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Preface

This guide describes the configuration and examples for system security. For system security command descriptions, usage guidelines, task IDs, and examples, refer to the *System Security Command Reference for Cisco NCS 5500 Series Routers and Cisco NCS 540 Series Routers*.

The preface contains the following sections:

- Changes to This Document, on page ix
- Communications, Services, and Additional Information, on page ix

## Changes to This Document

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

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<tr>
<td>September 2017</td>
<td>Initial release of this document.</td>
</tr>
<tr>
<td>March 2018</td>
<td>Republished for Release 6.3.2.</td>
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## Communications, Services, and Additional Information

- To receive timely, relevant information from Cisco, sign up at [Cisco Profile Manager](#).
- To get the business impact you’re looking for with the technologies that matter, visit [Cisco Services](#).
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- To find warranty information for a specific product or product family, access [Cisco Warranty Finder](#).
Cisco Bug Search Tool

Cisco Bug Search Tool (BST) is a web-based tool that acts as a gateway to the Cisco bug tracking system that maintains a comprehensive list of defects and vulnerabilities in Cisco products and software. BST provides you with detailed defect information about your products and software.
New and Changed Feature Information

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

- System Security Features Added or Modified in IOS XR Release 6.3.x, on page 1

System Security Features Added or Modified in IOS XR Release 6.3.x

<table>
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<td>Release 6.3.1</td>
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<td>This feature was introduced.</td>
<td>Release 6.3.2</td>
<td>See MPP for Third-Party Applications Chapter.</td>
</tr>
<tr>
<td>Fallback PSK</td>
<td>This feature was introduced.</td>
<td>Release 6.3.2</td>
<td>See Fallback PSK section of the Configure MACSec Chapter.</td>
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<tr>
<td>MACSec Data Delay Protection</td>
<td>This feature was introduced.</td>
<td>Release 6.3.2</td>
<td>See Creating a User-Defined MACsec Policy section of the Configure MACSec Chapter.</td>
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<tr>
<td>Global MACsec Shutdown</td>
<td>This feature was introduced.</td>
<td>Release 6.3.3</td>
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CHAPTER 2

Configuring AAA Services

This module describes the implementation of the administrative model of task-based authorization used to control user access in the software system. The major tasks required to implement task-based authorization involve configuring user groups and task groups.

User groups and task groups are configured through the software command set used for authentication, authorization and accounting (AAA) services. Authentication commands are used to verify the identity of a user or principal. Authorization commands are used to verify that an authenticated user (or principal) is granted permission to perform a specific task. Accounting commands are used for logging of sessions and to create an audit trail by recording certain user- or system-generated actions.

AAA is part of the software base package and is available by default.

- Prerequisites for Configuring AAA Services, on page 4
- Restrictions for Configuring AAA Services, on page 4
- Configure Task group, on page 4
- Configure User Groups, on page 6
- Configure Users, on page 7
- Configure Router to RADIUS Server Communication, on page 8
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- Configure Login Parameters, on page 28
- Task Maps, on page 29
- References for AAA Services, on page 31
Prerequisites for Configuring AAA Services

The following are the prerequisites to configure AAA services:

- 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.

- Establish a root system user using the initial setup dialog. The administrator may configure a few local users without any specific AAA configuration. The external security server becomes necessary when user accounts are shared among many routers within an administrative domain. A typical configuration would include the use of an external AAA security server and database with the local database option as a backup in case the external server becomes unreachable.

Restrictions for Configuring AAA Services

This section lists the restrictions for configuring AAA services.

Compatibility

Compatibility is verified with the Cisco freeware TACACS+ server and FreeRADIUS only.

Interoperability

Router administrators can use the same AAA server software and database (for example, CiscoSecure ACS) for the router and any other Cisco equipment that does not currently run the Cisco software. To support interoperability between the router and external TACACS+ servers that do not support task IDs, see the “Task IDs for TACACS+ and RADIUS Authenticated Users, on page 40” section.

Configure Task group

Task-based authorization employs the concept of a task ID as its basic element. A task ID defines the permission to execute an operation for a given user. Each user is associated with a set of permitted router operation tasks identified by task IDs. Users are granted authority by being assigned to user groups that are in turn associated with task groups. Each task group is associated with one or more task IDs. The first configuration task in setting up an authorization scheme to configure the task groups, followed by user groups, followed by individual users.

Specific task IDs can be removed from a task group by specifying the no prefix for the task command.

The task group itself can be removed. Deleting a task group that is still referred to elsewhere results in an error.

Before you begin

Before creating task groups and associating them with task IDs, you should have some familiarity with the router list of task IDs and the purpose of each task ID. Use the show aaa task supported command to display a complete list of task IDs.
Only users with write permissions for the AAA task ID can configure task groups.

### SUMMARY STEPS

1. configure
2. taskgroup taskgroup-name
3. description string
4. task {read | write | execute | debug} taskid-name
5. Repeat for each task ID to be associated with the task group named in Step 2.
6. commit

### DETAILED STEPS

**Step 1**
configure

**Step 2**

**Example:**

```console
RP/0/RP0/CPU0:router(config)# taskgroup beta
```

Creates a name for a particular task group and enters task group configuration submode.

- Specific task groups can be removed from the system by specifying the **no** form of the `taskgroup` command.

**Step 3**
description string

**Example:**

```console
RP/0/RP0/CPU0:router(config-tg)# description this is a sample task group description
```

(Optional) Creates a description of the task group named in Step 2.

**Step 4**
task {read | write | execute | debug} taskid-name

**Example:**

```console
RP/0/RP0/CPU0:router(config-tg)# task read bgp
```

Specifies a task ID to be associated with the task group named in Step 2.

- Assigns **read** permission for any CLI or API invocations associated with that task ID and performed by a member of the task group.

- Specific task IDs can be removed from a task group by specifying the **no** prefix for the `task` command.

**Step 5**
Repeat for each task ID to be associated with the task group named in Step 2.

**Step 6**
commit
What to do next
After completing configuration of a full set of task groups, configure a full set of user groups as described in the Configuring User Groups section.

Configure User Groups

User groups are configured with the command parameters for a set of users, such as task groups. Entering the `usergroup` command accesses the user group configuration submode. Users can remove specific user groups by using the `no` form of the `usergroup` command. Deleting a usergroup that is still referenced in the system results in a warning.

Before you begin

Note
Only users associated with the WRITE:AAA task ID can configure user groups. User groups cannot inherit properties from predefined groups, such as owner-sdr.

SUMMARY STEPS

1. `configure`
2. `usergroup usergroup-name`
3. `description string`
4. `inherit usergroup usergroup-name`
5. `taskgroup taskgroup-name`
6. Repeat Step for each task group to be associated with the user group named in Step 2.
7. `commit`  

DETAILED STEPS

Step 1 `configure`
Step 2 `usergroup usergroup-name`

Example:
```
RP/0/RP0/CPU0:router(config)# usergroup beta
```

Creates a name for a particular user group and enters user group configuration submode.

• Specific user groups can be removed from the system by specifying the `no` form of the `usergroup` command.

Step 3 `description string`

Example:
```
RP/0/RP0/CPU0:router(config-ug)#
description this is a sample user group description
```

(Optional) Creates a description of the user group named in Step 2.

Step 4 `inherit usergroup usergroup-name`
Examples:

RP/0/RP0/CPU0:router(config-ug)#
inherit usergroup sales

- Explicitly defines permissions for the user group.

Step 5  taskgroup  taskgroup-name
Example:

RP/0/RP0/CPU0:router(config-ug)# taskgroup beta

Associates the user group named in Step 2 with the task group named in this step.

- The user group takes on the configuration attributes (task ID list and permissions) already defined for the entered task group.

Step 6  Repeat Step for each task group to be associated with the user group named in Step 2.

---

Step 7  commit

---

Configure Users

Perform this task to configure a user.

Each user is identified by a username that is unique across the administrative domain. Each user should be made a member of at least one user group. Deleting a user group may orphan the users associated with that group. The AAA server authenticates orphaned users but most commands are not authorized.

**SUMMARY STEPS**

1. configure
2. username  user-name
3. Do one of the following:
   - password  {0 | 7} password
   - secret  {0 | 5} secret
4. group  group-name
5. Repeat step 4 for each user group to be associated with the user specified in step 2.
6. commit

**DETAILED STEPS**

Step 1  configure
Step 2  username  user-name

Example:

RP/0/RP0/CPU0:router(config)# username user1
Creates a name for a new user (or identifies a current user) and enters username configuration submode.

- The user-name argument can be only one word. Spaces and quotation marks are not allowed.

Step 3
Do one of the following:

- password {0 | 7} password
- secret {0 | 5} secret

Example:

RP/0/RP0/CPU0:router(config-un)# password 0 pwd1
or
RP/0/RP0/CPU0:router(config-un)# secret 0 sec1

Specifies a password for the user named in step 2.

- Use the secret command to create a secure login password for the user names specified in step 2.

- Entering 0 following the password command specifies that an unencrypted (clear-text) password follows. Entering 7 following the password command specifies that an encrypted password follows.

- Entering 0 following the secret command specifies that a secure unencrypted (clear-text) password follows. Entering 5 following the secret command specifies that a secure encrypted password follows.

- Type 0 is the default for the password and secret commands.

Step 4

group group-name

Example:

RP/0/RP0/CPU0:router(config-un)# group sysadmin

Assigns the user named in step 2 to a user group that has already been defined through the usergroup command.

- The user takes on all attributes of the user group, as defined by that user group’s association to various task groups.

- Each user must be assigned to at least one user group. A user may belong to multiple user groups.

Step 5
Repeat step 4 for each user group to be associated with the user specified in step 2.

Step 6
commit

Configure Router to RADIUS Server Communication

This task configures router to RADIUS server communication. The RADIUS host is normally a multiuser system running RADIUS server software from Cisco (CiscoSecure ACS), Livingston, Merit, Microsoft, or another software provider. Configuring router to RADIUS server communication can have several components:

- Hostname or IP address
- Authentication destination port
- Accounting destination port
• Retransmission value
• Timeout period
• Key string

RADIUS security servers are identified on the basis of their hostname or IP address, hostname and specific User Datagram Protocol (UDP) port numbers, or IP address and specific UDP port numbers. The combination of the IP address and UDP port numbers creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. In other words, this unique identifier enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address. If two different host entries on the same RADIUS server are configured for the same service—for example, accounting—the second host entry configured acts as an automatic switchover backup to the first one. Using this example, if the first host entry fails to provide accounting services, the network access server tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order they are configured.)

A RADIUS server and a Cisco router use a shared secret text string to encrypt passwords and exchange responses. To configure RADIUS to use the AAA security commands, you must specify the host running the RADIUS server daemon and a secret text (key) string that it shares with the router.

The timeout, retransmission, and encryption key values are configurable globally for all RADIUS servers, on a per-server basis, or in some combination of global and per-server settings. To apply these settings globally to all RADIUS servers communicating with the router, use the three unique global commands: `radius-server timeout`, `radius-server retransmit`, and `radius-server key`. To apply these values on a specific RADIUS server, use the `radius-server host` command.

---

**SUMMARY STEPS**

1. configure
2. `radius-server host {hostname|ip-address} [auth-port port-number] [acct-port port-number] [timeout seconds] [retransmit retries] [key string]
3. `radius-server retransmit` retries
4. `radius-server timeout` seconds
5. `radius-server key` {0 clear-text-key | 7 encrypted-key | clear-text-key}
6. `radius source-interface` type instance [vrf vrf-id]
7. Repeat step 2 through step 6 for each external server to be configured.
8. `commit`
9. `show radius`

---

**DETAILED STEPS**

**Step 1** configure
Configure Router to RADIUS Server Communication

**Step 2**

`radius-server host {hostname | ip-address} [auth-port port-number] [acct-port port-number] [timeout seconds] [retransmit retries] [key string]

Example:

```
RP/0/RP0/CPU0:router(config)# radius-server host host1
```

Specifies the hostname or IP address of the remote RADIUS server host.

- Use the `auth-port port-number` option to configure a specific UDP port on this RADIUS server to be used solely for authentication.
- Use the `acct-port port-number` option to configure a specific UDP port on this RADIUS server to be used solely for accounting.
- To configure the network access server to recognize more than one host entry associated with a single IP address, simply repeat this command as many times as necessary, making sure that each UDP port number is different. Set the timeout, retransmit, and encryption key values to use with the specific RADIUS host.
- If no timeout is set, the global value is used; otherwise, enter a value in the range 1 to 1000. If no retransmit value is set, the global value is used; otherwise enter a value in the range 1 to 100. If no key string is specified, the global value is used.

**Note** The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the `radius-server host` command syntax because the leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks themselves are part of the key.

**Step 3**

`radius-server retransmit retries`

Example:

```
RP/0/RP0/CPU0:router(config)# radius-server retransmit 5
```

Specifies the number of times the software searches the list of RADIUS server hosts before giving up.

- In the example, the number of retransmission attempts is set to 5.

**Step 4**

`radius-server timeout seconds`

Example:

```
RP/0/RP0/CPU0:router(config)# radius-server timeout 10
```

Sets the number of seconds a router waits for a server host to reply before timing out.

- In the example, the interval timer is set to 10 seconds.

**Step 5**

`radius-server key {0 clear-text-key | 7 encrypted-key | clear-text-key}

Example:

```
RP/0/RP0/CPU0:router(config)# radius-server key 0 samplekey
```

Sets the authentication and encryption key for all RADIUS communications between the router and the RADIUS daemon.

**Step 6**

`radius source-interface type instance [vrf vrf-id]

Example:

```
RP/0/RP0/CPU0:router(config)# radius source-interface 0/3/0/1
```

(Optional) Forces RADIUS to use the IP address of a specified interface or subinterface for all outgoing RADIUS packets.
• The specified interface or subinterface must have an IP address associated with it. If the specified interface or subinterface does not have an IP address or is in the down state, then RADIUS reverts to the default. To avoid this, add an IP address to the interface or subinterface or bring the interface to the up state.

The **vrf** keyword enables the specification on a per-VRF basis.

**Step 7**
Repeat step 2 through step 6 for each external server to be configured.

---

**Step 8**
*commit*

**Step 9**
*show radius*

**Example:**

```
RP/0/RP0/CPU0:router# show radius
(Optional) Displays information about the RADIUS servers that are configured in the system.
```

---

**Radius Summary Example**

```
radius source-interface Mgm0/rp0/cpu0/0 vrf default
radius-server timeout 10
radius-server retransmit 2

! OOB RADIUS
radius-server host 123.100.100.186 auth-port 1812 acct-port 1813
   key cisco123
timeout 10
retransmit 2

radius-server host 123.100.100.187 auth-port 1812 acct-port 1813
   key cisco123
timeout 10
retransmit 2

! aaa group server radius radgrp
server 123.100.100.186 auth-port 1812 acct-port 1813
server 123.100.100.187 auth-port 1812 acct-port 1813

! aaa authorization exec radauthen group radgrp local
aaa authentication login radlogin group radgrp local

line template vty
   authorization exec radauthen
   login authentication radlogin
timestamp disable
exec-timeout 0 0

vty-pool default 0 99 line-template vty
```
Configure RADIUS Dead-Server Detection

The RADIUS Dead-Server Detection feature lets you configure and determine the criteria that is used to mark a RADIUS server as dead. If no criteria is explicitly configured, the criteria is computed dynamically on the basis of the number of outstanding transactions. The RADIUS dead-server detection configuration results in the prompt detection of RADIUS servers that have stopped responding. The prompt detection of nonresponding RADIUS servers and the avoidance of swamped and dead-to-live-to-dead-again servers result in less deadtime and quicker packet processing.

You can configure the minimum amount of time, in seconds, that must elapse from the time that the router last received a valid packet from the RADIUS server to the time the server is marked as dead. If a packet has not been received since the router booted, and there is a timeout, the time criterion is treated as though it was met.

In addition, you can configure the number of consecutive timeouts that must occur on the router before the RADIUS server is marked as dead. If the server performs both authentication and accounting, both types of packets are included in the number. Improperly constructed packets are counted as though they are timeouts. Only retransmissions are counted, not the initial transmission. For example, each timeout causes one retransmission to be sent.

Note

Both the time criterion and the tries criterion must be met for the server to be marked as dead.

The **radius-server deadtime** command specifies the time, in minutes, for which a server is marked as dead, remains dead, and, after this period, is marked alive even when no responses were received from it. When the dead criteria are configured, the servers are not monitored unless the **radius-server deadtime** command is configured.

**SUMMARY STEPS**

1. configure
2. radius-server deadtime minutes
3. radius-server dead-criteria time seconds
4. radius-server dead-criteria tries tries
5. commit
6. show radius dead-criteria host ip-addr [auth-port auth-port] [acct-port acct-port]

**DETAILED STEPS**

Step 1  configure
Step 2  radius-server deadtime minutes

Example:

RP/0/RP0/CPU0:router(config)# radius-server deadtime 5

Improves RADIUS response times when some servers might be unavailable and causes the unavailable servers to be skipped immediately.
Configure TACACS+ Server

This task configures a TACACS+ server.

