 100G 3-5 yrs
ESS-ADN-AC100G-S5	1 ADV SIA 3 Tag	Access Essentials to Advantage Upgrade SIA 100G 5-10 yrs
ADN-AC-100G-SIA-3	1 ESS SIA 3 Tag + 1 ADV SIA 3 Tag	Access Advantage with Essentials SIA 100G 3-5 year term
ADN-AC-100G-SIA-5	1 ESS SIA 3 Tag + 1 ADV SIA 3 Tag	Access Advantage with Essentials SIA 100G 5-10 year term
ADN-AC-100G-SIA-ST	1 ESS SIA 3 Tag + 1 ADV SIA 3 Tag	Access Advantage with Essentials SIA 100G 1-35 month term

Software Innovation Access

Table 8: Feature History Table

	Release Information	Feature Description
Software Innovation Access (SIA) Entitlement	Release 7.3.1	SIA license grants you access to the latest software upgrades which contain new features, bug fixes, and security enhancements for devices on your network. Also, it enables the consumption of Advantage and Essential Right-to-Use (RTU) licenses on your device, and allows portability of these RTU licenses from one device to another.

Overview

Software Innovation Access (SIA) subscription, a type of FCM licensing, provides access to the latest software upgrades and features for your network. SIA licenses enable the consumption of Right-to-Use (RTU) licenses for your devices to access software innovation and avail support for your devices throughout the term of subscription.

The benefits of SIA subscription are:

- **Access to software innovation:** SIA subscription provides access to continuous software upgrades which contain latest features, security enhancements, and bug fixes for all your devices at a network level.
- **Pooling of licenses:** SIA subscription enables Right-to-Use (RTU) licenses to be shared across your FCM network from a common license pool through the virtual account.
- **Protects your investment:** SIA subscription enables the portability of perpetual RTU licenses purchased for your current device to a next-generation router when you expand or upgrade your network.

The initial term of a SIA subscription is for a term of three years. You can renew the subscription by contacting your Cisco account representative. An equal number of SIA licenses and corresponding RTU licenses are required to enjoy the benefits, and ensure that your network is in compliance. There are two types of SIA licenses available:

- : To utilize Advantage RTU licenses, you need Advantage SIA licenses.
- : Essential SIA licenses are required to utilise Essential RTU on your device.

If your device is in a state of SIA Out-of-Compliance (OOC) the benefits cease.

SIA Out-of-compliance (OOC) state

When your device is in a SIA Out-of-compliance state, support for major software version upgrades in your network devices are restricted. However, you can continue to perform minor updates, SMU installations, and RPM installations, and continue to utilize the RTU licenses without support for porting.

A device can get into a SIA Out-of-compliance (OOC) state in the following instances:

- The SIA License *EVAL* period of 90 days has expired.
- The number of SIA licenses consumed has exceeded the number of SIA licenses purchased. This can also occur when the RTU licenses consumed is higher than the number of SIA licenses purchased.
- The term of the SIA license has expired and you haven't renewed the subscription.
- The license authorization status is:
 - Not Authorized: The license authorization code installed doesn't contain sufficient counts for the request. This can occur when you attempt to use more licenses than the licenses available in your Virtual Account.
 - Authorization expired: The device hasn't been able to connect to CSSM for an extended period, due to which the authorization status couldn't be verified.



Note The CSSM smart license hierarchy applies to the Right-to-Use (RTU) license only. Therefore, if there is an insufficient RTU 100G license, CSSM can convert the RTU 400G license into four RTU 100G licenses. This is not applicable for SIA license.

In order to bring your device to In-Compliance state, perform one of the following steps:

- Register your device with CSSM if the SIA license *EVAL* period has expired.
- If the SIA license has expired or the number of SIA licenses consumed is more than the number of SIA licenses purchased, contact your Cisco Account Representative to purchase or renew the required licenses.

- If the authorization code has insufficient counts for the request, generate the code with sufficient counts.
- If the authorization has expired, connect the device with CSSM.

When the device enters an OOC state, a grace period of 90 days (cumulative of all the previous occurrences) begins. During this period, SIA license benefits can still be availed. The system attempts to renew the authorization period by connecting with the CSSM during the grace period, or even after the grace period has expired. If an attempt isn't successful, it remains in an OOC state. If the attempt is successful, a new authorization period begins and the device is In-Compliance.

Verification

To verify the device compliance status, use the **show license platform summary** command:

Examples

Status: In-Compliance

```
Router# show license platform summary
Mon Jan 25 20:52:35.954 UTC
Collection: LAST: Mon Jan 25 2021 21:30:42 UTC
           NEXT: Mon Jan 25 2021 21:31:42 UTC
Reporting:  LAST: Mon Jan 25 2021 21:30:42 UTC
           NEXT: Mon Jan 25 2021 21:31:42 UTC
SIA Status: In Compliance
```

Feature/Area	Entitlement	Count	
		Last	Next
FCM	Total A900-IMA8CS1Z-M LCs in the system	1	0
FCM	Total A900-IMA8Z LCs in the system	2	0
FCM	NCS560-4 Base Hardware Tracking PID	1	0

Status: Out-of-Compliance (Grace Period Remaining)

```
Router# show license platform summary
Mon Jan 25 20:52:35.954 UTC
Collection: LAST: Mon Jan 25 2021 20:51:51 UTC
           NEXT: Mon Jan 25 2021 20:52:51 UTC
Reporting:  LAST: Mon Jan 25 2021 20:51:51 UTC
           NEXT: Mon Jan 25 2021 20:52:51 UTC
*****IMPORTANT*****
SIA Status: Out of Compliance(Remaining Grace Period: 90 days, 0 hours)
           SIA license(s) status is Not Authorized.
           SW Upgrade will still be allowed as SIA Grace Period is remaining
*****
```

Feature/Area	Entitlement	Count	
		Last	Next
FCM	Total A900-IMA8CS1Z-M LCs in the system	1	0
FCM	Total A900-IMA8Z LCs in the system	2	0

Status: Out-of-Compliance (Grace Period expired and upgrades are blocked)

```
Router# show license platform summary
Mon Jan 25 20:52:35.954 UTC
Collection: LAST: Mon Jan 25 2021 21:51:51 UTC
           NEXT: Mon Jan 25 2021 21:52:51 UTC
Reporting:  LAST: Mon Jan 25 2021 21:51:51 UTC
           NEXT: Mon Jan 25 2021 21:52:51 UTC
*****IMPORTANT*****
SIA Status: Out of Compliance(Grace Period Expired)
```

```

SW Upgrades are blocked as SIA license(s) are in "Not Authorized" state
*****