The port, if not specified, defaults to the standard port number, 49. The timeout and key parameters can be specified globally for all TACACS+ servers. The timeout parameter specifies how long the AAA server waits to receive a response from the TACACS+ server. The key parameter specifies an authentication and encryption key shared between the AAA server and the TACACS+ server.

SUMMARY STEPS

1. configure
2. tacacs-server host host-name port port-number
3. tacacs-server host host-name timeout seconds
4. tacacs-server host host-name key [0 | 7] auth-key
5. tacacs-server host host-name single-connection
6. tacacs source-interface type instance
7. Repeat step 2 through step 5 for each external server to be configured.
8. commit
9. show tacacs
DETAILED STEPS

Step 1  configure

Step 2  tacacs-server host host-name port port-number

Example:

RP/0/RP0/CPU0:router(config)# tacacs-server host 209.165.200.226 port 51
RP/0/RP0/CPU0:router(config-tacacs-host)#

Specifies a TACACS+ host server and optionally specifies a server port number.

• This option overrides the default, port 49. Valid port numbers range from 1 to 65535.

Step 3  tacacs-server host host-name timeout seconds

Example:

RP/0/RP0/CPU0:router(config-tacacs-host)# tacacs-server host 209.165.200.226 timeout 30
RP/0/RP0/CPU0:router(config)#

Specifies a TACACS+ host server and optionally specifies a timeout value that sets the length of time the AAA server waits to receive a response from the TACACS+ server.

• This option overrides the global timeout value set with the tacacs-server timeout command for only this server. The timeout value is expressed as an integer in terms of timeout interval seconds. The range is from 1 to 1000.

Step 4  tacacs-server host host-name key [0 | 7] auth-key

Example:

RP/0/RP0/CPU0:router(config)# tacacs-server host 209.165.200.226 key 0 a_secret

Specifies a TACACS+ host server and optionally specifies an authentication and encryption key shared between the AAA server and the TACACS+ server.

• The TACACS+ packets are encrypted using this key. This key must match the key used by TACACS+ daemon. Specifying this key overrides the global key set by the tacacs-server key command for only this server.

• (Optional) Entering 0 indicates that an unencrypted (clear-text) key follows.

• (Optional) Entering 7 indicates that an encrypted key follows.

• The auth-key argument specifies the encrypted or unencrypted key to be shared between the AAA server and the TACACS+ server.

Step 5  tacacs-server host host-name single-connection

Example:

RP/0/RP0/CPU0:router(config)# tacacs-server host 209.165.200.226 single-connection

Prompts the router to multiplex all TACACS+ requests to this server over a single TCP connection. By default, a separate connection is used for each session.

Step 6  tacacs source-interface type instance

Example:

RP/0/RP0/CPU0:router(config)# tacacs source-interface 0/4/0/0
(Optional) Specifies the source IP address of a selected interface for all outgoing TACACS+ packets.

- The specified interface or subinterface must have an IP address associated with it. If the specified interface or subinterface does not have an IP address or is in the down state, then TACACS+ reverts to the default interface. To avoid this, add an IP address to the interface or subinterface or bring the interface to the up state.

- The `vrf` option specifies the Virtual Private Network (VPN) routing and forwarding (VRF) reference of an AAA TACACS+ server group.

**Step 7**  
Repeat step 2 through step 5 for each external server to be configured.

**Step 8**  
`commit`

**Step 9**  
`show tacacs`

**Example:**

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

(Optional) Displays information about the TACACS+ servers that are configured in the system.

---

**Tacacs Summary Example:**

```
! OOB TAC
  tacacs-server host 123.100.100.186 port 49
  key lm51
  !
  tacacs-server host 123.100.100.187 port 49
  key lm51
  !
  aaa group server tacacs+ tacgrp
  server 123.100.100.186
  server 123.100.100.187
  !
  aaa group server tacacs+ eem
  server 123.100.100.186
  server 123.100.100.187
  !
  aaa authorization exec tacauthen group tacgrp local
  aaa authentication login taclogin group tacgrp local
  !
  line console
  authorization exec tacauthen
  login authentication taclogin
  timeout login response 30
  timestamp
  exec-timeout 0 0
  session-timeout 15
  !
  vty-pool default 0 99 line-template console
```
Configure RADIUS Server Groups

This task configures RADIUS server groups. The user can enter one or more `server` commands. The `server` command specifies the hostname or IP address of an external RADIUS server along with port numbers. When configured, this server group can be referenced from the AAA method lists (used while configuring authentication, authorization, or accounting).

**Before you begin**

For configuration to succeed, the external server should be accessible at the time of configuration.

**SUMMARY STEPS**

1. `configure`
2. `aaa group server radius group-name`
3. `server {hostname | ip-address} [auth-port port-number] [acct-port port-number]`
4. Repeat step 4 for every external server to be added to the server group named in step 3.
5. `deadtime minutes`
6. `commit`
7. `show radius server-groups [group-name [detail]]`

**DETAILED STEPS**

**Step 1**

`configure`

**Step 2**

`aaa group server radius group-name`

**Example:**

`RP/0/RP0/CPU0:router(config)# aaa group server radius radgroup1`

Groups different server hosts into distinct lists and enters the server group configuration mode.

**Step 3**

`server {hostname | ip-address} [auth-port port-number] [acct-port port-number]`

**Example:**

`RP/0/RP0/CPU0:router(config-sg-radius)# server 192.168.20.0`

Specifies the hostname or IP address of an external RADIUS server.

* After the server group is configured, it can be referenced from the AAA method lists (used while configuring authentication, authorization, or accounting).

**Step 4**

Repeat step 4 for every external server to be added to the server group named in step 3.

**Step 5**

`deadtime minutes`

**Example:**

`RP/0/RP0/CPU0:router(config-sg-radius)# deadtime 1`

Confirms the deadtime value at the RADIUS server group level.
• The minutes argument specifies the length of time, in minutes, for which a RADIUS server is skipped over by transaction requests, up to a maximum of 1440 (24 hours). The range is from 1 to 1440.

The example specifies a one-minute deadtime for RADIUS server group radgroup1 when it has failed to respond to authentication requests for the **deadtime** command

**Note** You can configure the group-level deadtime after the group is created.

**Step 6** commit

**Step 7** show radius server-groups [group-name [detail]]

**Example:**
```
RP/0/RP0/CPU0:router# show radius server-groups
```

(Optional) Displays information about each RADIUS server group that is configured in the system.

---

**What to do next**

After configuring RADIUS server groups, define method lists by configuring authentication, authorization, and accounting.

**Configure TACACS+ Server Groups**

This task configures TACACS+ server groups.

You can enter one or more **server** commands. The **server** command specifies the hostname or IP address of an external TACACS+ server. Once configured, this server group can be referenced from the AAA method lists (used while configuring authentication, authorization, or accounting).

**Before you begin**

For successful configuration, the external server should be accessible at the time of configuration. When configuring the same IP address for global and vrf configuration, server-private parameters are required (see **Configure Per VRF TACACS+ Server Groups**, on page 19).

**SUMMARY STEPS**

1. configure
2. aaa group server tacacs+ group-name
3. server {hostname | ip-address}
4. Repeat step 3 for every external server to be added to the server group named in step 2.
5. server-private {hostname | ip-address in IPv4 or IPv6 format} [port port-number] [timeout seconds] [key string]
6. (Optional) vrf vrf-id
7. commit
8. show tacacs server-groups
**DETAILED STEPS**

Step 1  configure

Step 2  aaa group server tacacs+  group-name

**Example:**

```
RP/0/RP0/CPU0:router(config)# aaa group server tacacs+ tacgroup1
```

Groups different server hosts into distinct lists and enters the server group configuration mode.

Step 3  server  {hostname | ip-address}

**Example:**

```
RP/0/RP0/CPU0:router(config-sg-tacacs+)# server 192.168.100.0
```

Specifies the hostname or IP address of an external TACACS+ server.

- When configured, this group can be referenced from the AAA method lists (used while configuring authentication, authorization, or accounting).

Step 4  Repeat step 3 for every external server to be added to the server group named in step 2.

---

Step 5  server-private  {hostname | ip-address in IPv4 or IPv6 format} [port port-number] [timeout seconds] [key string]

**Example:**

```
Router(config-sg-tacacs+)# server-private 10.1.1.1 key a_secret
```

Configures the IP address of the private TACACS+ server for the group server.

**Note**  If private server parameters are not specified, global configurations are used. If global configurations are not specified, default values are used.

Step 6  (Optional) vrf  vrf-id

**Example:**

```
Router(config-sg-tacacs+)# vrf test-vrf
```

The vrf option specifies the Virtual Private Network (VPN) routing and forwarding (VRF) reference of an AAA TACACS+ server group.

Step 7  commit

Step 8  show tacacs server-groups

**Example:**

```
RP/0/RP0/CPU0:router# show tacacs server-groups
```

(Optional) Displays information about each TACACS+ server group that is configured in the system.
Configure Per VRF TACACS+ Server Groups

The Cisco IOS XR software supports per VRF AAA to be configured on TACACS+ server groups. You must use the `server-private` and `vrf` commands as listed below to configure this feature.

The global server definitions can be referred from multiple server groups, but all references use the same server instance and connect to the same server. In case of VRF, you do not need the global configuration because the server status, server statistics and the key could be different for different VRFs. Therefore, you must use the server-private configuration if you want to configure per VRF TACACS+ server groups. If you have the same server used in different groups with different VRFs, ensure that it is reachable through all those VRFs.

If you are migrating the servers to a VRF, then it is safe to remove the global server configuration with respect to that server.

**Prerequisites**

You must ensure these before configuring per VRF on TACACS+ server groups:

- Be familiar with configuring TACACS+, AAA, per VRF AAA, and group servers.
- Ensure that you have access to the TACACS+ server.
- Configure the VRF instance before configuring the specific VRF for a TACACS+ server and ensure that the VRF is reachable.

**Configuration Example**

Router#configure

/* Groups different server hosts into distinct lists and enters the server group configuration mode. You can enter one or more server commands. The server command specifies the hostname or IP address of an external TACACS+ server. Once configured, this server group can be referenced from the AAA method lists (used while configuring authentication, authorization, or accounting). */

Router(config)# aaa group server tacacs+ tacgroup1

/* Configures the IP address and the secret key of the private TACACS+ server that is reachable through specific VRF. You can have multiple such server configurations which are reachable through the same VRF. */

Router(config-sg-tacacs+)# server-private 10.1.1.1 port 49 key a_secret

/* The vrf option specifies the VRF reference of a AAA TACACS+ server group */
Router(config-sg-tacacs+)# vrf test-vrf
Router(config-sg-tacacs+)# commit

**Running Configuration**

```
aaa group server tacacs+ tacgroup1
vrf test-vrf
server-private 10.1.1.1 port 49
    key 7 0822455D0A16
```
Create Series of Authentication Methods

Authentication is the process by which a user (or a principal) is verified. Authentication configuration uses method lists to define an order of preference for the source of AAA data, which may be stored in a variety of data sources. You can configure authentication to define more than one method list and applications (such as login) can choose one of them. For example, console ports may use one method list and the vty ports may use another. If a method list is not specified, the application tries to use a default method list.

Note
Applications should explicitly refer to defined method lists for the method lists to be effective.
The authentication can be applied to tty lines through use of the **login authentication** line configuration submode command. If the method is RADIUS or TACACS+ servers, rather than server group, the RADIUS or TACACS+ server is chosen from the global pool of configured RADIUS and TACACS+ servers, in the order of configuration. Servers from this global pool are the servers that can be selectively added to a server group.

The subsequent methods of authentication are used only if the initial method returns an error, not if the request is rejected.

**Before you begin**

---

**Note**

The default method list is applied for all the interfaces for authentication, except when a non-default named method list is explicitly configured, in which case the named method list is applied.

The **group radius**, **group tacacs+**, and **group group-name** forms of the **aaa authentication** command refer to a set of previously defined RADIUS or TACACS+ servers. Use the **radius server-host or tacacs-server host** command to configure the host servers. Use the **aaa group server radius or aaa group server tacacs+** command to create a named group of servers.

---

### SUMMARY STEPS

1. configure
2. **aaa authentication {login} {default | list-name} method-list**
3. commit
4. Repeat Step 1 through Step 3 for every authentication method list to be configured.

### DETAILED STEPS

#### Step 1

configure

#### Step 2

**aaa authentication {login} {default | list-name} method-list**

**Example:**

```
RP/0//CPU0:router(config)# aaa authentication login default group tacacs+
```

Creates a series of authentication methods, or a method list.

- Using the **login** keyword sets authentication for login. Using the **ppp** keyword sets authentication for Point-to-Point Protocol.
- Entering the **default** keyword causes the listed authentication methods that follow this keyword to be the default list of methods for authentication.
- Entering a **list-name** character string identifies the authentication method list.
- Entering a **method-list** argument following the method list type. Method list types are entered in the preferred sequence. The listed method types are any one of the following options:
  - **group tacacs+**—Use a server group or TACACS+ servers for authentication
  - **group radius**—Use a server group or RADIUS servers for authentication
Create Series of Authorization Methods

Method lists for authorization define the ways authorization will be performed and the sequence in which these methods will be performed. A method list is a named list describing the authorization methods to be used (such as TACACS+), in sequence. Method lists enable you to designate one or more security protocols to be used for authorization, thus ensuring a backup system if the initial method fails. The software uses the first method listed to authorize users for specific network services; if that method fails to respond, the software selects the next method listed in the method list. This process continues until there is successful communication with a listed authorization method, or until all methods defined have been exhausted.

Note

The software attempts authorization with the next listed method only when there is no response or an error response (not a failure) from the previous method. If authorization fails at any point in this cycle—meaning that the security server or local username database responds by denying the user services—the authorization process stops and no other authorization methods are attempted.

When you create a named method list, you are defining a particular list of authorization methods for the indicated authorization type. When defined, method lists must be applied to specific lines or interfaces before any of the defined methods are performed. Do not use the names of methods, such as TACACS+, when creating a new method list.

“Command” authorization, as a result of adding a command authorization method list to a line template, is separate from, and is in addition to, “task-based” authorization, which is performed automatically on the router. The default behavior for command authorization is none. Even if a default method list is configured, that method list has to be added to a line template for it to be used.

The aaa authorization commands command causes a request packet containing a series of attribute value (AV) pairs to be sent to the TACACS+ daemon as part of the authorization process. The daemon can do one of the following:

- Accept the request as is.
- Refuse authorization.

Use the aaa authorization command to set parameters for authorization and to create named method lists defining specific authorization methods that can be used for each line or interface.
SUMMARY STEPS

1. configure
2. aaa authorization {commands | eventmanager | exec | network} {default | list-name} {none | local | group {tacacs+ | radius | group-name}}
3. commit

DETAILED STEPS

Example:

RP/0/CP00:router(config)# aaa authorization commands listname1 group tacacs+

Creates a series of authorization methods, or a method list.

- The **commands** keyword configures authorization for all XR EXEC mode shell commands. Command authorization applies to the EXEC mode commands issued by a user. Command authorization attempts authorization for all XR EXEC mode commands.

- The **eventmanager** keyword applies an authorization method for authorizing an event manager (fault manager).

- The **exec** keyword configures authorization for an interactive (XR EXEC mode) session.

- The **network** keyword configures authorization for network services like PPP or IKE.

- The **default** keyword causes the listed authorization methods that follow this keyword to be the default list of methods for authorization.

- A **list-name** character string identifies the authorization method list. The method list itself follows the method list name. Method list types are entered in the preferred sequence. The listed method list types can be any one of the following:
  - **none**—The network access server (NAS) does not request authorization information. Authorization always succeeds. No subsequent authorization methods will be attempted. However, the task ID authorization is always required and cannot be disabled.
  - **local**—Uses local database for authorization.

- **group tacacs+**—Uses the list of all configured TACACS+ servers for authorization. The NAS exchanges authorization information with the TACACS+ security daemon. TACACS+ authorization defines specific rights for users by associating AV pairs, which are stored in a database on the TACACS+ security server, with the appropriate user.

- **group radius**—Uses the list of all configured RADIUS servers for authorization.

- **group group-name**—Uses a named server group, a subset of TACACS+ or RADIUS servers for authorization as defined by the **aaa group server tacacs+** or **aaa group server radius** command.
Create Series of Accounting Methods

Use the `aaa accounting` command to create default or named method lists defining specific accounting methods that can be used for each line or interface.

Currently, the software supports both the TACACS+ and RADIUS methods for accounting. The router reports user activity to the TACACS+ or RADIUS security server in the form of accounting records. Each accounting record contains accounting AV pairs and is stored on the security server.

Method lists for accounting define the way accounting is performed, enabling you to designate a particular security protocol to be used on specific lines or interfaces for particular types of accounting services. When naming a method list, do not use the names of methods, such as TACACS+.

For minimal accounting, include the `stop-only` keyword to send a “stop accounting” notice at the end of the requested user process. For more accounting, you can include the `start-stop` keyword, so that the external AAA server sends a “start accounting” notice at the beginning of the requested process and a “stop accounting” notice at the end of the process. In addition, you can use the `aaa accounting update` command to periodically send update records with accumulated information. Accounting records are stored only on the TACACS+ or RADIUS server.

When AAA accounting is activated, the router reports these attributes as accounting records, which are then stored in an accounting log on the security server.

**SUMMARY STEPS**

1. configure
2. Do one of the following:
   - `aaa accounting {commands | exec | network} {default | list-name} {start-stop | stop-only}
   - {none | method}
3. commit

**DETAILED STEPS**

**Step 1**
configure

**Step 2**
Do one of the following:

- `aaa accounting {commands | exec | network} {default | list-name} {start-stop | stop-only}
- {none | method}

**Example:**

RP/0//CP00:router(config)# aaa accounting commands default stop-only group tacacs+

**Note**
Command accounting is not supported on RADIUS, but supported on TACACS.

Creates a series of accounting methods, or a method list.

- The `commands` keyword enables accounting for XR EXEC mode shell commands.
- The `exec` keyword enables accounting for an interactive (XR EXEC mode) session.
• The **network** keyword enables accounting for all network-related service requests, such as Point-to-Point Protocol (PPP).

• The **default** keyword causes the listed accounting methods that follow this keyword to be the default list of methods for accounting.

• A **list-name** character string identifies the accounting method list.

• The **start-stop** keyword sends a “start accounting” notice at the beginning of a process and a “stop accounting” notice at the end of a process. The requested user process begins regardless of whether the “start accounting” notice was received by the accounting server.

• The **stop-only** keyword sends a “stop accounting” notice at the end of the requested user process.

• The **none** keyword states that no accounting is performed.

• The method list itself follows the **start-stop** keyword. Method list types are entered in the preferred sequence. The method argument lists the following types:
  - **group tacacs+**—Use the list of all configured TACACS+ servers for accounting.
  - **group radius**—Use the list of all configured RADIUS servers for accounting.
  - **group group-name**—Use a named server group, a subset of TACACS+ or RADIUS servers for accounting as defined by the `aaa group server tacacs+` or `aaa group server radius` command.

• The example defines a **default** command accounting method list, in which accounting services are provided by a TACACS+ security server, with a stop-only restriction.

---

### Generate Interim Accounting Records

This task enables periodic interim accounting records to be sent to the accounting server. When the `aaa accounting update` command is activated, software issues interim accounting records for all users on the system.

#### Note

Interim accounting records are generated only for network sessions, such as Internet Key Exchange (IKE) accounting, which is controlled by the `aaa accounting` command with the **network** keyword. System, command, or EXEC accounting sessions cannot have interim records generated.

#### SUMMARY STEPS

1. configure
2. `aaa accounting update {newinfo | periodic minutes}`
3. commit
DETAILED STEPS

Step 1
configure

Step 2
aaa accounting update \{newinfo | periodic minutes\}

Example:

RP/0//CP00:router(config)# aaa accounting update periodic 30

Enables periodic interim accounting records to be sent to the accounting server.

• If the newinfo keyword is used, interim accounting records are sent to the accounting server every time there is new accounting information to report. An example of this report would be when IPCP completes IP address negotiation with the remote peer. The interim accounting record includes the negotiated IP address used by the remote peer.

• When used with the periodic keyword, interim accounting records are sent periodically as defined by the argument number. The interim accounting record contains all the accounting information recorded for that user up to the time the interim accounting record is sent.

Caution The periodic keyword causes heavy congestion when many users are logged in to the network.

Step 3
commit

---

Apply Method List

After you use the aaa authorization command to define a named authorization method list (or use the default method list) for a particular type of authorization, you must apply the defined lists to the appropriate lines in order for authorization to take place. Use the authorization command to apply the specified method lists (or, if none is specified, the default method list) to the selected line or group of lines.

SUMMARY STEPS

1. configure
2. line \{ console | default | template template-name\}
3. authorization \{commands | exec\} \{default | list-name\}
4. commit

DETAILED STEPS

Step 1
configure

Step 2
line \{ console | default | template template-name\}

Example:

RP/0//CP00:router(config)# line console

Enters line template configuration mode.
**Step 3**

authorization {commands | exec} {default | list-name}

**Example:**

RP/0//CPU0:router(config-line)# authorization commands listname5

Enables AAA authorization for a specific line or group of lines.

- The `commands` keyword enables authorization on the selected lines for all commands.
- The `exec` keyword enables authorization for an interactive (XR EXEC mode) session.
- Enter the `default` keyword to apply the name of the default method list, as defined with the `aaa authorization` command.
- Enter the name of a list of authorization methods to use. If no list name is specified, the system uses the default. The list is created with the `aaa authorization` command.
- The example enables command authorization using the method list named listname5.

**Step 4**

commit

---

**What to do next**

After applying authorization method lists by enabling AAA authorization, apply accounting method lists by enabling AAA accounting.

**Enable Accounting Services**

This task enables accounting services for a specific line of group of lines.

**SUMMARY STEPS**

1. configure
2. line { console | default | template template-name}
3. accounting {commands | exec} {default | list-name}
4. commit

**DETAILED STEPS**

**Step 1**

configure

**Step 2**

line { console | default | template template-name}

**Example:**

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

Enters line template configuration mode.

**Step 3**

accounting {commands | exec} {default | list-name}
Example:

RP/0//CPU0:router(config-line)# accounting commands listname7

Enables AAA accounting for a specific line or group of lines.

- The **commands** keyword enables accounting on the selected lines for all XR EXEC mode shell commands.
- The **exec** keyword enables accounting for an interactive (XR EXEC mode) session.
- Enter the **default** keyword to apply the name of the default method list, as defined with the **aaa accounting** command.
- Enter the name of a list of accounting methods to use. If no list name is specified, the system uses the default. The list is created with the **aaa accounting** command.
- The example enables command accounting using the method list named listname7.

Step 4  commit

What to do next

After applying accounting method lists by enabling AAA accounting services, configure login parameters.

**Configure Login Parameters**

This task sets the interval that the server waits for reply to a login.

**SUMMARY STEPS**

1. configure
2. line template  *template-name*
3. timeout login response  *seconds*
4. commit

**DETAILED STEPS**

Step 1  configure
Step 2  line template  *template-name*

Example:

RP/0//CPU0:router(config)# line template alpha

Specifies a line to configure and enters line template configuration mode.

Step 3  timeout login response  *seconds*

Example:

RP/0//CPU0:router(config-line)# timeout login response 20
Sets the interval that the server waits for reply to a login.

- The *seconds* argument specifies the timeout interval (in seconds) from 0 to 300. The default is 30 seconds.
- The example shows how to change the interval timer to 20 seconds.

## Task Maps

For users who are authenticated using an external TACACS+ server and RADIUS server, Cisco IOS XR software AAA supports a method to define task IDs remotely.

### Format of the Task String

The task string in the configuration file of the TACACS+ server consists of tokens delimited by a comma (,). Each token contains either a task ID name and its permissions or the user group to include for this particular user, as shown in the following example:

```
task = " permissions : taskid name , # usergroup name , ...
```

Cisco IOS XR software allows you to specify task IDs as an attribute in the external RADIUS or TACACS+ server. If the server is also shared by non-Cisco IOS XR software systems, these attributes are marked as optional as indicated by the server documentation. For example, CiscoSecure ACS and the freeware TACACS+ server from Cisco require an asterisk (*) instead of an equal sign (=) before the attribute value for optional attributes. If you want to configure attributes as optional, refer to the TACACS+ server documentation.

For example, to give a user named user1 BGP read, write, and execute permissions and include user1 in a user group named operator, the username entry in the external server’s TACACS+ configuration file would look similar to the following:

```
user = user1{
  member = some-tac-server-group
  opap = cleartext "lab"
  service = exec {
    task = "rwx:bgp,#operator"
  }
}
```

The r,w,x, and d correspond to read, write, execute and debug, respectively, and the pound sign (#) indicates that a user group follows.

The optional keyword must be added in front of “task” to enable interoperability with systems based on Cisco IOS software.

If CiscoSecure ACS is used, perform the following procedure to specify the task ID and user groups:
SUMMARY STEPS

1. Enter your username and password.
2. Click the Group Setup button to display the Group Setup window.
3. From the Group drop-down list, select the group that you want to update.
4. Click the Edit Settings button.
5. Use the scroll arrow to locate the Shell (exec) check box.
6. Check the Shell (exec) check box to enable the custom attributes configuration.
7. Check the Custom attributes check box.
8. Enter the following task string without any blank spaces or quotation marks in the field:
9. Click the Submit + Restart button to restart the server.

DETAILED STEPS

Step 1 Enter your username and password.
Step 2 Click the Group Setup button to display the Group Setup window.
Step 3 From the Group drop-down list, select the group that you want to update.
Step 4 Click the Edit Settings button.
Step 5 Use the scroll arrow to locate the Shell (exec) check box.
Step 6 Check the Shell (exec) check box to enable the custom attributes configuration.
Step 7 Check the Custom attributes check box.
Step 8 Enter the following task string without any blank spaces or quotation marks in the field:

Example:

```
task=rwx:bgp,#netadmin
```

Step 9 Click the Submit + Restart button to restart the server.

The following RADIUS Vendor-Specific Attribute (VSA) example shows that the user is part of the sysadmin predefined task group, can configure BGP, and can view the configuration for OSPF:

Example:

```
user Auth-Type := Local, User-Password == lab
Service-Type = NAS-Prompt-User,
Reply-Message = "Hello, %u",
Login-Service = Telnet,
Cisco-AVPair = "shell:tasks=#sysadmin,rwx:bgp,r:ospf"
```

After user1 successfully connects and logs in to the external TACACS+ server with username user1 and appropriate password, the `show user tasks` command can be used in XR EXEC mode to display all the tasks user1 can perform. For example:

Example:

```
Username:user1
Password:
RP/0/RP0/CPU0:router# show user tasks

Task: basic-services :READ WRITE EXECUTE DEBUG
Task: bgp :READ WRITE EXECUTE
```
Task: cdp :READ
Task: diag :READ
Task: ext-access :READ EXECUTE
Task: logging :READ

Alternatively, if a user named user2, who does not have a task string, logs in to the external server, the following information is displayed:

Example:

Username:user2
Password:
RP/0/RP0/CPU0:router# show user tasks
No task ids available

References for AAA Services

This section lists all the conceptual information that a software user must understand before configuring user groups and task groups through AAA or configuring Remote Authentication Dial-in User Service (RADIUS) or TACACS+ servers. Conceptual information also describes what AAA is and why it is important.

User, User Groups, and Task Groups

User attributes form the basis of the Cisco software administrative model. Each router user is associated with the following attributes:

- User ID (ASCII string) that identifies the user uniquely across an administrative domain
- Length limitation of 253 characters for passwords and one-way encrypted secrets
- List of user groups (at least one) of which the user is a member (thereby enabling attributes such as task IDs).

User Categories

Router users are classified into the following categories:

- Root Secure Domain Router (SDR) user (specific SDR administrative authority)
- SDR user (specific SDR user access)

Root System Users

The root system user is the entity authorized to “own” the entire router chassis. The root system user functions with the highest privileges over all router components and can monitor all secure domain routers in the system. At least one root system user account must be created during router setup. Multiple root system users can exist.

The root system user can perform any configuration or monitoring task, including the following:

- Configure secure domain routers.
• Create, delete, and modify root SDR users (after logging in to the secure domain router as the root system user).

• Create, delete, and modify secure domain router users and set user task permissions (after logging in to the secure domain router as the root system user).

• Access fabric racks or any router resource not allocated to a secure domain router, allowing the root system user to authenticate to any router node regardless of the secure domain router configurations.

**Root SDR Users**

A root SDR user controls the configuration and monitoring of a particular SDR. The root SDR user can create users and configure their privileges within the SDR. Multiple root SDR users can work independently. A single SDR may have more than one root SDR user.

A root SDR user can perform the following administrative tasks for a particular SDR:

• Create, delete, and modify secure domain router users and their privileges for the SDR.

• Create, delete, and modify user groups to allow access to the SDR.

• Manage nearly all aspects of the SDR.

A root SDR user cannot deny access to a root system user.

**Secure Domain Router (SDR) Users**

A SDR user has restricted access to an SDR as determined by the root SDR user. The SDR user performs the day-to-day system and network management activities. The tasks that the secure domain router user is allowed to perform are determined by the task IDs associated with the user groups to which the SDR user belongs. Multiple SDRs in a chasis are not supported.

**User Groups**

A *user group* defines a collection of users that share a set of attributes, such as access privileges. Cisco software allows the system administrator to configure groups of users and the job characteristics that are common in groups of users. Users are not assigned to groups by default hence the assignment needs to be done explicitly. A user can be assigned to more than one group.

Each user may be associated with one or more user groups. User groups have the following attributes:

• A user group consists of the list of task groups that define the authorization for the users. All tasks, except cisco-support, are permitted by default for root system users.

• Each user task can be assigned read, write, execute, or debug permission.

**Predefined User Groups**

The Cisco software provides a collection of user groups whose attributes are already defined. The predefined groups are as follows:

• **cisco-support**: This group is used by the Cisco support team.

• **netadmin**: Has the ability to control and monitor all system and network parameters.

• **operator**: A demonstration group with basic privileges.
• **root-lr**: Has the ability to control and monitor the specific secure domain router.

• **sysadmin**: Has the ability to control and monitor all system parameters but cannot configure network protocols.

• **serviceadmin**: Service administration tasks, for example, Session Border Controller (SBC).

**User-Defined User Groups**

Administrators can configure their own user groups to meet particular needs.

**User Group Inheritance**

A user group can derive attributes from another user group. (Similarly, a task group can derive attributes from another task group.) For example, when user group A inherits attributes from user group B, the new set of task attributes of the user group A is a union of A and B. The inheritance relationship among user groups is dynamic in the sense that if group A inherits attributes from group B, a change in group B affects group A, even if the group is not reinherited explicitly.

**Task Groups**

Task groups are defined by lists of permitted task IDs for each type of action (such as read, write, and so on). The task IDs are basically defined in the router system. Task ID definitions may have to be supported before task groups in external software can be configured.

Task IDs can also be configured in external TACACS+ or RADIUS servers.

**Predefined Task Groups**

The following predefined task groups are available for administrators to use, typically for initial configuration:

• **cisco-support**: Cisco support personnel tasks

• **netadmin**: Network administrator tasks

• **operator**: Operator day-to-day tasks (for demonstration purposes)

• **root-lr**: Secure domain router administrator tasks

• **sysadmin**: System administrator tasks

• **serviceadmin**: Service administration tasks, for example, SBC

**User-Defined Task Groups**

Users can configure their own task groups to meet particular needs.

**Group Inheritance**

Task groups support inheritance from other task groups. (Similarly, a user group can derive attributes from another user group. For example, when task group A inherits task group B, the new set of attributes of task group A is the union of A and B.)
Command Access in XR and Admin Modes

The XR user group and task is mapped to the System Admin VM group when the System Admin mode is accessed from XR mode using `admin` command. The corresponding access permission on System Admin VM is available to the user. Currently, only `aaa`, admin task and `root-lr` groups are mapped to System Admin VM group or task. The other tasks like protocols are not mapped as these services are not supported in System Admin VM. The disaster-recovery user of System Admin VM is synced with the Host VM.

<table>
<thead>
<tr>
<th>XR Task or Group</th>
<th>Sysadmin VM Group</th>
<th>Access</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>root-lr</td>
<td>Root-system group</td>
<td>Full access to the system configuration.</td>
<td>RP/0/RP0/CPU0:ios#show user group Mon Nov 3 13:48:54.536 UTC root-lr, cisco-support RP/0/RP0/CPU0:ios#show user tasks</td>
</tr>
<tr>
<td>Admin-r/w/x/d</td>
<td>Admin-r</td>
<td>Read only commands on Sysadmin VM</td>
<td>taskgroup tg-admin-write task write admin task execute admin ! usergroup ug-admin-write taskgroup tg-admin-write ! username admin-write group ug-admin-write password admin-write ! Rp/0/RP0/CPU0:ios#show user group Mon Nov 3 14:09:29.676 UTC ug-admin-write Rp/0/RP0/CPU0:ios#show user tasks Mon Nov 3 14:09:35.244 UTC Task: admin : READ WRITE EXECUTE Rp/0/RP0/CPU0:ios#admin Mon Nov 3 14:09:40.401 UTC admin-write connected from 127.0.0.1 using console on xr-vm_node0_RP0_CPU0 sysadmin-vm:0_RP0# show aaa user-group Mon Nov 3 13:53:00.790 UTC User group : admin-r</td>
</tr>
</tbody>
</table>
### Administrative Model

The router operates in two planes: the administration (admin) plane and secure domain router (SDR) plane. The admin (shared) plane consists of resources shared across all SDRs, while the SDR plane consists of those resources specific to the particular SDR.