```

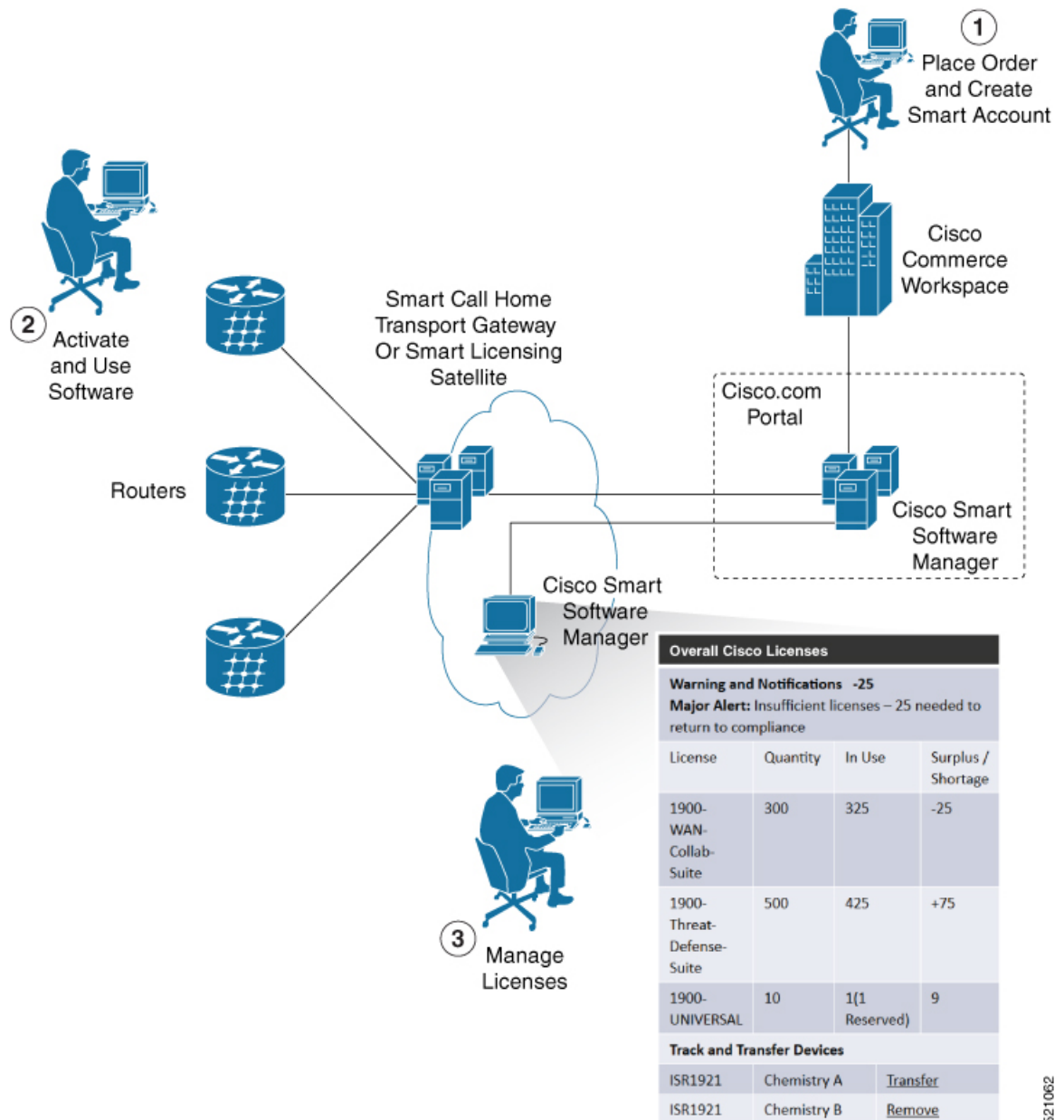
Feature/Area	Entitlement	Count Last Next
FCM	Total A900-IMA8CS1Z-M LCs in the system	1 0
FCM	Total A900-IMA8Z LCs in the system	2 0

How Does Smart Licensing Work?

Table 9: Feature History Table

Feature Name	Release Information	Feature Description
Smart Transport Support	Release 7.4.1	<p>You can now use Smart transport to communicate with CSSM. Smart transport is a transport method where a Smart Licensing (JSON) message is contained within an HTTPs message, and exchanged between a product instance and CSSM, to communicate. The following Smart transport configuration options are available:</p> <ul style="list-style-type: none"> • Smart transport: In this method, a product instance uses a specific Smart transport licensing server URL. This must be configured exactly as shown in the workflow section. • Smart transport through an HTTPs proxy: In this method, a product instance uses a proxy server to communicate with the licensing server, and eventually, CSSM.

Figure 4: Smart Licensing - Workflow



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1. Place Order and Create Smart Account—You must have a Smart Account to set up Smart Licensing.
 - a. Go to <https://software.cisco.com/>.
 - b. Under the **Administration** section, click **Get a Smart Account or Request Access to an Existing Smart Account**.
 - c. Verify or enter your Cisco.com profile details to complete creating a Smart Account.
2. Activate and Use Software—Register your product. For more information, see the *Registering your Router* section. You can use either of the following options to communicate with the CSSM:

- Smart Transport—The Smart Transport method is a transport method where a Smart Licensing (JSON) message is contained within a HTTPs message, and exchanged between a product instance and CSSM to communicate. The following Smart transport configuration options are available.
 - Smart Transport: In this method, a product instance uses a specific Smart transport licensing server URL. This must be configured exactly as shown in the workflow section.
 - Smart transport through an HTTPs proxy: In this method, a product instance uses a proxy server to communicate with the licensing server, and eventually, CSSM.
 - Smart Call Home—The Smart Call Home feature is automatically configured. Smart Call Home is used by Smart Licensing as a medium for communication with the CSSM. You can use this feature to page a network support engineer, email a Network Operations Center, or use Cisco Smart Call Home services to generate a case with the Technical Assistance Center. The Call Home feature can deliver alert messages containing information about diagnostics and environmental faults and events. For more information on Smart Call Home feature, see the [Smart Call Home Deployment Guide](#).
 - Smart Licensing CSSM On-Prem—The Smart licensing on-premise option provides an on-premises collector that can be used to consolidate and manage Smart license usage, as well as facilitate communications back to the CSSM at Cisco.com.
3. Manage Licenses—You can manage and view reports about your overall license usage in the Smart Software Manager portal.

What is Cisco Smart Software Manager?

Cisco Smart Software Manager enables you to manage all of your Cisco Smart software licenses from one centralized website. With Cisco Smart Software Manager, you organize and view your licenses in groups called virtual accounts (collections of licenses and product instances). The Cisco Smart Software Manager allows you to:

- Create, manage, or view virtual accounts
- Create and manage Product Instance Registration Tokens
- Transfer licenses between virtual accounts or view licenses
- Transfer, remove, or view product instances
- Run reports against your virtual accounts
- Modify your email notification settings
- View overall account information

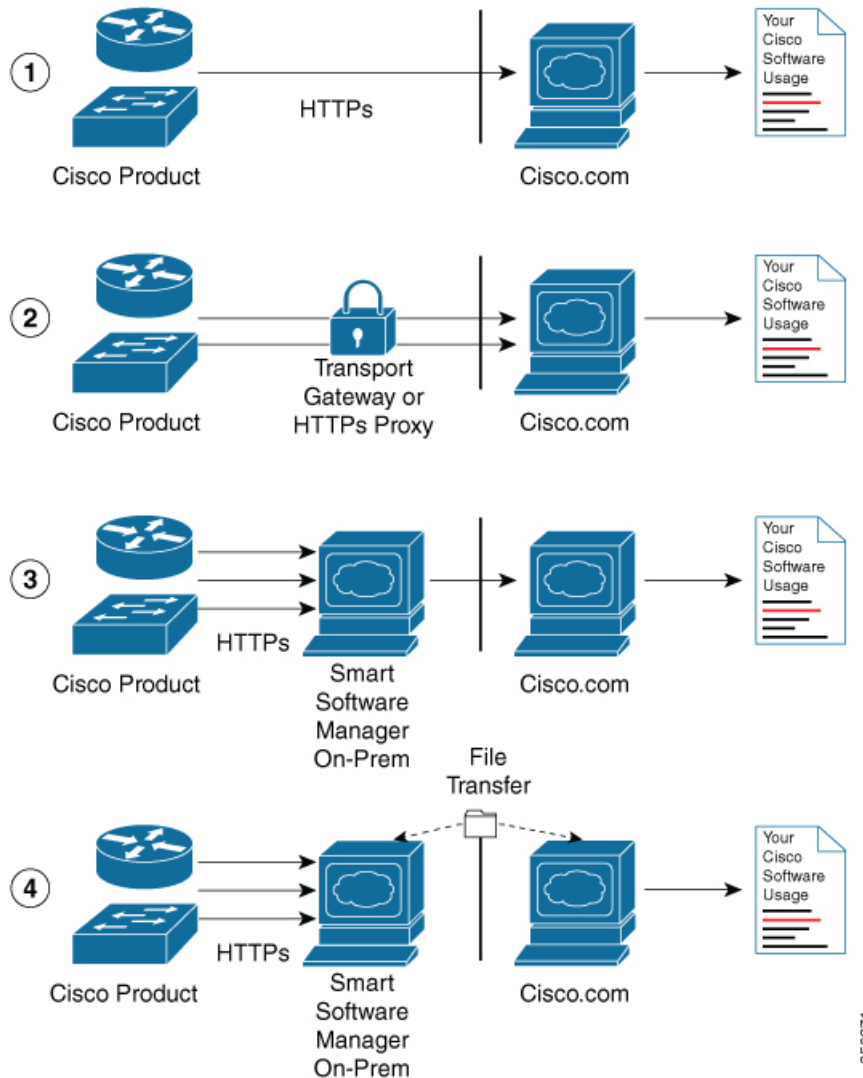
To access the Cisco Smart Software Manager:

- Go to <https://software.cisco.com>.
- Under the **License** section, click **Smart Software Licensing**.

Smart Licensing Deployment Options

The following illustration shows the various options available for deploying Smart Licensing:

Figure 5: Smart Licensing Deployment Options



1. Direct cloud access—In this method, Cisco products send usage information directly over the internet to CSSM on <http://www.cisco.com>; no additional components are needed for deployment.
2. Direct cloud access through an HTTPs proxy—In direct cloud access through an HTTPs proxy deployment method, Cisco products send usage information over the internet through a proxy server—either a Smart Call Home Transport Gateway or off-the-shelf Proxy (such as Apache) to CSSM on <http://www.cisco.com>.
3. Mediated access through an on-premises collector-connected—In mediated access through an on-premises collector-connected deployment method, Cisco products send usage information to a locally connected collector, which acts as a local license authority. Periodically, the information is exchanged to keep the databases in synchronization.

4. Mediated access through an on-premises collector-disconnected—In the mediated access through an on-premises collector-disconnected deployment method, Cisco products send usage information to a local disconnected collector, which acts as a local license authority. Exchange of human-readable information is performed occasionally (once a month) to keep the databases in synchronization.

Options 1 and 2 provide easy deployment options, whereas options 3 and 4 provide secure environment deployment options.



Note Smart Software On-Premise provides support for options 3 and 4.

The communication between Cisco devices and CSSM is facilitated by the Smart Call Home software.

YANG Data Models for Smart Licensing

YANG is a data modeling language that helps to create configurations, retrieve operational data and execute actions. The router acts on the data definition when these operations are requested using NETCONF RPCs. The data model handles the following types of requirements on the routers for smart licensing functionality:

Data	Data Model	CLI Commands
Configuration data: a set of writable data that is required to configure smart licensing on the router.	Native data model: Cisco-IOS-XR-smart-license-cfg.yang	<ul style="list-style-type: none"> • license smart reservation • [no] license smart reservation • license smart flexible-consumption enable • [no] license smart flexible-consumption enable
Operational state data: a set of data that the system obtains at run time.	Common data model: cisco-smart-license.yang Native data model: Cisco-IOS-XR-smart-license-platform-oper.yang Cisco-IOS-XR-infra-smartlicense-oper.yang	<ul style="list-style-type: none"> • show license platform summary • show license platform detail • show license [all summary usage udi]

Data	Data Model	CLI Commands
Actions: a set of NETCONF actions that support robust networkwide configuration transactions.	Native data model: Cisco-IOS-XR-smart-license-act.yang	<ul style="list-style-type: none"> • license smart register id token • license smart deregister • license smart renew id • license smart renew auth • license smart reservation request local • license smart reservation cancel local • license smart reservation install file <file path> • license smart reservation return local • license smart reservation return authorization file <file path> • license smart transport smart • license smart url <url> • license smart software-upgrade enable • license smart proxy hostname <hostname/ip> • license smart proxy port <port>

You can access the data models from the [Github](#) repository. To learn more about the data models and put them to use, see the *Programmability Configuration Guide*.

Configuring Smart Licensing

Prerequisites for Configuring Smart Licensing

Ensure that you have completed the following activities on Cisco Smart Software Manager:

- Set up a Cisco Smart Account. For more information, see the *How Smart Licensing Works* section in this document.
- Set up Virtual Account or accounts. For more information, see the *Virtual Accounts* section in the [Smart Software Manager Help](#).
- Create user roles in the **Users** tab in the **Manage Smart Account** page. Provide the appropriate user access rights.
- Accept the Smart Software Licensing Agreement on Cisco Smart Software Manager to register your router.
- Have a layer 3 connection set up on your router.

- Configure a valid DNS and proper time on the router to connect CSSM or CSSM On-Prem.

Setting up the Router for Smart Licensing

Table 10: Three-step Roadmap to Set up the Router for Smart Licensing

Activity	Communication Connection Options		
Step 1—Configure Communications	See the <i>Configuring a Direct Cloud Connection</i> section.	See the <i>Configuring a Connection through a HTTP Proxy</i> section.	See the <i>Connecting to CSSM On-Premise</i> section.
Step 2—Register and Activate	See the <i>Registering and Activating your Router</i> section.		
Step 3—Verify the Configuration	See the <i>Verifying your Smart Licensing Configuration</i> section.		

Configuring a Communications Connection Between the Router and Cisco Smart Software Manager

Configuring a Direct Cloud Connection

In this deployment option, the **configure call-home profile** is configured by default. Use the **show call-home profile all** command to check the profile status.

Call Home service provides email-based and web-based notification of critical system events to Cisco Smart Software Manager.

To configure and enable Call Home service:

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 2	call-home Example: Router(config)# call-home	Enters Call Home configuration mode.
Step 3	service active Example: Router(config-call-home)# service active	Activates Call Home service.

	Command or Action	Purpose
Step 4	contact-email-addr <i>email-address</i> Example: <pre>Router(config-call-home) # contact-email-addr username@example.com</pre>	Assigns the provided email address. You can enter up to 200 characters in email address format. Note Spaces are not allowed in the email address.
Step 5	profile CiscoTAC-1 Example: <pre>Router(config-call-home) # profile CiscoTAC-1</pre>	Enables the CiscoTAC-1 profile to be used with the Call Home service. By default, the CiscoTAC-1 profile is disabled.
Step 6	destination transport-method http Example: <pre>Router(config-call-home-profile) # destination transport-method http</pre>	Enables the Call Home service through an HTTP connection.
Step 7	destination address http url Example: <pre>Router(config-call-home-profile) # destination address http https://tools.cisco.com/its/service/otbe/services/LICService</pre>	Connects the router to the Cisco Smart Software Manager.
Step 8	active Example: <pre>Router(config-call-home-profile) # active</pre>	Enables the destination profile.
Step 9	no destination transport-method email Example: <pre>Router(config-call-home-profile) # no destination transport-method email</pre>	Disables the email option for the Call Home service.
Step 10	commit Example: <pre>Router(config-call-home-profile) # commit</pre>	Commits the configuration.
Step 11	exit Example: <pre>Router(config-call-home-profile) # exit</pre>	Exits the Call Home destination profile configuration mode and returns to the Call Home configuration mode.
Step 12	exit Example: <pre>Router(config-call-home) # exit Router(config) #</pre>	Exits the Call Home configuration mode and returns to the global configuration mode.