Each SDR has its own AAA configuration including, local users, groups, and TACACS+ and RADIUS configurations. Users created in one SDR cannot access other SDRs unless those same users are configured in the other SDRs.

#### Administrative Access

Administrative access to the system can be lost if the following operations are not well understood and carefully planned.

- Configuring authentication that uses remote AAA servers that are not available, particularly authentication for the console.

---

**Note**

The `none` option without any other method list is not supported.

- Configuring command authorization or XR EXEC mode authorization on the console should be done with extreme care, because TACACS+ servers may not be available or may deny every command, which locks the user out. This lockout can occur particularly if the authentication was done with a user not known to the TACACS+ server, or if the TACACS+ user has most or all the commands denied for one reason or another.

To avoid a lockout, we recommend one or both of the following:

<table>
<thead>
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<th>Sysadmin VM Group</th>
<th>Access</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netadmin or sysadmin group</td>
<td>Aaa -r and admin -r</td>
<td>Read only commands on Sysadmin VM</td>
<td>RP/0/RP0/CPU0:ios#show user group Mon Nov 3 13:44:39.176 UTC netadmin RP/0/RP0/CPU0:ios#show user tasks</td>
</tr>
</tbody>
</table>

---

**Example AccessSysadmin VM Group**

<table>
<thead>
<tr>
<th>XR Task or Group</th>
<th>Sysadmin VM Group</th>
<th>Access</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netadmin or sysadmin group</td>
<td>Aaa -r and admin -r</td>
<td>Read only commands on Sysadmin VM</td>
<td>RP/0/RP0/CPU0:ios#show user group Mon Nov 3 13:44:39.176 UTC netadmin RP/0/RP0/CPU0:ios#show user tasks</td>
</tr>
</tbody>
</table>
• Before turning on TACACS+ command authorization or XR EXEC mode authorization on the console, make sure that the user who is configuring the authorization is logged in using the appropriate user permissions in the TACACS+ profile.

• If the security policy of the site permits it, use the none option for command authorization or XR EXEC mode authorization so that if the TACACS+ servers are not reachable, AAA rolls over to the none method, which permits the user to run the command.

AAA Database

The AAA database stores the users, groups, and task information that controls access to the system. The AAA database can be either local or remote. The database that is used for a specific situation depends on the AAA configuration.

Local Database

AAA data, such as users, user groups, and task groups, can be stored locally within a secure domain router. The data is stored in the in-memory database and persists in the configuration file. The stored passwords are encrypted.

Note

The database is local to the specific secure domain router (SDR) in which it is stored, and the defined users or groups are not visible to other SDRs in the same system.

You can delete the last remaining user from the local database. If all users are deleted when the next user logs in, the setup dialog appears and prompts you for a new username and password.

Note

The setup dialog appears only when the user logs into the console.

Remote Database

AAA data can be stored in an external security server, such as CiscoSecure ACS. Security data stored in the server can be used by any client (such as a network access server [NAS]) provided that the client knows the server IP address and shared secret.

Remote AAA Configuration

Products such as CiscoSecure ACS can be used to administer the shared or external AAA database. The router communicates with the remote AAA server using a standard IP-based security protocol (such as TACACS+ or RADIUS).

Client Configuration

The security server should be configured with the secret key shared with the router and the IP addresses of the clients.

User Groups

User groups that are created in an external server are not related to the user group concept that is used in the context of local AAA database configuration on the router. The management of external TACACS+ server
or RADIUS server user groups is independent, and the router does not recognize the user group structure. The remote user or group profiles may contain attributes that specify the groups (defined on the router) to which a user or users belong, as well as individual task IDs.

Configuration of user groups in external servers comes under the design of individual server products. See the appropriate server product documentation.

**Task Groups**

Task groups are defined by lists of permitted task IDs for each type of action (such as read, write, and so on). The task IDs are basically defined in the router system. Task ID definitions may have to be supported before task groups in external software can be configured.

Task IDs can also be configured in external TACACS+ or RADIUS servers.

**AAA Configuration**

This section provides information about AAA configuration.

**Method Lists**

AAA data may be stored in a variety of data sources. AAA configuration uses *method lists* to define an order of preference for the source of AAA data. AAA may define more than one method list and applications (such as login) can choose one of them. For example, console ports may use one method list and the vty ports may use another. If a method list is not specified, the application tries to use a default method list. If a default method list does not exist, AAA uses the local database as the source.

**Rollover Mechanism**

AAA can be configured to use a prioritized list of database options. If the system is unable to use a database, it automatically rolls over to the next database on the list. If the authentication, authorization, or accounting request is rejected by any database, the rollover does not occur and the request is rejected.

The following methods are available:

- **Local**: Use the locally configured database (not applicable for accounting and certain types of authorization)
- **TACACS+**: Use a TACACS+ server (such as CiscoSecure ACS)
- **RADIUS**: Use a RADIUS server
- **Line**: Use a line password and user group (applicable only for authentication)
- **None**: Allow the request (not applicable for authentication)

**Server Grouping**

Instead of maintaining a single global list of servers, the user can form server groups for different AAA protocols (such as RADIUS and TACACS+) and associate them with AAA applications (such as PPP and XR EXEC mode).

**Authentication**

Authentication is the most important security process by which a principal (a user or an application) obtains access to the system. The principal is identified by a username (or user ID) that is unique across an administrative domain. The applications serving the user (such as or Management Agent) procure the username and the credentials from the user. AAA performs the authentication based on the username and credentials
Authenticating Non-Owner Secure Domain Router User

When logging in from a non-owner secure domain router, the root system user must add the “@admin” suffix to the username. Using the “@admin” suffix sends the authentication request to the owner secure domain router for verification. The owner secure domain router uses the methods in the list-name remote method list for choosing the authentication method. The remote method list is configured using the `aaa authentication login remote method1 method2...` command.

Authenticating Owner Secure Domain Router User

An owner secure domain router user can log in only to the nodes belonging to the specific secure domain router associated with that owner secure domain router user. If the user is member of a root-sdr group, the user is authenticated as an owner secure domain router user.

Authentication Flow of Control

AAA performs authentication according to the following process:

1. A user requests authentication by providing a username and password (or secret).
2. AAA verifies the user’s password and rejects the user if the password does not match what is in the database.
3. AAA determines the role of the user (root SDR user, or SDR user).
   - If the user has been configured as a member of an owner secure domain router user group, then AAA authenticates the user as an owner secure domain router user.
   - If the user has not been configured as a member of an owner secure domain router user group, AAA authenticates the user as a secure domain router user.

Clients can obtain a user’s permitted task IDs during authentication. This information is obtained by forming a union of all task group definitions specified in the user groups to which the user belongs. Clients using such information typically create a session for the user (such as an API session) in which the task ID set remains static. Both the XR EXEC mode and external API clients can use this feature to optimize their operations. XR EXEC mode can avoid displaying the commands that are not applicable and an EMS application can, for example, disable graphical user interface (GUI) menus that are not applicable.

If the attributes of a user, such as user group membership and, consequently, task permissions, are modified, those modified attributes are not reflected in the user’s current active session; they take effect in the user’s next session.

Password Types

In configuring a user and that user’s group membership, you can specify two types of passwords: encrypted or clear text.
The router supports both two-way and one-way (secret) encrypted user passwords. Secret passwords are ideal for user login accounts because the original unencrypted password string cannot be deduced on the basis of the encrypted secret. Some applications (PPP, for example) require only two-way passwords because they must decrypt the stored password for their own function, such as sending the password in a packet. For a login user, both types of passwords may be configured, but a warning message is displayed if one type of password is configured while the other is already present.

If both secret and password are configured for a user, the secret takes precedence for all operations that do not require a password that can be decrypted, such as login. For applications such as PPP, the two-way encrypted password is used even if a secret is present.

### Task-based Authorization

AAA employs “task permissions” for any control, configure, or monitor operation through CLI or API. The Cisco IOS software concept of privilege levels has been replaced in software by a task-based authorization system.

### Task IDs

The operational tasks that enable users to control, configure, and monitor Cisco software are represented by task IDs. A task ID defines the permission to run an operation for a command. Users are associated with sets of task IDs that define the breadth of their authorized access to the router.

Task IDs are assigned to users through the following means:

- Each user is associated with one or more user groups. Every user group is associated with one or more task groups; in turn, every task group is defined by a set of task IDs. Consequently, a user’s association with a particular user group links that user to a particular set of task IDs. A user that is associated with a task ID can execute any operation associated with that task ID.

### General Usage Guidelines for Task IDs

Most router control, configuration, or monitoring operation (CLI, Netconf, Restconf, XML API) is associated with a particular set of task IDs. Typically, a given CLI command or API invocation is associated with at least one or more task IDs. Neither the `config` nor the `commit` commands require any specific task ID permissions. The configuration and commit operations do not require specific task ID permissions. Aliases also don't require any task ID permissions. You cannot perform a configuration replace unless root-lr permissions are assigned. If you want to deny getting into configuration mode you can use the TACACS+ command authorization to deny the config command. These associations are hard-coded within the router and may not be modified. Task IDs grant permission to perform certain tasks; task IDs do not deny permission to perform tasks. Task ID operations can be one, all, or a combination of classes that are listed in this table.

**Table 2: Task ID Classes**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read</td>
<td>Specifies a designation that permits only a read operation.</td>
</tr>
<tr>
<td>Write</td>
<td>Specifies a designation that permits a change operation and implicitly allows a read operation.</td>
</tr>
</tbody>
</table>

**Note**

Restconf will be supported in a future release.
<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Execute</td>
<td>Specifies a designation that permits an access operation; for example ping and Telnet.</td>
</tr>
<tr>
<td>Debug</td>
<td>Specifies a designation that permits a debug operation.</td>
</tr>
</tbody>
</table>

The system verifies that each CLI command and API invocation conforms with the task ID permission list for the user. If you are experiencing problems using a CLI command, contact your system administrator.

Multiple task ID operations separated by a slash (for example read/write) mean that both operations are applied to the specified task ID.

Multiple task ID operations separated by a comma (for example read/write, execute) mean that both operations are applied to the respective task IDs. For example, the `copy ipv4 access-list` command can have the read and write operations applied to the acl task ID, and the execute operation applied to the `filesystem` task ID.

If the task ID and operations columns have no value specified, the command is used without any previous association to a task ID and operation. In addition, users do not have to be associated to task IDs to use ROM monitor commands.

Users may need to be associated to additional task IDs to use a command if the command is used in a specific configuration submode. For example, to execute the `show redundancy` command, a user needs to be associated to the system (read) task ID and operations as shown in the following example:

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

### Task IDs for TACACS+ and RADIUS Authenticated Users

Cisco software AAA provides the following means of assigning task permissions for users authenticated with the TACACS+ and RADIUS methods:

- Specify the text version of the task map directly in the configuration file of the external TACACS+ and RADIUS servers.
- Specify the privilege level in the configuration file of the external TACACS+ and RADIUS servers.
- Create a local user with the same username as the user authenticating with the TACACS+ and RADIUS methods.
- Specify, by configuration, a default task group whose permissions are applied to any user authenticating with the TACACS+ and RADIUS methods.

### Privilege Level Mapping

For compatibility with TACACS+ daemons that do not support the concept of task IDs, AAA supports a mapping between privilege levels defined for the user in the external TACACS+ server configuration file and local user groups. Following TACACS+ authentication, the task map of the user group that has been mapped from the privilege level returned from the external TACACS+ server is assigned to the user. For example, if a privilege level of 5 is returned from the external TACACS server, AAA attempts to get the task map of the local user group priv5. This mapping process is similar for other privilege levels from 1 to 13. For privilege level 14 maps to the user group owner-sdr.

For example, with the Cisco freeware tac plus server, the configuration file has to specify `privlvl` in its configuration file, as shown in the following example:
user = sampleuser1{
    member = bar
    service = exec-ext {
        priv_lvl = 5
    }
}

The number 5 in this example can be replaced with any privilege level that has to be assigned to the user sampleuser.

**XML Schema for AAA Services**

The extensible markup language (XML) interface uses requests and responses in XML document format to configure and monitor AAA. The AAA components publish the XML schema corresponding to the content and structure of the data used for configuration and monitoring. The XML tools and applications use the schema to communicate to the XML agent for performing the configuration.

The following schema are published by AAA:

- Authentication, Authorization and Accounting configuration
- User, user group, and task group configuration
- TACACS+ server and server group configuration
- RADIUS server and server group configuration

**Netconf and Restconf for AAA Services**

Just as in XML schemas, in Netconf and Restconf, username and password is controlled by either local or triple A (AAA) services.

---

**Note**
Restconf will be supported in a future release.

**About RADIUS**

RADIUS is a distributed client/server system that secures networks against unauthorized access. In the Cisco implementation, RADIUS clients run on Cisco routers and send authentication and accounting requests to a central RADIUS server that contains all user authentication and network service access information.

RADIUS is a fully open protocol, distributed in source code format, that can be modified to work with any security system currently available on the market.

Cisco supports RADIUS under its AAA security paradigm. RADIUS can be used with other AAA security protocols, such as TACACS+, Kerberos, and local username lookup.

---

**Note**
RADIUS is supported on all Cisco platforms, but some RADIUS-supported features run only on specified platforms.
RADIUS has been implemented in a variety of network environments that require high levels of security while maintaining network access for remote users.

Use RADIUS in the following network environments that require access security:

• Networks with multiple-vendor access servers, each supporting RADIUS. For example, access servers from several vendors use a single RADIUS server-based security database. In an IP-based network with multiple vendors’ access servers, dial-in users are authenticated through a RADIUS server that has been customized to work with the Kerberos security system.

• Turnkey network security environments in which applications support the RADIUS protocol, such as in an access environment that uses a “smart card” access control system. In one case, RADIUS has been used with Enigma security cards to validate users and grant access to network resources.

• Networks already using RADIUS. You can add a Cisco router with RADIUS to the network. This might be the first step when you make a transition to a Terminal Access Controller Access Control System Plus (TACACS+) server.

• Networks in which a user must access only a single service. Using RADIUS, you can control user access to a single host, utility such as Telnet, or protocol such as Point-to-Point Protocol (PPP). For example, when a user logs in, RADIUS identifies this user as having authorization to run PPP using IP address 10.2.3.4 and the defined access list is started.

• Networks that require resource accounting. You can use RADIUS accounting independent of RADIUS authentication or authorization. The RADIUS accounting functions allow data to be sent at the start and end of services, indicating the amount of resources (such as time, packets, bytes, and so on) used during the session. An Internet service provider (ISP) might use a freeware-based version of RADIUS access control and accounting software to meet special security and billing needs.

• Networks that support preauthentication. Using the RADIUS server in your network, you can configure AAA preauthentication and set up the preauthentication profiles. Preauthentication enables service providers to better manage ports using their existing RADIUS solutions and to efficiently manage the use of shared resources to offer differing service-level agreements.

### Network Security Situations in Which RADIUS is Unsuitable

RADIUS is not suitable in the following network security situations:

• Multiprotocol access environments. RADIUS does not support the following protocols:
  • NetBIOS Frame Control Protocol (NBFCP)
  • NetWare Asynchronous Services Interface (NASI)
  • X.25 PAD connections

• Router-to-router situations. RADIUS does not provide two-way authentication. RADIUS can be used to authenticate from one router to a router other than a Cisco router if that router requires RADIUS authentication.

• Networks using a variety of services. RADIUS generally binds a user to one service model.

### RADIUS Operation

When a user attempts to log in and authenticate to an access server using RADIUS, the following steps occur:
1. The user is prompted for and enters a username and password.

2. The username and encrypted password are sent over the network to the RADIUS server.

3. The user receives one of the following responses from the RADIUS server:
   1. ACCEPT—The user is authenticated.
   2. REJECT—The user is not authenticated and is prompted to reenter the username and password, or access is denied.
   3. CHALLENGE—A challenge is issued by the RADIUS server. The challenge collects additional data from the user.
   4. CHANGE PASSWORD—A request is issued by the RADIUS server, asking the user to select a new password.

The ACCEPT or REJECT response is bundled with additional data used for XR EXEC mode or network authorization. You must first complete RADIUS authentication before using RADIUS authorization. The additional data included with the ACCEPT or REJECT packets consists of the following:

- Services that the user can access, including Telnet, rlogin, or local-area transport (LAT) connections, and PPP, Serial Line Internet Protocol (SLIP), or XR EXEC mode services.
- Connection parameters, including the host or client IP address, access list, and user timeouts.
CA interoperability permits devices and CAs to communicate so that your device can obtain and use digital certificates from the CA. Although IPSec can be implemented in your network without the use of a CA, using a CA provides manageability and scalability for IPSec.

**Note**

IPSec will be supported in a future release.

---

### Implementing Certification Authority Interoperability

CA interoperability permits devices and CAs to communicate so that your device can obtain and use digital certificates from the CA. Although IPSec can be implemented in your network without the use of a CA, using a CA provides manageability and scalability for IPSec.

**Note**

IPSec will be supported in a future release.

### Prerequisites for Implementing Certification Authority

The following prerequisites are required to implement CA interoperability:

- 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.

- You must install and activate the Package Installation Envelope (PIE) for the security software.
  
  For detailed information about optional PIE installation, refer to the *System Management Guide*.

- You need to have a CA available to your network before you configure this interoperability feature. The CA must support Cisco Systems PKI protocol, the simple certificate enrollment protocol (SCEP) (formerly called certificate enrollment protocol [CEP]).
Restrictions for Implementing Certification Authority

Configure Router Hostname and IP Domain Name

This task configures a router hostname and IP domain name.

You must configure the hostname and IP domain name of the router if they have not already been configured. The hostname and IP domain name are required because the router assigns a fully qualified domain name (FQDN) to the keys and certificates used by IPSec, and the FQDN is based on the hostname and IP domain name you assign to the router. For example, a certificate named router20.example.com is based on a router hostname of router20 and a router IP domain name of example.com.

SUMMARY STEPS

1. configure
2. hostname name
3. domain name domain-name
4. commit

DETAILED STEPS

Step 1 configure
Step 2 hostname name
Example:

```
RP/0/RP0/CPU0:router(config)# hostname myhost
```
Configures the hostname of the router.

Step 3 domain name domain-name
Example:

```
RP/0/RP0/CPU0:router(config)# domain name mydomain.com
```
Configures the IP domain name of the router.

Step 4 commit

Generate RSA Key Pair

This task generates an RSA key pair.

RSA key pairs are used to sign and encrypt IKE key management messages and are required before you can obtain a certificate for your router.

SUMMARY STEPS

1. crypto key generate rsa [usage keys | general-keys] [keypair-label]
2. `crypto key zeroize rsa [keypair-label]`
3. `show crypto key mypubkey rsa`

**DETAILED STEPS**

**Step 1**  
`crypto key generate rsa [usage keys | general-keys] [keypair-label]`

**Example:**
```
RP/0/RP0/CPU0:router# crypto key generate rsa general-keys
```
Generates RSA key pairs.
- Use the `usage keys` keyword to specify special usage keys; use the `general-keys` keyword to specify general-purpose RSA keys.
- The `keypair-label` argument is the RSA key pair label that names the RSA key pairs.

**Step 2**  
`crypto key zeroize rsa [keypair-label]`

**Example:**
```
RP/0/RP0/CPU0:router# crypto key zeroize rsa key1
```
(Optional) Deletes all RSAs from the router.
- Under certain circumstances, you may want to delete all RSA keys from your router. For example, if you believe the RSA keys were compromised in some way and should no longer be used, you should delete the keys.
- To remove a specific RSA key pair, use the `keypair-label` argument.

**Step 3**  
`show crypto key mypubkey rsa`

**Example:**
```
RP/0/RP0/CPU0:router# show crypto key mypubkey rsa
```
(Optional) Displays the RSA public keys for your router.

---

**Import Public Key to the Router**

This task imports a public key to the router.

A public key is imported to the router to authenticate the user.

**SUMMARY STEPS**

1. `crypto key import authentication rsa [usage keys | general-keys] [keypair-label]`
2. `show crypto key mypubkey rsa`
DETAILED STEPS

Step 1  
crypto key import authentication rsa [usage keys | general-keys] [keypair-label]

Example:

RP/0/RP0/CPU0:router# crypto key import authentication rsa general-keys
Generates RSA key pairs.

- Use the usage keys keyword to specify special usage keys; use the general-keys keyword to specify general-purpose RSA keys.
- The keypair-label argument is the RSA key pair label that names the RSA key pairs.

Step 2  
show crypto key mypubkey rsa

Example:

RP/0/RP0/CPU0:router# show crypto key mypubkey rsa
(Optional) Displays the RSA public keys for your router.

Declare Certification Authority and Configure Trusted Point

This task declares a CA and configures a trusted point.

SUMMARY STEPS

1. configure
2. crypto ca trustpoint ca-name
3. enrollment url CA-URL
4. query url LDAP-URL
5. enrollment retry period minutes
6. enrollment retry count number
7. rsakeypair keypair-label
8. commit

DETAILED STEPS

Step 1  
configure
Step 2  
crypto ca trustpoint ca-name

Example:

RP/0/RP0/CPU0:router(config)# crypto ca trustpoint myca
Declares a CA.

- Configures a trusted point with a selected name so that your router can verify certificates issued to peers.
• Enters trustpoint configuration mode.

**Step 3** enrollment url CA-URL

**Example:**

```
RP/0/RP0/CPU0:router(config-trustp)# enrollment url http://ca.domain.com/certsrv/mscep/mscep.dll
```

Specifies the URL of the CA.

• The URL should include any nonstandard cgi-bin script location.

**Step 4** query url LDAP-URL

**Example:**

```
RP/0/RP0/CPU0:router(config-trustp)# query url ldap://my-ldap.domain.com
```

(Optional) Specifies the location of the LDAP server if your CA system supports the LDAP protocol.

**Step 5** enrollment retry period minutes

**Example:**

```
RP/0/RP0/CPU0:router(config-trustp)# enrollment retry period 2
```

(Optional) Specifies a retry period.

• After requesting a certificate, the router waits to receive a certificate from the CA. If the router does not receive a certificate within a period of time (the retry period) the router will send another certificate request.

• Range is from 1 to 60 minutes. Default is 1 minute.

**Step 6** enrollment retry count number

**Example:**

```
RP/0/RP0/CPU0:router(config-trustp)# enrollment retry count 10
```

(Optional) Specifies how many times the router continues to send unsuccessful certificate requests before giving up.

• The range is from 1 to 100.

**Step 7** rsakeypair keypair-label

**Example:**

```
RP/0/RP0/CPU0:router(config-trustp)# rsakeypair mykey
```

(Optional) Specifies a named RSA key pair generated using the **crypto key generate rsa** command for this trustpoint.

• Not setting this key pair means that the trustpoint uses the default RSA key in the current configuration.

**Step 8** commit
Authenticate CA

This task authenticates the CA to your router.

The router must authenticate the CA by obtaining the self-signed certificate of the CA, which contains the public key of the CA. Because the certificate of the CA is self-signed (the CA signs its own certificate), manually authenticate the public key of the CA by contacting the CA administrator to compare the fingerprint of the CA certificate.

SUMMARY STEPS

1. crypto ca authenticate ca-name
2. show crypto ca certificates

DETAILED STEPS

Step 1  crypto ca authenticate ca-name
Example:

```
RP/0/RP0/CPU0:router# crypto ca authenticate myca
```

(Authenticates the CA to your router by obtaining a CA certificate, which contains the public key for the CA.

Step 2  show crypto ca certificates
Example:

```
RP/0/RP0/CPU0:router# show crypto ca certificates
```

(Optional) Displays information about the CA certificate.

Request Your Own Certificates

This task requests certificates from the CA.

You must obtain a signed certificate from the CA for each of your router’s RSA key pairs. If you generated general-purpose RSA keys, your router has only one RSA key pair and needs only one certificate. If you previously generated special usage RSA keys, your router has two RSA key pairs and needs two certificates.

SUMMARY STEPS

1. crypto ca enroll ca-name
2. show crypto ca certificates

DETAILED STEPS

Step 1  crypto ca enroll ca-name
Example:
RP/0/RP0/CPU0:router# crypto ca enroll myca

Requests certificates for all of your RSA key pairs.

- This command causes your router to request as many certificates as there are RSA key pairs, so you need only perform this command once, even if you have special usage RSA key pairs.
- This command requires you to create a challenge password that is not saved with the configuration. This password is required if your certificate needs to be revoked, so you must remember this password.
- A certificate may be issued immediately or the router sends a certificate request every minute until the enrollment retry period is reached and a timeout occurs. If a timeout occurs, contact your system administrator to get your request approved, and then enter this command again.

Step 2  show crypto ca certificates

Example:

RP/0/RP0/CPU0:router# show crypto ca certificates

(Optional) Displays information about the CA certificate.

---

**Configure Certificate Enrollment Using Cut-and-Paste**

This task declares the trustpoint certification authority (CA) that your router should use and configures that trustpoint CA for manual enrollment by using cut-and-paste.

**SUMMARY STEPS**

1. `configure`
2. `crypto ca trustpoint ca-name`
3. `enrollment terminal`
4. `commit`
5. `crypto ca authenticate ca-name`
6. `crypto ca enroll ca-name`
7. `crypto ca import ca-name certificate`
8. `show crypto ca certificates`

**DETAILED STEPS**

**Step 1** `configure`

**Step 2** `crypto ca trustpoint ca-name`

Example:

RP/0/RP0/CPU0:router(config)# crypto ca trustpoint myca
RP/0/RP0/CPU0:router(config-trustp)#

Declares the CA that your router should use and enters trustpoint configuration mode.

- Use the `ca-name` argument to specify the name of the CA.
Configure Certificate Enrollment Using Cut-and-Paste

Step 3 enrollment terminal

Example:
RP/0/RP0/CPU0:router(config-trustp)# enrollment terminal

Specifies manual cut-and-paste certificate enrollment.

Step 4 commit

Step 5 crypto ca authenticate ca-name

Example:
RP/0/RP0/CPU0:router# crypto ca authenticate myca

Authenticates the CA by obtaining the certificate of the CA.

• Use the ca-name argument to specify the name of the CA. Use the same name that you entered in step 2.

Step 6 crypto ca enroll ca-name

Example:
RP/0/RP0/CPU0:router# crypto ca enroll myca

Obtains the certificates for your router from the CA.

• Use the ca-name argument to specify the name of the CA. Use the same name that you entered in Step 2.

Step 7 crypto ca import ca-name certificate

Example:
RP/0/RP0/CPU0:router# crypto ca import myca certificate

Imports a certificate manually at the terminal.

• Use the ca-name argument to specify the name of the CA. Use the same name that you entered in Step 2.

Note You must enter the crypto ca import command twice if usage keys (signature and encryption keys) are used. The first time the command is entered, one of the certificates is pasted into the router; the second time the command is entered, the other certificate is pasted into the router. (It does not matter which certificate is pasted first.

Step 8 show crypto ca certificates

Example:
RP/0/RP0/CPU0:router# show crypto ca certificates

Displays information about your certificate and the CA certificate.

---

The following example shows how to configure CA interoperability.

Comments are included within the configuration to explain various commands.

configure
hostname myrouter
domain name mydomain.com
end
Uncommitted changes found, commit them? [yes]: yes

crypto key generate rsa mykey

The name for the keys will be: mykey
Choose the size of the key modulus in the range of 360 to 2048 for your General Purpose Keypair
Choosing a key modulus greater than 512 may take a few minutes.
How many bits in the modulus [1024]:
Generating RSA keys ...
Done w/ crypto generate keypair
[OK]

show crypto key mypubkey rsa

Key label: mykey
Type : RSA General purpose
Size : 1024
Created : 17:33:23 UTC Thu Sep 18 2003
Data :
30819F30 0D06092A 864886F7 0D010101 05000381 8D003081 89028181 00CB8D86
BF6707AA FD7E4F08 A1F70080 B9E6016B 8128004C B477817B BCF35106 BC60B06E
07A417FD 79792D22 B35465A6 103B870D 136A2FED 7F91D5A0 CFB0EE91 B9D52C69
7CA7F0BD F6ED8A58 890EF776 1C54AF7F 293P3004
C15B08A8 C6965F1E 289DD724 BD40AF59 E90E44D5 7D590000 5C4BEA9D B5020301
0001

! The following commands declare a CA and configure a trusted point.

configure
crypto ca trustpoint myca
enrollment url http://xyz-ultra5
enrollment retry count 25
enrollment retry period 2
rsakeypair mykey
end

Uncommitted changes found, commit them? [yes]: yes

! The following command authenticates the CA to your router.
crypto ca authenticate myca

Serial Number : 01
Subject Name :
cn=Root coax-u10 Certificate Manager, ou=HFR, o=Cisco Systems, l=San Jose, st=CA, c=US
Issued By :
cn=Root coax-u10 Certificate Manager, ou=HFR, o=Cisco Systems, l=San Jose, st=CA, c=US
Validity Start : 07:00:00 UTC Tue Aug 19 2003
Validity End : 07:00:00 UTC Wed Aug 19 2020
Fingerprint: 58 71 FB 94 55 65 D4 64 38 91 2B 00 61 E9 F8 05
Do you accept this certificate?? [yes/no]: yes

! The following command requests certificates for all of your RSA key pairs.
crypto ca enroll myca

% Start certificate enrollment ...
% Create a challenge password. You will need to verbally provide this password to the CA Administrator in order to revoke your certificate.
% For security reasons your password will not be saved in the configuration.
% Please make a note of it.
Password:
Re-enter Password:
Fingerprint: 17D8B38D ED2BDF2E DF8ADBF7 A7DBE35A

! The following command displays information about your certificate and the CA certificate.

show crypto ca certificates

Trustpoint :myca

-------------------------------------------------------------------------------
CA certificate
Serial Number :01
Subject Name :
cn=Root coax-u10 Certificate Manager,ou=HFR,o=Cisco Systems,l=San Jose,ST=CA,c=US
Issued By :
cn=Root coax-u10 Certificate Manager,ou=HFR,o=Cisco Systems,l=San Jose,ST=CA,c=US
Validity Start :07:00:00 UTC Tue Aug 19 2003
Validity End :07:00:00 UTC Wed Aug 19 2020

Router certificate
Key usage :General Purpose
Status :Available
Serial Number :6E
Subject Name :
unstructuredName=myrouter.mydomain.com,o=Cisco Systems
Issued By :
cn=Root coax-u10 Certificate Manager,ou=HFR,o=Cisco Systems,l=San Jose,ST=CA,c=US
Validity Start :21:43:14 UTC Mon Sep 22 2003
Validity End :21:43:14 UTC Mon Sep 29 2003
CRL Distribution Point
  ldap://coax-u10.cisco.com/CN=Root coax-u10 Certificate Manager,O=Cisco Systems

Certificate Authority Trust Pool Management

The trust pool feature is used to authenticate sessions, such as HTTPS, that occur between devices by using commonly recognized trusted agents called certificate authorities (CAs). This feature is enabled by default in the software to create a scheme to provision, store, and manage a pool of certificates from known CAs in a way similar to the services a browser provides for securing sessions. A special trusted point called a trust pool is designated, containing multiple known CA certificates from Cisco and possibly from other vendors. The trust pool consists of both built-in and downloaded CA certificates.

Implementing Certification Authority Interoperability provides details on Certificate Authority and trusted point.

CA Certificate Bundling in the Trust Pool

The router uses a built-in CA certificate bundle that is packaged into the asr9k-k9sec PIE. The bundle is contained in a special certificate store called a CA trust pool, which is updated automatically by Cisco. This trust pool is known by Cisco and other vendors. A CA certificate bundle can be in the following formats:

- Privilege Management Infrastructure (PMI) certificates in Distinguished Encoding Rules (DER) binary format enveloped within a public-key cryptographic message syntax standard 7 (pkcs7).
- A file containing concatenated X.509 certificates in Privacy Enhanced Mail (PEM) format with PEM headers.
Prerequisites for CA Trust Pool Management

Restrictions for CA trust pool management

Updating the CA Trustpool

The CA trustpool must be updated when the following conditions occur:

- A certificate in the trustpool is due to expire or has been reissued.
- The published CA certificate bundle contains additional trusted certificates that are needed by a given application.
- The configuration has been corrupted.

The CA trustpool is considered as a single entity. As such, any update you perform will replace the entire trustpool.

Note

A built-in certificate in the trustpool cannot be physically replaced. However, a built-in certificate is rendered inactive after an update if its X.509 subject-name attribute matches the certificate in the CA certificate bundle.

Following are the methods available for updating the certificates in the trustpool:

- **Automatic update**: A timer is established for the trustpool that matches the CA certificate with the earliest expiration time. If the timer is running and a bundle location is not configured and not explicitly disabled, syslog warnings should be issued at reasonable intervals to alert the admin that this trustpool policy option is not set. Automatic trustpool updates use the configured URL. When the CA trustpool expires, the policy is read, the bundle is loaded, and the PKI trustpool is replaced. If the automatic CA trustpool update encounters problems when initiating, then the following schedule is used to initiate the update until the download is successful: 20 days, 15 days, 10 days, 5 days, 4 days, 3 days, 2 days, 1 day, and then once every hour.

- **Manual update**: Manually Update Certificates in Trust Pool, on page 55 provides details.

Manually Update Certificates in Trust Pool

The CA trust pool feature is enabled by default and uses the built-in CA certificate bundle in the trust pool, which receives automatic updates from Cisco. Perform this task to manually update certificates in the trust pool if they are not current, are corrupt, or if certain certificates need to be updated.