Configuring a Connection Through an HTTP Proxy

The Call Home service can be configured through an HTTPs proxy server.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: Router# configure terminal	Enters global configuration mode.
Step 2	call-home Example: Router(config)# call-home	Enters Call Home configuration mode.
Step 3	service active Example: Router(config-call-home)# service active	Enables the Call Home feature.
Step 4	contact-email-address email-address Example: Router(config-call-home)# contact-email-addr sch-smart-licensing@cisco.com	Configures the default email address.
Step 5	http-proxy proxy-address port port-number Example: Router(config-call-home)# http-proxy 198.51.100.10 port 3128	Provides the proxy server information to the Call Home service.
Step 6	profile CiscoTAC-1 Example: Router(config-call-home)# profile CiscoTAC-1	Enables the CiscoTAC-1 profile to be used with the Call Home service. By default, the CiscoTAC-1 profile is disabled.
Step 7	no destination transport-method email Example: Router(config-call-home-profile)# no destination transport-method email	Disables the email option for the Call Home service.
Step 8	exit Example: Router(config-call-home-profile)# exit Router(config-call-home)#	Exits the Call Home destination profile configuration mode and returns to the Call Home configuration mode.
Step 9	profile profile-name Example: Router(config-call-home)# profile test1	Enters the Call Home destination profile configuration mode for the specified destination profile name. If the specified destination profile does not exist, it is created.

	Command or Action	Purpose
Step 10	reporting smart-licensing-data Example: Router(config-call-home-profile)# reporting smart-licensing-data	Enables data sharing with the Call Home service through the configured transport method, in this case, HTTP.
Step 11	destination transport-method http Example: Router(config-call-home-profile)# destination transport-method http	Enables the HTTP message transport method.
Step 12	destination address http url Example: Router(config-call-home-profile)# destination address http https://tools.cisco.com/its/service/otbe/services/IDEService	Connects the router to the Cisco Smart Software Manager.
Step 13	active Example: Router(config-call-home-profile)# active	Enables the destination profile.
Step 14	exit Example: Router(config-call-home-profile)# exit	Exits the Call Home destination profile configuration mode and returns to the Call Home configuration mode.
Step 15	exit Example: Router(config-call-home)# exit Router(config)#	Exits the Call Home configuration mode and returns to the global configuration mode.
Step 16	commit Example: Router(config)# commit	Commits the configuration.

Connecting to CSSM On-Premise

This section describes how to configure the Call Home service for on-premise smart software through connected or disconnected mode.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: Router# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
Step 2	call-home Example: Router(config)# call-home	Enters Call Home configuration mode.
Step 3	profile <i>profile-name</i> Example: Router(config-call-home)# profile test1	Enters the Call Home destination profile configuration mode for the specified destination profile name. If the specified destination profile does not exist, it is created.
Step 4	reporting smart-licensing-data Example: Router(config-call-home-profile)# reporting smart-licensing-data	Enables data sharing with the Call Home service through the configured transport method, in this case, HTTP.
Step 5	destination transport-method http Example: Router(config-call-home-profile)# destination transport-method http	Enables the HTTP message transport method.
Step 6	destination address http <i>url</i> Example: Router(config-call-home-profile)# destination address http http://209.165.201.15/TransportGateway/services/DeviceRequestHandler Or Router(config-call-home-profile)# destination address http https://209.165.201.15/TransportGateway/services/DeviceRequestHandler	Configures the destination URL (CSSM) to which Call Home messages are sent. Ensure the IP address or the fully qualified domain name (FQDN) in the destination URL matches the IP address or the FQDN as configured for the Host Name on the CSSM On-Prem.
Step 7	no destination address http <i>url</i> Example: Router(config-call-home-profile)# no destination address http https://tools.cisco.com/its/service/cube/services/DOEService	Removes the default destination address.
Step 8	destination preferred-msg-format {long-text short-text xml} Example: Router(config-call-home-profile)# destination preferred-msg-format xml	(Optional) Configures a preferred message format. The default message format is XML.
Step 9	active Example: Router(config-call-home-profile)# active	Enables the destination profile.

	Command or Action	Purpose
Step 10	exit Example: <code>Router(config-call-home-profile)# exit</code>	Exits the Call Home destination profile configuration mode and returns to the Call Home configuration mode.
Step 11	exit Example: <code>Router(config-call-home)# exit</code> <code>Router(config)#</code>	Exits the Call Home configuration mode and returns to the global configuration mode.
Step 12	http client source-interface <i>ip-version interface-type interface-number</i> Example: <code>Router(config)# http client source-interface ipv4 Vlan100</code>	Configures a source interface for the HTTP client. Note This command is mandatory for a VRF interface.
Step 13	crypto ca trustpool policy <i>crl optional</i> Example: <code>Router(config)# crypto ca trustpool policy <i>crl optional</i></code>	(Optional) Bypasses the Certificate Revocation Lists (CRLs) check and establishes the connection. By default, the CRLs check is mandatory while establishing a TLS connection. We recommend this step when the smart licensing-enabled router is within a network and can rely on the License server to check the certificate status without retrieving and caching each CRL for every peer.
Step 14	commit Example: <code>Router(config)# commit</code>	Commits the configuration.
Step 15	end Example: <code>Router(config)# end</code>	Returns to the global configuration mode.

Installing CSSM On-Premise

For information on installation instructions, see the [Smart Software Manager On-Prem Installation Guide](#).

Registering and Activating Your Router

Product registration securely associates a device with the Smart Account and the Virtual Account of your choice. It also establishes trust between the end product and the CSSM. Tokens are used to register a product with the appropriate Virtual Account on CSSM Cloud (on Cisco.com) or CSSM On-Premise.



Note When the router is in an unregistered state, the licenses are in EVAL (evaluation) mode. Evaluation period will last for 90 days.

A Registration Token:

- Can be either used once or reused multiple times. You can set a limit to the number of times a token can be reused when you create the token.
- Can be created and revoked at any time.
- Expires after a period of time (default is 30 days; minimum is one day; maximum is 365 days)

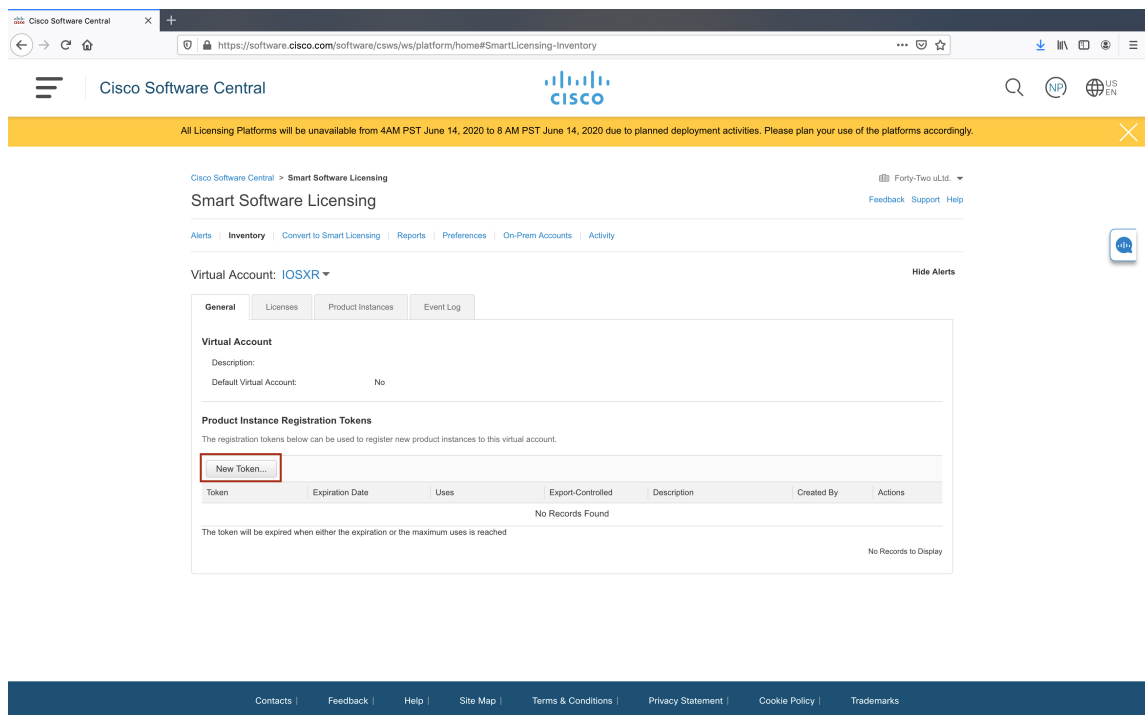
A Registration Token is not:

- Product specific: The same Registration Token can be used on different product types.
- A license, key, or PAK.
- Stored on the Cisco device and they are not persistent.
- Required after the product is registered. Token expiration has no effect on previously registered products; it simply means that that token can no longer be used to register a new product.

Generating a New Token from CSSM

Procedure

- Step 1** If you choose the direct cloud access deployment option, log in to CSSM from <https://software.cisco.com/#>.
If you chose the mediated access deployment option, log in to CSSM On-Prem from <https://<on-prem-ip-address>:8443>.
- Step 2** Select the **Inventory** tab.
- Step 3** From the Virtual Account drop-down list, choose the virtual account to which you want to register your product.
- Step 4** Select the **General** tab.
- Step 5** Click **New Token**.



The **Create Registration Token** window is displayed.

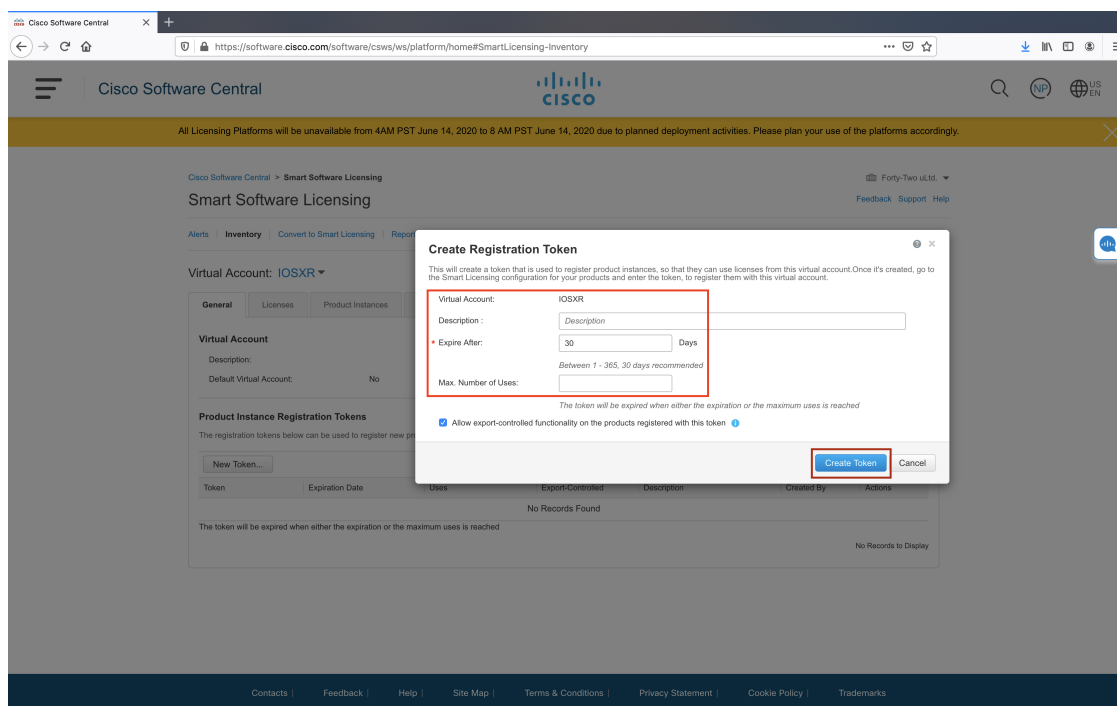
Step 6

In the **Description** field, enter the token description.

In the **Expire After** field, enter the number of days the token must be active. The default value is 30 days.

In the **Max. Number of Uses** field, enter the maximum number of uses allowed after which the token expires.

Select the **Allow export-controlled functionality on the products registered with this token** checkbox to ensure Cisco compliance with US and country-specific export policies and guidelines. For more information, see <https://www.cisco.com/c/en/us/about/legal/global-export-trade.html>.