**SUMMARY STEPS**

1. `crypto ca trustpool import url clean`
2. `crypto ca trustpool import url url1`
3. `show crypto ca trustpool policy`
### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td>crypto ca trustpool import url clean</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>RP/0/RSP0/CP00#crypto ca trustpool import url clean</td>
</tr>
<tr>
<td></td>
<td>(Optional) Manually removes all downloaded CA certificates. This command is run in the EXEC mode.</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td>crypto ca trustpool import url url</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>RP/0/RSP0/CP00#crypto ca trustpool import url <a href="http://www.cisco.com/security/pki/trs/ios.p7b">http://www.cisco.com/security/pki/trs/ios.p7b</a></td>
</tr>
<tr>
<td></td>
<td>Specify the URL from which the CA trust pool certificate bundle must be downloaded. This manually imports (downloads) the CA certificate bundle into the CA trust pool to update or replace the existing CA certificate bundle.</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td>show crypto ca trustpool policy</td>
</tr>
<tr>
<td><strong>Example:</strong></td>
<td>RP/0/RSP0/CP00#show crypto ca trustpool</td>
</tr>
<tr>
<td></td>
<td>Displays the CA trust pool certificates of the router in a verbose format.</td>
</tr>
</tbody>
</table>

### Configuring Optional Trustpool Policy Parameters

**SUMMARY STEPS**

1. configure
2. crypto ca trustpool policy
3. cabundle url URL
4. crl optional
5. description LINE
### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> configure</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> crypto ca trustpool policy</td>
<td>Enters ca-trustpool configuration mode where commands can be accessed to configure CA trustpool policy parameters.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>RP/0/RSP0/CPU0:IMC0(config)#crypto ca trustpool policy</td>
<td></td>
</tr>
<tr>
<td>RP/0/RSP0/CPU0:IMC0(config-trustpool)#</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> cabundle url URL</td>
<td>Specifies the URL from which the CA trustpool certificate bundle is downloaded.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>RP/0/RSP0/CPU0:IMC0(config-trustpool)#cabundle url</td>
<td><a href="http://www.cisco.com/security/pki/crl/crca2048.crl">http://www.cisco.com/security/pki/crl/crca2048.crl</a></td>
</tr>
<tr>
<td><strong>Step 4</strong> crl optional</td>
<td>Enables revocation checking when the trustpool policy is being used. By default, the router enforces a check of the revocation status of the certificate by querying the certificate revocation list (CRL).</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>RP/0/RSP0/CPU0:IMC0(config-trustpool)#crl optional</td>
<td></td>
</tr>
<tr>
<td><strong>Step 5</strong> description LINE</td>
<td></td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>RP/0/RSP0/CPU0:IMC0(config-trustpool)#description</td>
<td>Trustpool for Test.</td>
</tr>
</tbody>
</table>

### Handling of CA Certificates appearing both in Trust Pool and Trust Point

There may be cases where a CA resides in both the trust pool and a trust point; for example, a trust point is using a CA and a CA bundle is downloaded later with this same CA inside. In this scenario, the CA in the trust point and its policy is considered, before the CA in the trust pool or trust pool policy to ensure that any current behavior is not altered when the trust pool feature is implemented on the router.

The policy indicates how the security appliance obtains the CA certificate and the authentication policies for user certificates issued by the CA.

### Information About Implementing Certification Authority

**Supported Standards for Certification Authority Interoperability**

Cisco supports the following standards:

- IKE—A hybrid protocol that implements Oakley and Skeme key exchanges inside the Internet Security Association Key Management Protocol (ISAKMP) framework. Although IKE can be used with other protocols, its initial implementation is with the IPSec protocol. IKE provides authentication of the IPSec peers, negotiates IPSec keys, and negotiates IPSec security associations (SAs).

- Public-Key Cryptography Standard #7 (PKCS #7)—A standard from RSA Data Security Inc. used to encrypt and sign certificate enrollment messages.
Certification Authorities

Purpose of CAs

CAs are responsible for managing certificate requests and issuing certificates to participating IPSec network devices. These services provide centralized key management for the participating devices.

CAs simplify the administration of IPSec network devices. You can use a CA with a network containing multiple IPSec-compliant devices, such as routers.

Digital signatures, enabled by public key cryptography, provide a means of digitally authenticating devices and individual users. In public key cryptography, such as the RSA encryption system, each user has a key pair containing both a public and a private key. The keys act as complements, and anything encrypted with one of the keys can be decrypted with the other. In simple terms, a signature is formed when data is encrypted with a user’s private key. The receiver verifies the signature by decrypting the message with the sender’s public key. The fact that the message could be decrypted using the sender’s public key indicates that the holder of the private key, the sender, must have created the message. This process relies on the receiver’s having a copy of the sender’s public key and knowing with a high degree of certainty that it does belong to the sender and not to someone pretending to be the sender.

Digital certificates provide the link. A digital certificate contains information to identify a user or device, such as the name, serial number, company, department, or IP address. It also contains a copy of the entity’s public key. The certificate is itself signed by a CA, a third party that is explicitly trusted by the receiver to validate identities and to create digital certificates.

To validate the signature of the CA, the receiver must first know the CA’s public key. Normally, this process is handled out-of-band or through an operation done at installation. For instance, most web browsers are configured with the public keys of several CAs by default. IKE, an essential component of IPSec, can use digital signatures to authenticate peer devices for scalability before setting up SAs.

Without digital signatures, a user must manually exchange either public keys or secrets between each pair of devices that use IPSec to protect communication between them. Without certificates, every new device added to the network requires a configuration change on every other device with which it communicates securely. With digital certificates, each device is enrolled with a CA. When two devices want to communicate, they exchange certificates and digitally sign data to authenticate each other. When a new device is added to the network, a user simply enrolls that device with a CA, and none of the other devices needs modification. When the new device attempts an IPSec connection, certificates are automatically exchanged and the device can be authenticated.

CA Registration Authorities
Implementing Keychain Management

This module describes how to implement keychain management on. Keychain management is a common method of authentication to configure shared secrets on all entities that exchange secrets such as keys, before establishing trust with each other. Routing protocols and network management applications on Cisco IOS XR software often use authentication to enhance security while communicating with peers.

- Implementing Keychain Management, on page 59

Restrictions for Implementing Keychain Management

You must be aware that changing the system clock impacts the validity of the keys in the existing configuration.

Configure Keychain

This task configures a name for the keychain.

You can create or modify the name of the keychain.

SUMMARY STEPS

1. `configure`
2. `key chain key-chain-name`
3. `commit`
4. `show key chain key-chain-name`

DETAILED STEPS

Step 1 configure
## Step 2  

**key chain** `key-chain-name`

**Example:**

```
RP/0/RP0/CPU0:router(config)# key chain isis-keys
RP/0/RP0/CPU0:router(config-isis-keys)#
```

Creates a name for the keychain.

**Note**  
Configuring only the keychain name without any key identifiers is considered a nonoperation. When you exit the configuration, the router does not prompt you to commit changes until you have configured the key identifier and at least one of the mode attributes or keychain-key configuration mode attributes (for example, lifetime or key string).

## Step 3  

**commit**

## Step 4  

**show key chain** `key-chain-name`

**Example:**

```
RP/0/RP0/CPU0:router# show key chain isis-keys
```

(Optional) Displays the name of the keychain.

**Note**  
The `key-chain-name` argument is optional. If you do not specify a name for the `key-chain-name` argument, all the keychains are displayed.

---

**Example**

The following example shows how to configure keychain management:

```
configure
key chain isis-keys
accept-tolerance infinite
key 8
  key-string mykey91abcd
  cryptographic-algorithm MD5
  send-lifetime 1:00:00 june 29 2006 infinite
  accept-lifetime 1:00:00 june 29 2006 infinite
end

Uncommitted changes found, commit them? [yes]: yes

show key chain isis-keys

Key-chain: isis-keys/ -
  accept-tolerance -- infinite
  Key 8 -- text "1104000E120B520005282820"
    cryptographic-algorithm -- MD5
    Send lifetime:  01:00:00, 29 Jun 2006 - Always valid [Valid now]
    Accept lifetime: 01:00:00, 29 Jun 2006 - Always valid [Valid now]
```
Configure Tolerance Specification to Accept Keys

This task configures the tolerance specification to accept keys for a keychain to facilitate a hitless key rollover for applications, such as routing and management protocols.

SUMMARY STEPS

1. configure
2. key chain key-chain-name
3. accept-tolerance value [infinite]
4. commit

DETAILED STEPS

Step 1 configure
Step 2 key chain key-chain-name
Example:
RP/0//CPU0:router(config)# key chain isis-keys
Creates a name for the keychain.

Step 3 accept-tolerance value [infinite]
Example:
RP/0//CPU0:router(config-isis-keys)# accept-tolerance infinite
Configures a tolerance value to accept keys for the keychain.
- Use the value argument to set the tolerance range in seconds. The range is from 1 to 8640000.
- Use the infinite keyword to specify that the tolerance specification is infinite.

Step 4 commit

Configure Key Identifier for Keychain

This task configures a key identifier for the keychain.
You can create or modify the key for the keychain.

SUMMARY STEPS

1. configure
2. key chain key-chain-name
3. key key-id
4. commit
DETAILED STEPS

Step 1 configure

Step 2 key chain key-chain-name

Example:

RP/0//CPU0:router(config)# key chain isis-keys

Creates a name for the keychain.

Step 3 key key-id

Example:

RP/0//CPU0:router(config-isis-keys)# key 8

Creates a key for the keychain. The key ID number is translated from decimal to hexadecimal to create the command mode subprompt.

• Use the key-id argument as a 48-bit integer.

Step 4 commit

Configure Text for Key String

This task configures the text for the key string.

SUMMARY STEPS

1. configure
2. key chain key-chain-name
3. key key-id
4. key-string [clear | password] key-string-text
5. commit

DETAILED STEPS

Step 1 configure

Step 2 key chain key-chain-name

Example:

RP/0//CPU0:router(config)# key chain isis-keys

Creates a name for the keychain.

Step 3 key key-id

Example:
RP/0/0/CPU0:router(config-isis-keys)# key 8
RP/0/0/CPU0:router(config-isis-keys-0x8)#

Creates a key for the keychain.

**Step 4**

```plaintext
key-string [clear | password] key-string-text
```

**Example:**

```
RP/0/0/CPU0:router(config-isis-keys-0x8)# key-string password 8
```

Specifies the text string for the key.

- Use the `clear` keyword to specify the key string in clear text form; use the `password` keyword to specify the key in encrypted form.

**Step 5**

```plaintext
commit
```

---

**Determine Valid Keys**

This task determines the valid keys for local applications to authenticate the remote peers.

**SUMMARY STEPS**

1. `configure`
2. `key chain key-chain-name`
3. `key key-id`
4. `accept-lifetime start-time [duration duration-value | infinite | end-time]`
5. `commit`

**DETAILED STEPS**

**Step 1**

```plaintext
configure
```

**Step 2**

```plaintext
key chain key-chain-name
```

**Example:**

```
RP/0/RP0/CPU0:router(config)# key chain isis-keys
```

Creates a name for the keychain.

**Step 3**

```plaintext
key key-id
```

**Example:**

```
RP/0/RP0/CPU0:router(config-isis-keys)# key 8
RP/0/RP0/CPU0:router(config-isis-keys-0x8)#
```

Creates a key for the keychain.

**Step 4**

```plaintext
accept-lifetime start-time [duration duration-value | infinite | end-time]
```

**Example:**

```
```
Configure Keys to Generate Authentication Digest for Outbound Application Traffic

This task configures the keys to generate authentication digest for the outbound application traffic.

**SUMMARY STEPS**

1. configure
2. key chain *key-chain-name*
3. key *key-id*
4. send-lifetime *start-time* [duration *duration-value* | infinite | *end-time*]
5. commit

**DETAILED STEPS**

**Step 1**  configure

**Step 2**  key chain *key-chain-name*

Example:

```
RP/0/RP0/CPU0:router(config)# key chain isis-keys
```

Creates a name for the keychain.

**Step 3**  key *key-id*

Example:

```
RP/0/RP0/CPU0:router(config-isis-keys)# key 8
```

Creates a key for the keychain.

**Step 4**  send-lifetime *start-time* [duration *duration-value* | infinite | *end-time*]

Example:

```
RP/0/RP0/CPU0:router(config-isis-keys)# key 8
```

(Optional) Specifies the set time period during which an authentication key on a keychain is valid to be sent. You can specify the validity of the key lifetime in terms of clock time.
In addition, you can specify a start-time value and one of the following values:

- **duration** keyword (seconds)
- **infinite** keyword
- **end-time** argument

If you intend to set lifetimes on keys, Network Time Protocol (NTP) or some other time synchronization method is recommended.

**Step 5**  
commit

---

**Configure Cryptographic Algorithm**

This task allows the keychain configuration to accept the choice of the cryptographic algorithm.

**SUMMARY STEPS**

1. configure  
2. key chain *key-chain-name*  
3. key *key-id*  
4. cryptographic-algorithm [HMAC-MD5 | HMAC-SHA1-12 | HMAC-SHA1-20 | MD5 | SHA-1]  
5. commit

**DETAILED STEPS**

**Step 1**  
configure  

**Step 2**  
key chain *key-chain-name*  

**Example:**

```
RP/0/RP0/CPU0:router(config)# key chain isis-keys
RP/0/RP0/CPU0:router(config-isis-keys)#
```

Creates a name for the keychain.

**Step 3**  
key *key-id*  

**Example:**

```
RP/0/RP0/CPU0:router(config-isis-keys)# key 8
RP/0/RP0/CPU0:router(config-isis-keys-0x8)#
```

Creates a key for the keychain.

**Step 4**  
cryptographic-algorithm [HMAC-MD5 | HMAC-SHA1-12 | HMAC-SHA1-20 | MD5 | SHA-1]  

**Example:**

```
RP/0/RP0/CPU0:router(config-isis-keys-0x8)# cryptographic-algorithm MD5
```

Specifies the choice of the cryptographic algorithm. You can choose from the following list of algorithms:
• HMAC-MD5
• HMAC-SHA1-12
• HMAC-SHA1-20
• MD5
• SHA-1

The routing protocols each support a different set of cryptographic algorithms:
• Border Gateway Protocol (BGP) supports only HMAC-MD5 and HMAC-SHA1-12.
• Intermediate System-to-Intermediate System (IS-IS) supports HMAC-MD5, SHA-1, MD5.
• Open Shortest Path First (OSPF) supports MD5, HMAC-MD5.

Step 5 commit

Lifetime of Key

If you are using keys as the security method, you must specify the lifetime for the keys and change the keys on a regular basis when they expire. To maintain stability, each party must be able to store and use more than one key for an application at the same time. A keychain is a sequence of keys that are collectively managed for authenticating the same peer, peer group, or both.

Keychain management groups a sequence of keys together under a keychain and associates each key in the keychain with a lifetime.

Any key that is configured without a lifetime is considered invalid; therefore, the key is rejected during configuration.

The lifetime of a key is defined by the following options:
• Start-time—Specifies the absolute time.
• End-time—Specifies the absolute time that is relative to the start-time or infinite time.

Each key definition within the keychain must specify a time interval for which that key is activated; for example, lifetime. Then, during a given key's lifetime, routing update packets are sent with this activated key. Keys cannot be used during time periods for which they are not activated. Therefore, we recommend that for a given keychain, key activation times overlap to avoid any period of time for which no key is activated. If a time period occurs during which no key is activated, neighbor authentication cannot occur; therefore, routing updates can fail.

Multiple keychains can be specified.
CHAPTER 5

Configure MACSec

This module describes how to configure Media Access Control Security (MACsec) encryption on the NCS 5500 Network Convergence System Routers. MACsec is a Layer 2 IEEE 802.1AE standard for encrypting packets between two MACsec-capable routers.

Command History

<table>
<thead>
<tr>
<th>Release</th>
<th>Modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release 6.1.3</td>
<td>This feature is introduced for physical interfaces and bundle member interfaces.</td>
</tr>
<tr>
<td>Release 6.3.3</td>
<td>This feature was introduced to enable global MACsec shutdown.</td>
</tr>
</tbody>
</table>

- Understanding MACsec Encryption, on page 67
- MKA Authentication Process, on page 68
- MACsec Frame Format, on page 69
- Advantages of Using MACsec Encryption, on page 69
- MACsec Support on Line Cards, on page 69
- MACsec PSK, on page 70
- Fallback PSK, on page 70
- Configuring and Verifying MACsec Encryption, on page 70
- Creating a MACsec Keychain, on page 71
- Creating a User-Defined MACsec Policy, on page 77
- Applying MACsec Configuration on an Interface, on page 80
- Verifying MACsec Encryption on IOS XR, on page 81
- Verifying MACsec Encryption on NCS 5500, on page 85
- MACsec SecY Statistics, on page 88
- Global MACsec Shutdown, on page 96

Understanding MACsec Encryption

Security breaches can occur at any layer of the OSI model. At Layer 2, some of the common breaches are MAC address spoofing, ARP spoofing, Denial of Service (DoS) attacks against a DHCP server, and VLAN hopping.
MACsec secures data on physical media, making it impossible for data to be compromised at higher layers. As a result, MACsec encryption takes priority over any other encryption method such as IPsec and SSL at higher layers. MACsec is configured on the Customer Edge (CE) router interfaces that connect to Provider Edge (PE) routers and on all the provider router interfaces.

**MKA Authentication Process**

MACsec provides the secure MAC Service on a frame-by-frame basis, using GCM-AES algorithm. MACsec uses the MACsec Key Agreement protocol (MKA) to exchange session keys, and manage encryption keys.

The MACsec encryption process is illustrated in the following figure and description.

*Figure 1: MKA Encryption Process*

**Step 1**: When a link is first established between two routers, they become peers. Mutual peer authentication takes place by configuring a Pre-shared Key (PSK).

**Step 2**: On successful peer authentication, a connectivity association is formed between the peers, and a secure Connectivity Association Key Name (CKN) is exchanged. After the exchange, the MKA ICV is validated with a Connectivity Association Key (CAK), which is effectively a secret key.

**Step 3**: A key server is selected between the routers, based on the configured key server priority. Lower the priority value, higher the preference for the router to become the key server. If no value is configured, the default value of 16 is taken to be the key server priority value for the router. Lowest priority value configures that router as the key server, while the other router functions as a key client. The following rules apply to key server selection:

- Numerically lower values of key server priority and SCI are accorded the highest preference.
- Each router selects a peer advertising the highest preference as its key server provided that peer has not selected another router as its key server or is not willing to function as the key server.
- In the event of a tie for highest preferred key server, the router with the highest priority SCI is chosen as key server (KS).
Step 4: A security association is formed between the peers. The key server generates and distributes the Secure Association Key (SAK) to the key client (peer). Each secure channel is supported by an overlapped sequence of Security Associations (SA). Each SA uses a new Secure Association Key (SAK).

Step 5: Encrypted data is exchanged between the peers.

**MACsec Frame Format**

The MACsec header in a frame consists of three components as illustrated in the following figure.

*Figure 2: MACsec Frame Format*

- **SecTAG**: The security tag is 8-16 bytes in length and identifies the SAK to be used for the frame. With Secure Channel Identifier (SCI) encoding, the security tag is 16 bytes in length, and without the encoding, 8 bytes in length (SCI encoding is optional). The security tag also provides replay protection when frames are received out of sequence.

- **Secure Data**: This is the data in the frame that is encrypted using MACsec and can be 2 or more octets in length.

- **ICV**: The ICV provides the integrity check for the frame and is usually 8-16 bytes in length, depending on the cipher suite. Frames that do not match the expected ICV are dropped at the port.

**Advantages of Using MACsec Encryption**

- **Data Integrity Check**: Integrity check value (ICV) is used to perform integrity check. The ICV is sent with the protected data unit and is recalculated and compared by the receiver to detect data modification.

- **Data Encryption**: Enables a port to encrypt outbound frames and decrypt MACsec-encrypted inbound frames.

- **Replay Protection**: When frames are transmitted through the network, there is a strong possibility of frames getting out of the ordered sequence. MACsec provides a configurable window that accepts a specified number of out-of-sequence frames.

- **Support for Clear Traffic**: If configured accordingly, data that is not encrypted is allowed to transit through the port.

**MACsec Support on Line Cards**

The MACsec technology is supported only on 36-port 100 GE line cards.
MACsec PSK

A pre-shared key includes a connectivity association key name (CKN) and a connectivity association key (CAK). A pre-shared key is exchanged between two devices at each end of a point-to-point link to enable MACsec using static CAK security mode. The MACsec Key Agreement (MKA) protocol is enabled after the pre-shared keys are successfully verified and exchanged. The pre-shared keys, the CKN and CAK, must match on both ends of a link.

For more information on MACsec PSK configuration, see Step 3, on page 80 of the Applying MACsec Configuration on an Interface, on page 80 section.

Fallback PSK

Fallback is a session recovery mechanism when primary PSK fails to bring up secured MKA session. It ensures that a PSK is always available to perform MACsec encryption and decryption.

- In CAK rollover of primary keys, if latest active keys are mismatched, system performs a hitless rollover from current active key to fallback key, provided the fallback keys match.
- If a session is up with fallback, and primary latest active key configuration mismatches are rectified between peers, system performs a hitless rollover from fallback to primary latest active key.

Note

A valid Fallback PSK (CKN and CAK) must be configured with infinite lifetime. If the fallback PSK is configured with CAK mismatch, the only recovery mechanism is to push a new set of PSK configurations (both on fallback PSK keychain and primary PSK chain in that order) on all the association members.

The following is a sample syslog for session secured with fallback PSK:

%L2-MKA-5-SESSION_SECURED_WITH_FALLBACK_PSK : (Hu0/1/0/0) MKA session secured, CKN:ABCD

For more information on MACsec fallback PSK configuration, see Step 3, on page 80 of the Applying MACsec Configuration on an Interface, on page 80 section.

Configuring and Verifying MACsec Encryption

MACsec can be configured on physical ethernet interfaces or interface bundles (link bundles), as explained in this section.

The following section describes procedures for configuring and verifying MACsec configuration in the described deployment modes.

Prior to configuring MACsec on a router interface the MACsec keychain must be defined. If you apply the MACsec keychain on the router without specifying a MACsec policy, the default policy is applied. A default MACsec policy is pre-configured with default values. If you need to change any of the pre-configured values, create a different MACsec policy.

Configuring MACsec involves the following steps:
1. Creating a MACsec keychain
2. Creating a user-defined MACsec policy
3. Applying MACsec configuration on physical interfaces

Creating a MACsec Keychain

A MACsec keychain is a collection of keys used to authenticate peers needing to exchange encrypted information. While creating a keychain, we define the key(s), key string with password, the cryptographic algorithm, and the key lifetime.

<table>
<thead>
<tr>
<th>MACsec Keychain Keyword</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key</td>
<td>The MACsec key or the CKN can be up to 64 characters in length. The key must be of an even number of characters. Entering an odd number of characters will exit the MACsec configuration mode.</td>
</tr>
<tr>
<td>Key-string</td>
<td>The MACsec key-string or the CAK can be either 32 characters or 64 characters in length (32 for AES-128, 64 for AES-256).</td>
</tr>
<tr>
<td>Lifetime</td>
<td>This field specifies the validity period of a key. It includes a start time, and an expiry time. We recommend you to set the value for expiry time as infinite.</td>
</tr>
</tbody>
</table>

Guidelines for Configuring MACsec Keychain

MACsec keychain management has the following configuration guidelines:

- MKA protocol uses the latest active key available in the Keychain. This key has the latest Start Time from the existing set of currently active keys. You can verify the values using the `show key chain keychain-name` command.

- Deletion or expiry of current active key brings down the MKA session resulting in traffic hit. We recommend you to configure the keys with infinite lifetime. If fallback is configured, traffic is safeguarded using fallback on expiry or deletion of primary-keychain active key.

- To achieve successful key rollover (CAK-rollover), the new key should be configured such that it is the latest active key, and kicks-in before the current key expires.

- We recommend an overlap of at least one minute for hitless CAK rollover from current key to new key.

- Start time and Expiry time can be configured with future time stamps, which allows bulk configuration for daily CAK rotation without any intervention of management agent.

SUMMARY STEPS

1. Enter the global configuration mode and provide a name for the MACsec keychain; for example, mac_chain.
2. Provide a name for the MACsec key.
3. Enter the key string and the cryptographic algorithm to be used for the key.
4. Enter the validity period for the MACsec key (CKN) also known as the lifetime period.
5. Commit your configuration.

### DETAILED STEPS

#### Step 1
Enter the global configuration mode and provide a name for the MACsec keychain; for example, `mac_chain`.

**Example:**

```
RP/0/RP0/CPU0:router(config)# keychain mac_chain
```

#### Step 2
Provide a name for the MACsec key.

The key can be up to 64 characters in length. The key must be of an even number of characters. Entering an odd number of characters will exit the MACsec configuration mode.

**Example:**

```
RP/0/RP0/CPU0:router(config-mac_chain-MACsec) # key 1234abcd5678
```

You can also configure a fall-back pre-shared key (PSK) to ensure that a PSK is always available to perform MACsec encryption and decryption. The fallback PSK along with the primary PSK ensures that the session remains active even if the primary PSK is mismatched or there is no active key for the primary PSK.

The configured key is the CKN that is exchanged between the peers.

**Note** If you are configuring MACsec to interoperate with a MACsec server that is running software prior to Cisco IOS XR Release 6.1.3, then ensure that the MACsec key length is of 64 characters. You can add extra zero characters to the MACsec key so that the length of 64 characters is achieved. If the key length is lesser than 64 characters, authentication will fail.

#### Step 3
Enter the key string and the cryptographic algorithm to be used for the key.

**Example:**

The key string is the CAK that is used for ICV validation by the MKA protocol.

* For AES 128-bit encryption

```
RP/0/RP0/CPU0:router(config-mac_chain-MacSec-1234abcd5678)#
key-string 12345678123456781234567812345678 cryptographic-algorithm AES-128-CMAC
```

* For AES 256-bit encryption

```
RP/0/RP0/CPU0:router(config-mac_chain-MacSec-1234abcd5678)#
key-string 1234567812345678123456781234567812345678123456781234567812345678123456781234567812345678 cryptographic-algorithm AES-256-CMAC
```

**Note** In this example, we have used the AES 256-bit encryption algorithm, and therefore, the key string is 64 hexadecimal characters in length. A 256-bit encryption algorithm uses a larger key that requires more rounds of hacking to be cracked. 256-bit algorithms provide better security against large mass security attacks, and include the security provided by 128-bit algorithms.

#### Step 4
Enter the validity period for the MACsec key (CKN) also known as the lifetime period.
The lifetime period can be configured, with a duration in seconds, as a validity period between two dates (for example, Jan 01 2014 to Dec 31 2014), or with infinite validity.

The key is valid from the time you configure (in HH:MM:SS format). Duration is configured in seconds.

Example:

```
RP/0/RP0/CPU0:router(config- mac_chain-MacSec-1234abcd5678)# lifetime 05:00:00 01 January 2015 duration 1800
```

An example of configuring the lifetime for a defined period:

```
RP/0/RP0/CPU0:router(config-mac_chain-MacSec-1234abcd5678)# lifetime 05:00:00 20 february 2015 12:00:00 30 september 2015
```

An example of configuring the lifetime as infinite:

```
RP/0/RP0/CPU0:router(config- mac_chain-MacSec-1234abcd5678)# lifetime 05:00:00 01 January 2015 infinite
```

Note When a key has expired, the MACsec session is torn down and running the `show macesec mka session` command does not display any information. If you run the `show macesec mka interface detail` command, the output displays *** No Active Keys Present *** in the PSK information.

Step 5 Commit your configuration.

Example:

```
RP/0/RP0/CPU0:router(config- mac_chain-MacSec-1234abcd5678)# exit
RP/0/RP0/CPU0:router (config)# commit
```

This completes the configuration of the MACsec keychain.

**Securing the MACsec Pre-shared Key (PSK) Using Type 6 Password Encryption**

Using the Type 6 password encryption feature, you can securely store MACsec plain text key string (CAK) in Type 6 encrypted format.

The master key is the password or key used to encrypt all plain text MACsec key strings (CAK) in the router configuration with the use of an Advance Encryption Standard (AES) symmetric cipher. The master key is not stored in the router configuration and cannot be seen or obtained in any way while connected to the router.

The Type 6 password encryption is effective only if a master key is configured. The Type 6 Password Encryption is currently available on NCS-55A1-36H-SE-S Router.

**Configuring a Master Key and Enabling the Type 6 Password Encryption Feature**

You can configure a master key for Type 6 encryption and enable the Advanced Encryption Standard (AES) password encryption feature for securing the MACsec keys (key string/CAK).
SUMMARY STEPS

1. key config-key password-encryption [delete]
2. configure terminal
3. [no] password6 encryption aes
4. commit

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> key config-key password-encryption [delete]</td>
<td>Configuring a Master Key</td>
</tr>
<tr>
<td><strong>Example:</strong> Configuring a Master Key</td>
<td></td>
</tr>
<tr>
<td>Router# <strong>key config-key password-encryption</strong></td>
<td></td>
</tr>
<tr>
<td>New password Requirements: Min-length 6, Max-length 64</td>
<td></td>
</tr>
<tr>
<td>Characters restricted to [A-Z][a-z][0-9]</td>
<td></td>
</tr>
<tr>
<td>Enter new key : Enter confirm key :</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Modifying the Master Key</td>
<td></td>
</tr>
<tr>
<td>Router# <strong>key config-key password-encryption</strong></td>
<td></td>
</tr>
<tr>
<td>New password Requirements: Min-length 6, Max-length 64</td>
<td></td>
</tr>
<tr>
<td>Characters restricted to [A-Z][a-z][0-9]</td>
<td></td>
</tr>
<tr>
<td>Enter old key : Enter new key : Enter confirm key :</td>
<td></td>
</tr>
<tr>
<td><strong>Example:</strong> Deleting the Master Key</td>
<td></td>
</tr>
<tr>
<td>Router# <strong>key config-key password-encryption delete</strong></td>
<td></td>
</tr>
</tbody>
</table>

| **Step 2** configure terminal | Enters global configuration mode. |
| **Example:** | |
| Router# configure terminal | |
| Router(config)# | |
### Purpose

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>[no] password6 encryption aes</td>
<td>Enables or disables the Type 6 password encryption feature. If you enable the Type 6/AES password encryption feature before configuring a master key, password encryption will not take place.</td>
</tr>
</tbody>
</table>

**Step 3**
Example:

```
Router(config)# password6 encryption aes
```

### Step 4
Example:

```
Router(config)# commit
```

Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

---

#### Example

### Configuring MACSec Pre-shared Key (PSK)

**Before you begin**

Ensure that you have configured a master key using the **key config-key password-encryption** command and enabled the Type 6 encryption feature using the **password6 encryption aes** command.

#### SUMMARY STEPS

1. **configure terminal**
2. **key chain** *key chain name macsec*
3. **key** *hex string of even length and max 64 bytes*
4. **key-string** *hex string of length 32 bytes or 64 bytes cryptographic-algorithm {aes-128-cmac | aes-256-cmac}*
5. **lifetime** *(hh:mm:ss) {1-31} month year infinite*
6. **commit**
7. **show running-config key chain** *keychain name*

#### DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> <strong>configure terminal</strong></td>
<td>Enters global configuration mode.</td>
</tr>
</tbody>
</table>
| Example: 
Router# configure terminal 
Router(config)# | |
| **Step 2** **key chain** *key chain name macsec* | Configures a key chain with the MACsec submode. |
| Example: 
Router(config)# key chain kcl macsec 
Router(config-kcl-MacSec)# | |
### Configure MACSec Pre-shared Key (PSK)

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 3</strong></td>
<td><strong>key hex string of even length and max 64 bytes</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config-kc1-MacSec)# key 1111&lt;br&gt;Router(config-kc1-MacSec-1111)#</td>
</tr>
<tr>
<td></td>
<td>Configures MACsec CKN as hex string of even length upto 64 bytes. <strong>Caution</strong> Configuring a hex string of odd number length exits from the MACsec submode. In that case, repeat from Step 2 to enter the MACsec submode again.</td>
</tr>
<tr>
<td><strong>Step 4</strong></td>
<td><strong>key-string hex string of length 32 bytes or 64 bytes</strong>&lt;br&gt;**cryptographic-algorithm {aes-128-cmac</td>
</tr>
<tr>
<td></td>
<td>Configures a plain text CAK of 32 byte hex string or 64 byte hex string with corresponding MKA (control plane) cryptographic algorithm (aes-128-cmac/ aes-256-cmac).</td>
</tr>
<tr>
<td><strong>Step 5</strong></td>
<td><strong>lifetime {hh:mm:ss} {1-31} month year infinite</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config-kc1-MacSec-1111)#&lt;br&gt;lifetime 00:00:00 1 january 2017 infinite</td>
</tr>
<tr>
<td></td>
<td>Configures a valid lifetime for MACsec PSK. <strong>Note</strong> Without configuring a valid lifetime, MACsec PSK will be an inactive key.</td>
</tr>
<tr>
<td><strong>Step 6</strong></td>
<td><strong>commit</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router(config)# commit</td>
</tr>
<tr>
<td></td>
<td>Use the <strong>commit</strong> command to save the configuration changes to the running configuration file and remain within the configuration session.</td>
</tr>
<tr>
<td><strong>Step 7</strong></td>
<td><strong>show running-config key chain keychain name</strong>&lt;br&gt;<strong>Example:</strong>&lt;br&gt;Router# show running-config key chain kc1&lt;br&gt;key chain kc1&lt;br&gt;macsec&lt;br&gt;key 1111&lt;br&gt;key-string password6&lt;br&gt;5d63525a58594657565e68454468426596554862424c5&lt;br&gt;95d696554694a424c59655f504a575e6648484c484b4646&lt;br&gt;535d49675e535a60644e6045654a655f666858414142&lt;br&gt;cryptographic-algorithm aes-128-cmac&lt;br&gt;lifetime 00:00:00 january 01 2017 infinite ! ! !</td>
</tr>
<tr>
<td></td>
<td>[Optional] Displays the Type 6 encrypted key string.</td>
</tr>
</tbody>
</table>
Creating a User-Defined MACsec Policy

SUMMARY STEPS

1. Enter the global configuration mode, and enter a name (mac_policy) for the MACsec policy.
2. Configure the cipher suite to be used for MACsec encryption.
3. Configure the confidentiality offset for MACsec encryption.
4. Enter the key server priority.
5. Configure the security policy parameters, either Must-Secure or Should-Secure.
6. Configure data delay protection under MACsec policy.
7. Configure the replay protection window size.
8. Configure the ICV for the frame arriving on the port.
9. Commit your configuration and exit the global configuration mode.
10. Confirm the MACsec policy configuration.