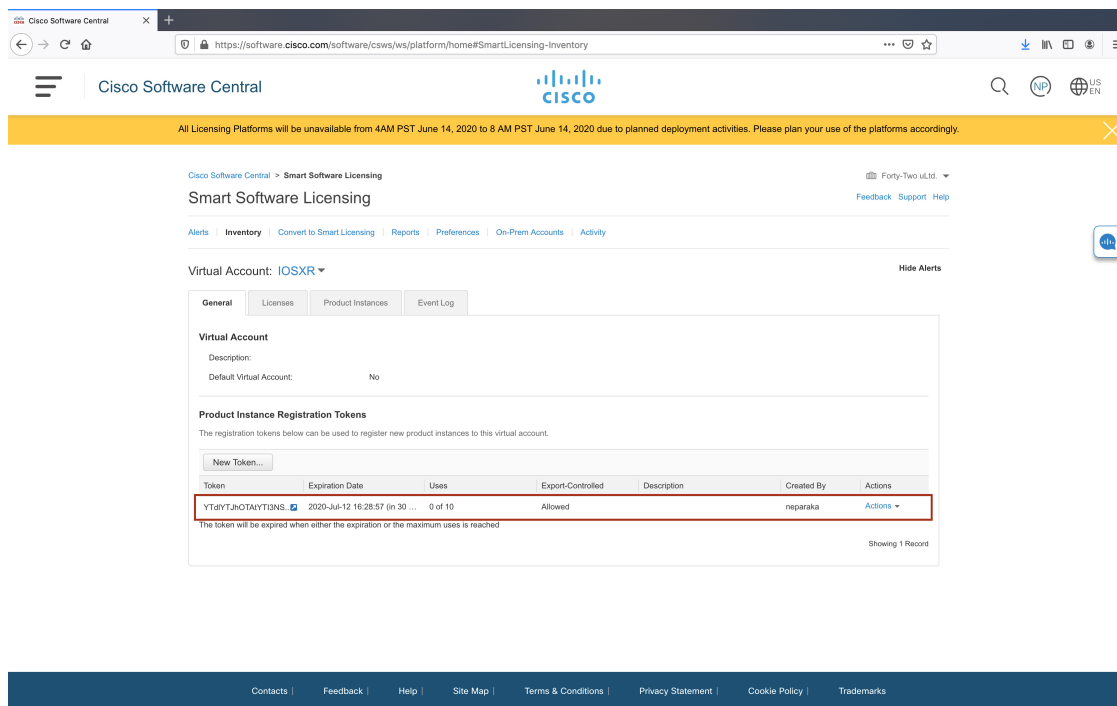


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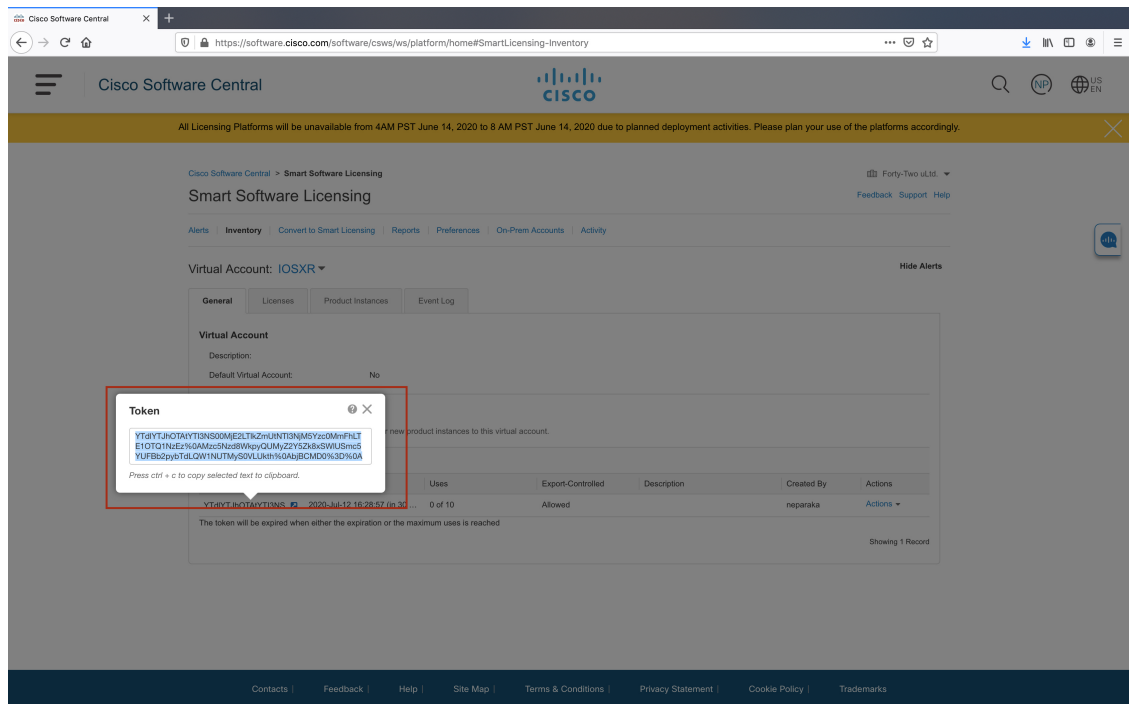
Click **Create Token**.

Step 7

After the token is created, select and copy the token to a text file.



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You need this token to register your router.

What to do next

See the *Registering Your Device With the Token* section.

Registering Your Device With the Token

Procedure

	Command or Action	Purpose
Step 1	license smart register idtoken <i>token-ID</i> Example: <pre>license smart register idtoken \$T14Uy7nVBE5sLck6vUw65aHzJZFdaLw5Pa%0hRmz0%3D%0A</pre>	Registers Smart Licensing on the router using the registration token created in the CSSM. On successful registration, the product instance is created in the CSSM virtual account and its license usage is displayed on the CSSM.

Example

Register Device Using YANG Data Model

As an alternative to the CLI command, the `Cisco-IOS-XR-smart-license-act` YANG data model can also be used to register your device with CSSM On-prem server. The following example shows the NETCONF RPC request:

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="101">
  <register-id-token xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-smart-license-act">
    <id-token>$Tl4UytrNXBzbEs1ck8veUtWaG5abnZJOfdDa1FwbVRa%0Ab1RMbz0%3D%0A</id-token>
  </register-id-token>
</rpc>
```

Renewing Your Smart Licensing Registration

Your registration is automatically renewed every six months. To find the status of the license, use the **license smart renew auth** command.

As long as the license is in an 'Authorized' or 'Out-of-compliance' (OOC) state, the authorization period is renewed. Grace period starts when an authorization period expires. During the grace period or when the grace period is in the 'Expired' state, the system continues to try to renew the authorization period. If a retry is successful, a new authorization period starts.



Note If the smart license renewal fails, then the product instance goes to an unidentified state and starts consuming the evaluation period.

Before you begin

Ensure that the following conditions are met to renew your smart license:

- Smart licensing is enabled.
- The router is registered.

Procedure

	Command or Action	Purpose
Step 1	license smart renew {auth id} Example: Router# license smart renew auth	Renews your token ID or authorization with Cisco smart licensing.

Deregistering Your Router from CSSM

When a router is taken off the inventory, shipped elsewhere for redeployment, or returned to Cisco for replacement, you can deregister that router.

Before you begin

Ensure that a Layer 3 connection to CSSM is available to successfully deregister the device.

Procedure

	Command or Action	Purpose
Step 1	license smart deregister Example: <pre>Router# license smart deregister</pre>	Cancels the registration of the router and sends the router into evaluation mode. All smart licensing entitlements and certificates on the corresponding platform are removed. The product instance of the router stored on CSSM is also removed.

Verifying the Smart Licensing Configuration

Use the following **show** commands to verify the default Smart Licensing configuration. If any issue is detected, take corrective action before making further configurations.

Procedure

	Command or Action	Purpose
Step 1	show license status Example: <pre>Router# show license status</pre>	Displays the compliance status of Smart Licensing. Following are the possible status: <ul style="list-style-type: none"> • Waiting—Indicates that the initial state after your device has made a license entitlement request. The device establishes communication with Cisco and successfully registers itself with the Cisco license manager. • Authorized—Indicates that your device is able to communicate with the Cisco license manager, and is authorized to initiate requests for license entitlements. • Out-Of-Compliance—Indicates that one or more of your licenses are out-of-compliance. Buy more licenses, or renew the existing licenses. • Eval Period—Indicates that Smart Licensing is consuming the evaluation period. Register the device with the Cisco Licensing manager, else your license expires.

	Command or Action	Purpose
		<p>Note Repetitive 'Smart Licensing evaluation expired' warning messages are displayed on the console every hour, but there is no functionality impact on the device. To stop these repetitive messages, register the device again with new a registration token.</p> <ul style="list-style-type: none"> • Disabled—Indicates that Smart Licensing is disabled. • Invalid—Indicates that Cisco does not recognize the entitlement tag as the tag is not in the database.
Step 2	show license all Example: Router# show license all	Displays all entitlements in use. The output also displays the associated licensing certificates, compliance status, Unique Device Identifier (UDI), and other details.
Step 3	show license status Example: Router# show license status	Displays the status of all entitlements in use.
Step 4	show license udi Example: Router# show license udi	Displays the Unique Device Identifier (UDI) information.
Step 5	show license summary Example: Router# show license summary	Displays a summary of all entitlements in use.
Step 6	show license platform summary Example: Router# show license platform summary	Displays the registration status and provides detailed information about the essential, advantage without essentials, advantage with essentials, and tracking license consumption in generic or vortex license model.
Step 7	show license platform detail Example: Router# show license platform detail	Displays detailed information about: <ul style="list-style-type: none"> • Licenses that can be consumed on a platform in both, generic and vortex models • The active model, whether generic or vortex model

	Command or Action	Purpose
		<ul style="list-style-type: none"> The current count and the next consumption count of a license
Step 8	show call-home smart-licensing statistics Example: <pre>Router# show call-home smart-licensing statistics</pre>	Displays statistics of the communication between the Smart Licensing manager and the Cisco back-end using Smart Call Home. Note If the communication fails or drops, check your call home configuration for any errors.

Smart Licensing Configuration Examples

Example: Viewing the Call Home Profile

To display the **http Call Home profile** or the **On-Prem Call Home profile**, use the **show call-home profile all** command.

```
Router# show call-home profile all
```

```
Mon Jul 6 07:12:03.728 UTC
```

```
Profile Name: CiscoTAC-1
Profile status: ACTIVE
Profile mode: Full Reporting
Reporting Data: Smart Call Home, Smart Licensing
Preferred Message Format: xml
Message Size Limit: 3145728 Bytes
Transport Method: http
HTTP address(es): https://tools.cisco.com/its/service/oddce/services/DDCEService
Other address(es): default
```

```
Periodic configuration info message is scheduled every 5 day of the month at 9 :51
```

```
Periodic inventory info message is scheduled every 5 day of the month at 9 :36
```

```
Alert-group          Severity
-----
inventory            normal
```

```
Syslog-Pattern       Severity
-----
.*                   critical
```

```
Router# show call-home profile all
```

```
Tue Jul 7 18:48:47.325 UTC
```

```
Profile Name: CiscoTAC-1
Profile status: ACTIVE
Profile mode: Full Reporting
Reporting Data: Smart Call Home, Smart Licensing
Preferred Message Format: xml
Message Size Limit: 3145728 Bytes
Transport Method: http
```

HTTP address(es): http://10.30.110.38/Transportgateway/services/RouterRequestHandler

Other address(es): default

Periodic configuration info message is scheduled every 5 day of the month at 9 :51

Periodic inventory info message is scheduled every 5 day of the month at 9 :36

Alert-group	Severity
-----	-----
inventory	normal
Syslog-Pattern	Severity
-----	-----
.*	critical

Example: Viewing License Information Before Registration

To display the license entitlements, use the **show license all** command:

```
Router# show license all
Mon Jul  6 07:25:24.369 UTC

Smart Licensing Status
=====

Smart Licensing is ENABLED

Registration:
  Status: UNREGISTERED
  Export-Controlled Functionality: NOT ALLOWED

License Authorization:
  Status: EVAL EXPIRED on Jul 31 2019 10:11:28 UTC

Export Authorization Key:
  Features Authorized:
    <none>

Utility:
  Status: DISABLED

Data Privacy:
  Sending Hostname: yes
  Callhome hostname privacy: DISABLED
  Smart Licensing hostname privacy: DISABLED
  Version privacy: DISABLED

Transport:
  Type: Callhome

License Usage
=====

(ESS-AC-100G-RTU-1):
  Description:
  Count: 1
  Version: 1.0
  Status: EVAL EXPIRED
  Export status: NOT RESTRICTED

(N560-4-SYS-E-TRK):
  Description:
  Count: 1
```

Example: Viewing License Information Before Registration

```

Version: 1.0
Status: EVAL EXPIRED
Export status: NOT RESTRICTED

(A900-IMA8Z-TRK):
Description:
Count: 2
Version: 1.0
Status: EVAL EXPIRED
Export status: NOT RESTRICTED

(A900-IMA8CS1ZM-TRK):
Description:
Count: 1
Version: 1.0
Status: EVAL EXPIRED
Export status: NOT RESTRICTED
Product Information
=====
UDI: PID:NCS560-4,SN:FOX2305P81D

Agent Version
=====
Smart Agent for Licensing: 4.9.6_rel/41

Reservation Info
=====
License reservation: DISABLED

```

To display the license usage information, use the **show license usage** command:

```

Router# show license usage
Mon Jul  6 07:26:07.579 UTC

License Authorization:
  Status: EVAL EXPIRED on Jul 31 2019 10:11:28 UTC

(ESS-AC-100G-RTU-1):
Description:
Count: 1
Version: 1.0
Status: EVAL EXPIRED
Export status: NOT RESTRICTED

(N560-4-SYS-E-TRK):
Description:
Count: 1
Version: 1.0
Status: EVAL EXPIRED
Export status: NOT RESTRICTED

(A900-IMA8Z-TRK):
Description:
Count: 2
Version: 1.0
Status: EVAL EXPIRED
Export status: NOT RESTRICTED

(A900-IMA8CS1ZM-TRK):
Description:
Count: 1
Version: 1.0
Status: EVAL EXPIRED
Export status: NOT RESTRICTED

```

To display all the license summaries, use the **show license summary** command:

```
Router# show license summary
Mon Jul  6 07:27:23.696 UTC

Smart Licensing is ENABLED

Registration:
  Status: UNREGISTERED
  Export-Controlled Functionality: NOT ALLOWED

License Authorization:
  Status: EVAL EXPIRED

License Usage:
  License                               Entitlement tag                               Count Status
  -----
                                (ESS-AC-100G-RTU-1)                        1 EVAL EXPIRED
                                (N560-4-SYS-E-TRK)                        1 EVAL EXPIRED
                                (A900-IMA8Z-TRK)                         2 EVAL EXPIRED
                                (A900-IMA8CS1ZM-TRK)                       1 EVAL EXPIRED
```

To display the license status information, use the **show license status** command:

```
Router# show license status
Mon Jul  6 07:28:23.414 UTC

Smart Licensing is ENABLED

Utility:
  Status: DISABLED

Data Privacy:
  Sending Hostname: yes
  Callhome hostname privacy: DISABLED
  Smart Licensing hostname privacy: DISABLED
  Version privacy: DISABLED

Transport:
  Type: Callhome

Registration:
  Status: UNREGISTERED
  Export-Controlled Functionality: NOT ALLOWED

License Authorization:
  Status: EVAL EXPIRED on Jul 31 2019 10:11:28 UTC

Export Authorization Key:
  Features Authorized:
    <none>
```

Example: Registering the Router

To register a device, use the **license smart register idtoken** command:

```
Router# license smart register idtoken
Tl4UytrNXBzbEs1ck8veUtWaG5abnZJOfdDalFwbVRa%0Ab1RMbz0%3D%0A
```

Example: Viewing License Information After Registration

To display the license entitlements, use the **show license all** command

Example: Viewing License Information After Registration

```

Router# show license all
Mon Jul  6 07:13:23.823 UTC

Smart Licensing Status
=====

Smart Licensing is ENABLED

Registration:
  Status: REGISTERED
  Smart Account: Forty-Two uLtd.
  Virtual Account: IOSXR
  Export-Controlled Functionality: ALLOWED
  Initial Registration: SUCCEEDED on Jul 01 2020 07:14:24 UTC
  Last Renewal Attempt: None
  Next Renewal Attempt: Dec 28 2020 07:14:23 UTC
  Registration Expires: Jul 01 2021 07:01:42 UTC

License Authorization:
  Status: OUT OF COMPLIANCE on Jul 01 2020 07:14:38 UTC
  Last Communication Attempt: SUCCEEDED on Jul 05 2020 19:15:51 UTC
  Next Communication Attempt: Jul 06 2020 07:15:50 UTC
  Communication Deadline: Oct 03 2020 19:10:49 UTC

Export Authorization Key:
  Features Authorized:
    <none>

Utility:
  Status: DISABLED

Data Privacy:
  Sending Hostname: yes
    Callhome hostname privacy: DISABLED
    Smart Licensing hostname privacy: DISABLED
  Version privacy: DISABLED

Transport:
  Type: Callhome

License Usage
=====

Access Essentials SW Right-to-Use v1.0 per 100G (ESS-AC-100G-RTU-1):
  Description: Access Essentials SW Right-to-Use v1.0 per 100G
  Count: 1
  Version: 1.0
  Status: OUT OF COMPLIANCE
  Export status: NOT RESTRICTED

Tracking PID for N560-4-SYS-E Vortex ATO (N560-4-SYS-E-TRK):
  Description: Tracking PID for N560-4-SYS-E Vortex ATO
  Count: 1
  Version: 1.0
  Status: AUTHORIZED
  Export status: NOT RESTRICTED

Tracking PID for ASR 900 8-port 10GE Interface Module (A900-IMA8Z-TRK):
  Description: Tracking PID for ASR 900 8-port 10GE Interface Module
  Count: 2
  Version: 1.0
  Status: AUTHORIZED
  Export status: NOT RESTRICTED

```

Tracking PID for ASR 900 8/16-port 1GE + 1-port 10GE Interface Module (A900-IMA8CS1ZM-TRK):

Description: Tracking PID for ASR 900 8/16-port 1GE 1-port 10GE Interface
Module

Count: 1
Version: 1.0
Status: AUTHORIZED
Export status: NOT RESTRICTED

Product Information
=====

UDI: PID:NCS560-4,SN:FOX2305P81D

Agent Version
=====

Smart Agent for Licensing: 4.9.6_rel/41

Reservation Info
=====

License reservation: DISABLED

To display the license usage information, use the **show license usage** command:

```
Router# show license usage
Mon Jul 6 07:14:55.554 UTC
```

```
License Authorization:
  Status: OUT OF COMPLIANCE on Jul 01 2020 07:14:38 UTC
```

Access Essentials SW Right-to-Use v1.0 per 100G (ESS-AC-100G-RTU-1):

Description: Access Essentials SW Right-to-Use v1.0 per 100G
Count: 1
Version: 1.0
Status: OUT OF COMPLIANCE
Export status: NOT RESTRICTED

Tracking PID for N560-4-SYS-E Vortex ATO (N560-4-SYS-E-TRK):

Description: Tracking PID for N560-4-SYS-E Vortex ATO
Count: 1
Version: 1.0
Status: AUTHORIZED
Export status: NOT RESTRICTED

Tracking PID for ASR 900 8-port 10GE Interface Module (A900-IMA8Z-TRK):

Description: Tracking PID for ASR 900 8-port 10GE Interface Module
Count: 2
Version: 1.0
Status: AUTHORIZED
Export status: NOT RESTRICTED

Tracking PID for ASR 900 8/16-port 1GE + 1-port 10GE Interface Module (A900-IMA8CS1ZM-TRK):

Description: Tracking PID for ASR 900 8/16-port 1GE 1-port 10GE Interface
Module

Count: 1
Version: 1.0
Status: AUTHORIZED
Export status: NOT RESTRICTED

To display all the license summaries, use the **show license summary** command:

```
Router# show license summary
Mon Jul 6 07:16:30.036 UTC
```

Smart Licensing is ENABLED

Example: Viewing License Information After Registration

```

Registration:
  Status: REGISTERED
  Smart Account: Forty-Two uLtd.
  Virtual Account: IOSXR
  Export-Controlled Functionality: ALLOWED
  Last Renewal Attempt: None
  Next Renewal Attempt: Dec 28 2020 07:14:24 UTC

License Authorization:
  Status: OUT OF COMPLIANCE
  Last Communication Attempt: SUCCEEDED
  Next Communication Attempt: Jul 06 2020 19:15:57 UTC

```

```

License Usage:
  License                               Entitlement tag                Count Status
  -----
  Access Essentials SW... (ESS-AC-100G-RTU-1)          1 OUT OF COMPLIANCE
  Tracking PID for N56... (N560-4-SYS-E-TRK)           1 AUTHORIZED
  Tracking PID for ASR... (A900-IMA8Z-TRK)             2 AUTHORIZED
  Tracking PID for ASR... (A900-IMA8CS1ZM-TRK)         1 AUTHORIZED

```

To display the license status information, use the **show license status** command:

```

Router# show license status
Mon Jul  6 07:17:27.729 UTC

Smart Licensing is ENABLED

Utility:
  Status: DISABLED

Data Privacy:
  Sending Hostname: yes
  Callhome hostname privacy: DISABLED
  Smart Licensing hostname privacy: DISABLED
  Version privacy: DISABLED

Transport:
  Type: Callhome

Registration:
  Status: REGISTERED
  Smart Account: Forty-Two uLtd.
  Virtual Account: IOSXR
  Export-Controlled Functionality: ALLOWED
  Initial Registration: SUCCEEDED on Jul 01 2020 07:14:24 UTC
  Last Renewal Attempt: None
  Next Renewal Attempt: Dec 28 2020 07:14:23 UTC
  Registration Expires: Jul 01 2021 07:01:42 UTC

License Authorization:
  Status: OUT OF COMPLIANCE on Jul 01 2020 07:14:38 UTC
  Last Communication Attempt: SUCCEEDED on Jul 06 2020 07:15:57 UTC
  Next Communication Attempt: Jul 06 2020 19:15:57 UTC
  Communication Deadline: Oct 04 2020 07:10:56 UTC

Export Authorization Key:
  Features Authorized:
    <none>

```



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 125](#)
- [Overview of FPD Image Upgrade Support, on page 125](#)
- [FPD upgrade service, on page 126](#)

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.
- 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.



Important FPD auto upgrade is not supported on this router.

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
```

Location	Card type	HWver	FPD device	ATR Status	FPD Versions	
					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)
```

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 indicate 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					
Card Type	FPD Description	Req Reload	SW Ver	Min Req SW Ver	Min Req 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-PrimMCU (A)	NO	0.11	0.11	0.0
	DCA-SecMCU (A)	NO	1.04	1.04	0.0
A900-PWR1200-D	LIT-PrimMCU (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-PrimMCU (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

upgrade hw-module fpd Command Output: Example

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 11: 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.
-
- 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

Location	Card type	HWver	FPD device	ATR Status	FPD Versions	
					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 12: Action Required on FPDs After Auto Upgrade

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

Location	Card type	HWver	FPD device	ATR Status	FPD Versions	
					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-mpis-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-mpis-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_imfpnga[121]: %INFRA-FPD_Driver-6-UPGRADE_RESULT
: Upgrade completes 50 percent for fpd IMFPNGA@location 0/5.
RP/0/RP0/CPU0:Jun 28 21:45:14.616 UTC: fpd_imfpnga[121]: %INFRA-FPD_Driver-6-UPGRADE_RESULT
: Upgrade completes 50 percent for fpd IMFPNGA@location 0/3.
RP/0/RP0/CPU0:Jun 28 21:48:24.763 UTC: fpd_imfpnga[121]: %INFRA-FPD_Driver-6-UPGRADE_RESULT
: Upgrade completes 90 percent for fpd IMFPNGA@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

Location	Card type	HWver	FPD device	ATR Status	FPD Versions	
					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#						

Automatic FPD Upgrade for PSU

During the installation and Power Supply Unit (PSU) insertion process, the Field-Programmable Devices (FPD) associated with the PSUs are automatically upgraded.



Note The PSUs are upgraded sequentially, hence the PSU FPD upgrades take longer. You can choose to exclude PSUs from the auto upgrade flow. This restricts the PSUs from being upgraded either upon insertion, or during system upgrade.

To exclude the PSU FPDs from auto upgrading, use the following CLI:

fpd auto-upgrade exclude pm

```
RP/0/RSP0/CPU0:router# show running-config fpd auto-upgrade
Wed Mar 30 20:52:55.079 UTC
fpd auto-upgrade enable
fpd auto-upgrade exclude pm
```



Note When you upgrade from an earlier unsupported version to a version that supports Automatic FPD upgrade for PSU, the PSU upgrade might happen on bootup.

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.
-