DETAILED STEPS

Step 1

Enter the global configuration mode, and enter a name (mac_policy) for the MACsec policy.

Example:

RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# macsec-policy mac_policy

Step 2

Configure the cipher suite to be used for MACsec encryption.

Example:

RP/0/RP0/CPU0:router(config-mac_policy)# cipher-suite GCM-AES-XPN-256
RP/0/RP0/CPU0:router(config-mac_policy)# GCM-AES-128
GCM-AES-256
GCM-AES-XPN-128
GCM-AES-XPN-256

Note

In this example, we have used the GCM-AES-XPN-256 encryption algorithm. A 256-bit encryption algorithm uses a larger key that requires more rounds of hacking to be cracked. 256-bit algorithms provide better security against large mass security attacks, and include the security provided by 128-bit algorithms. Extended Packet Numbering (XPN) is used to reduce the number of key rollovers while data is sent over high speed links. It is therefore highly recommended to use GCM-AES-XPN-256 encryption algorithm for higher data ports.

Step 3

Configure the confidentiality offset for MACsec encryption.

Example:

RP/0/RP0/CPU0:router(config-mac_policy)# conf-offset CONF-OFFSET-30

Step 4

Enter the key server priority.

You can enter a value between 0-255. Lower the value, higher the preference to be selected as the key server.
In this example, a value of 0 configures the router as the key server, while the other router functions as a key client. The key server generates and maintains the SAK between the two routers. The default key server priority value is 16.

**Example:**

```
RP/0/RP0/CPU0:router(config-mac_policy)# key-server-priority 0
```

**Step 5**

Configure the security policy parameters, either Must-Secure or Should-Secure.

**Must-Secure:** Must-Secure imposes only MACsec encrypted traffic to flow. Hence, until MKA session is not secured, traffic will be dropped.

**Example:**

```
RP/0/RP0/CPU0:router(config-mac_policy)# security-policy must-secure
```

**Should-Secure:** Should-Secure allows unencrypted traffic to flow until MKA session is secured. After the MKA session is secured, Should-Secure policy imposes only encrypted traffic to flow.

**Example:**

```
RP/0/RP0/CPU0:router(config-mac_policy)# security-policy should-secure
```

**Table 3: MACsec Security Policies**

<table>
<thead>
<tr>
<th>MKA</th>
<th>Secured MKA Session</th>
<th>Unsecured MKA Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security Policy</td>
<td>Must-secure</td>
<td>Encrypted traffic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic drop (no Tx and no Rx)</td>
</tr>
<tr>
<td></td>
<td>Should-secure</td>
<td>Encrypted traffic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plain text or unencrypted traffic</td>
</tr>
</tbody>
</table>

**Step 6**

Configure data delay protection under MACsec policy.

Data delay protection allows MKA participants to ensure that the data frames protected by MACsec are not delayed by more than 2 seconds. Each SecY uses MKA to communicate the lowest PN used for transmission with the SAK within two seconds. Traffic delayed longer than 2 seconds are rejected by the interfaces enabled with delay protection.

By default, the data delay protection feature is disabled. Configuring the `delay-protection` command under MACsec-policy attached to MACsec interface will enable the data delay protection feature on that interface.

**Example:**

```
RP/0/RP0/CPU0:router# configure terminal
RP/0/RP0/CPU0:router(config)# macsec-policy mp1
RP/0/RP0/CPU0:router(config-macsec-policy)# delay-protection
RP/0/RP0/CPU0:router(config-macsec-policy)# commit
```

**Verification:**

The following show command output verifies that the data delay protection feature is enabled.

**Example:**

```
RP/0/RP0/CPU0:router# show macsec mka session interface GigabitEthernet 0/1/0/1 detail
MKA Policy Name : mp1
Key Server Priority : 16
Delay Protection : TRUE
Replay Window Size : 64
Confidentiality Offset : 0
Algorithm Agility : 80C201
SAK Cipher Suite : (NONE)
```
MACsec Capability : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired : YES

**Step 7** Configure the replay protection window size.

**Example:**
RP/0/RP0/CPU0:router(config-mac_policy)# window-size 64

This dictates the maximum out-of-sequence frames that are accepted. You can configure a value between 0 and 1024.

**Step 8** Configure the ICV for the frame arriving on the port.

**Example:**
RP/0/RP0/CPU0:router(config-mac_policy)# include-icv-indicator

This parameter configures inclusion of the optional ICV Indicator as part of the transmitted MACsec Key Agreement PDU (MKPDU). This configuration is necessary for MACsec to interoperate with routers that run software prior to IOS XR version 6.1.3. This configuration is also important in a service provider WAN setup where MACsec interoperates with other vendor MACsec implementations that expect ICV indicator to be present in the MKPDU.

**Step 9** Commit your configuration and exit the global configuration mode.

**Example:**
RP/0/RP0/CPU0:router(config-mac_policy)# exit
RP/0/RP0/CPU0:router(config)# commit
RP/0/RP0/CPU0:router(config)# exit

**Step 10** Confirm the MACsec policy configuration.

**Example:**
RP/0/RP0/CPU0:router# show running-config macsec-policy

macsec-policy mac_policy
conf-offset CONF-OFFSET-30
security-policy must-secure
window-size 64
cipher-suite GCM-AES-XPN-256
key-server-priority 0
include-icv-indicator

This completes the configuration of the MACsec policy.

---

**Note**

- Small packets might be dropped when Data Delay Protection (DDP) is enabled on many MACsec enabled interfaces of a scaled setup. To avoid this, enable DDP only on the interfaces which are absolutely necessary.

- For Cisco NCS 5500 Series Routers to interoperate with Cisco ASR9000 Series Routers that are older than Release 6.2.3, configure a user defined MACsec policy with the `policy-exception lacp-in-clear` command to bring up the MKA sessions over bundle interfaces running in LACP modes.
Applying MACsec Configuration on an Interface

The MACsec service configuration is applied to the host-facing interface of a CE router.

Guidelines for MACsec Interface Configuration

Following are the guidelines for configuring MACsec interface:

- Configure different keychains for primary and fallback PSKs.
- We do not recommend to update both primary and fallback PSKs simultaneously, because fallback PSK is intended to recover MACsec session on primary key mismatch.

SUMMARY STEPS

1. Enter the global configuration mode.
2. Enter the interface configuration mode.
3. Apply the MACsec configuration on an interface.
4. Commit your configuration.

DETAILED STEPS

Step 1
Enter the global configuration mode.

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

Step 2
Enter the interface configuration mode.

Example:
```
RP/0/RP0/CPU0:router(config)# interface Te0/3/0/1/4
```

Step 3
Apply the MACsec configuration on an interface.

MACsec PSK Configuration

To apply MACsec PSK configuration on an interface, use the following command.

Example:
```
RP/0/RP0/CPU0:router(config-if)# macsec psk-keychain mac_chain policy mac_policy
RP/0/RP0/CPU0:router(config-if)# exit
```

To apply MACsec configuration on a physical interface without the MACsec policy, use the following command.

Example:
```
RP/0/RP0/CPU0:router(config-if)# macsec psk-keychain script_key_chain2
RP/0/RP0/CPU0:router(config-if)# exit
```

MACsec Fallback PSK Configuration

To apply MACsec configuration on a physical interface with a fallback PSK, use the following command.

Example:
It is optional to configure a fallback PSK. If a fallback PSK is configured, the fallback PSK along with the primary PSK ensures that the session remains active even if the primary PSK is mismatched, or there is no active key for the primary PSK.

Step 4  Commit your configuration.

Example:
RP/0/RP0/CPU0:router(config)# commit

Verifying MACsec Encryption on IOS XR

MACsec encryption on IOS XR can be verified by running relevant commands in the Privileged Executive Mode. The verification steps are the same for MACsec encryption on L2VPN or L3VPN network.

To verify if MACsec encryption has been correctly configured, follow these steps.

**SUMMARY STEPS**

1. Verify the MACsec policy configuration.
2. Verify the MACsec configuration on the respective interface.
3. Verify whether the interface of the router is peering with its neighbor after MACsec configuration. The MACsec PSK validation detects inconsistency or mismatch of primary and fallback keys (CAK) being used by MKA, allowing operators to rectify the mismatch.
4. Verify whether the MKA session is secured with MACsec on the respective interface.
5. Verify the MACsec session counter statistics.

**DETAILED STEPS**

**Step 1**  Verify the MACsec policy configuration.

Example:

```
RP/0/RP0/CPU0:router# show macsec policy mac_policy
```

```
Policy          Cipher Key-Svr Window Conf
name            Suite Priority Size Offset
```

```
mac_policy      GCM-AES-XPN-256 0   64   30
```

If the values you see are different from the ones you configured, then check your configuration by running the `show run macsec-policy` command.
Step 2  Verify the MACsec configuration on the respective interface.

You can verify the MACsec encryption on the configured interface bundle (MPLS network).

Example:

```
RP/0/RP0/CPU0:router# show macsec mka summary

NODE: node0_0_CPU0

==================================================================
<table>
<thead>
<tr>
<th>Interface</th>
<th>Status</th>
<th>Cipher Suite</th>
<th>KeyChain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fo0/0/0/0</td>
<td>Secured</td>
<td>GCM-AES-XPN-256</td>
<td>mac_chain</td>
</tr>
</tbody>
</table>

Total MACSec Sessions : 1
Secured Sessions : 1
Pending Sessions : 0
```

The `Status` field in the output confirms that the respective interface is `Secured`. If MACsec encryption is not successfully configured, you will see a status such as `Pending` or `Init`.

Note  In the VPLS network, because of the configuration on a multi-point interface, the number of live peers displayed is more than 1.

Run the `show run macsec-policy` command in the privileged executive mode to troubleshoot the configuration entered.

Step 3  Verify whether the interface of the router is peering with its neighbor after MACsec configuration. The MACsec PSK validation detects inconsistency or mismatch of primary and fallback keys (CAK) being used by MKA, allowing operators to rectify the mismatch.

Example:

The `show macsec mka session interface interface detail` command carries the Peer Validation status in the Peer CAK field. The values of this field can be either `Match` or `Mismatch`.

The following show command output verifies that the primary and fallback keys (CAK) are matched on both peer ends.

```
* RP/0/RP0/CPU0:router# show macsec mka session detail
Peers Status:
  Last Tx MKPDU : 2017 Sep 02 11:24:52.369
  Peer Count   : 1
  RxSCI        : 008A960060900001
  MI           : C2213E81C953A202C08DB999
  Peer CAK     : Match
  Latest Rx MKPDU : 2017 Sep 02 11:24:53.360
  Fallback Data:
    CKN        : ABCD
    MI         : 84E724B4BA07CE414FEA84EF
    MN         : 8
    Peers Status:
      Last Tx MKPDU: 2017 Sep 02 11:24:52.369
      Peer Count  : 1
      RxSCI       : 008A960060900001
      MI          : D2B902453F90389BD3385F84
```
Peer CAK: Match
Latest Rx MKPDU: 2017 Sep 02 11:24:53.360

* Syslog

$L2-MKA-6-MKPDU_ICV_SUCCESS: (Hu0/5/0/1), ICV verification success for RxSCI(008a.9600.6090/0001), CKN(1000)
$L2-MKA-6-FALLBACK_PSK_MKPDU_ICV_SUCCESS: (Hu0/5/0/1), ICV verification success for RxSCI(008a.9600.6090/0001), CKN(FFFF)

The following show command output verifies that the primary and fallback keys (CAK) are mismatched on both peer ends.

* RP/0/RP0/CPU0# show macsec mka session detail

Peers Status:
Last Tx MKPDU: 2017 Sep 02 11:24:52.369
Peer Count: 1
RxSCI: 008A960060900001
MI: C2213E81C953A202C08DB999

Peer CAK: Mismatch
Latest Rx MKPDU: 2017 Sep 02 11:24:53.360
Fallback Data:
CKN: ABCD
MI: 84E724B4BA07CE414FEA84EF
MN: 8

Peers Status:
Last Tx MKPDU: 2017 Sep 02 11:24:52.369
Peer Count: 1
RxSCI: 008A960060900001
MI: D2B902453F90389BD3385F84

Peer CAK: Mismatch
Latest Rx MKPDU: 2017 Sep 02 11:24:53.360

* Syslog

$L2-MKA-3-MKPDU_ICV_FAILURE: (Hu0/5/0/1), ICV verification failed for RxSCI(008a.9600.6090/0001), CKN(1111)
$L2-MKA-3-FALLBACK_PSK_MKPDU_ICV_FAILURE: (Hu0/5/0/1), ICV verification failed for RxSCI(008a.9600.6090/0001), CKN(9999)

Note

The #Peers field in the following output confirms the presence of the peer you have configured on the physical interface, Fo0/0/0/1/0. If the number of peers is not reflected accurately in this output, run the show run command and verify the peer configuration on the interface.

RP/0/RP0/CPU0# show macsec mka session

NODE: node0_0_CPU0

-----------------------------------------------------------------------------------------------
Interface Local-TxSCI # Peers Status Key-Server
-----------------------------------------------------------------------------------------------
Fo0/0/0/1/0 001d.e5e9.aa39/0005 1 Secured YES

Step 4

Verify whether the MKA session is secured with MACsec on the respective interface.

Example:
The **Status** field in the output verifies if the MKA session is secured with MACsec encryption. The output also displays information about the interface and other MACsec parameters.

**Step 5**

Verify the MACsec session counter statistics.

**Example:**

RP/0/RP0/CPU0:router# `show macsec mka statistics interface Fo0/0/0/1/0`

MKA Statistics for Session on interface (Fo0/0/0/1/0)
```
Reauthentication Attempts.. 0

CA Statistics
Pairwise CAKs Derived... 0
Pairwise CAK Rekeys..... 0
Group CAKs Generated.... 0
```
Group CAKs Received..... 0

SA Statistics
SAKs Generated......... 3
SAKs Rekeyed............ 2
SAKs Received........... 0
SAK Responses Received.. 3

MKPDU Statistics
MKPDUs Transmitted...... 5425
"Distributed SAK".. 8
"Distributed CAK".. 0
MKPDUs Validated & Rx... 4932
"Distributed SAK".. 0
"Distributed CAK".. 0

MKA IDB Statistics
MKPDUs Tx Success........ 5425
MKPDUs Tx Fail.......... 0
MKPDUs Tx Pkt build fail... 0
MKPDUs Rx CA Not found.... 0
MKPDUs Rx Error........ 0
MKPDUs Rx Success....... 4932

MKPDU Failures
MKPDU Rx Validation (ICV).............. 0
MKPDU Rx Bad Peer MN............... 0
MKPDU Rx Non-recent Peerlist MN....... 0
MKPDU Rx Drop SAKUSE, KN mismatch...... 0
MKPDU Rx Drop SAKUSE, Rx Not Set...... 0
MKPDU Rx Drop SAKUSE, Key MI mismatch.. 0
MKPDU Rx Drop SAKUSE, AN Not in Use.... 0
MKPDU Rx Drop SAKUSE, KS Rx/Tx Not Set. 0

SAK Failures
SAK Generation............... 0
Hash Key Generation.......... 0
SAK Encryption/Wrap......... 0
SAK Decryption/Unwrap....... 0

The counters display the MACsec PDUs transmitted, validated, and received. The output also displays transmission errors, if any.

This completes the verification of MACsec encryption on the IOS-XR.

**Verifying MACsec Encryption on NCS 5500**

MACsec encryption on the router hardware can be verified by running relevant commands in the Privileged Executive Mode.

To verify if MACsec encryption has been correctly configured, follow these steps.

**SUMMARY STEPS**

1. Verify the MACsec encryption and hardware interface descriptor block (IDB) information on the interface.
2. Use the IDB handle retrieved from Step 1 to verify the platform hardware information.
3. Use the Transmitter SA retrieved from Step 2 to verify the MACsec SA information programmed in the hardware.
4. Verify the MACsec Secure Channel (SC) information programmed in the hardware.

**DETAILED STEPS**

**Step 1**
Verify the MACsec encryption and hardware interface descriptor block (IDB) information on the interface.

**Example:**

```
RP/0/RP0/CPU0:router# show macsec ea idb interface Fo0/0/1/0
```

**IDB Details:**
- if_sname: Fo0/0/0/1/0
- if_handle: 0x3480
- Replay window size: 64
- Local MAC: 00:1d:e5:e9:aa:39
- Rx SC Option(s): Validate-Frames Replay-Protect
- Tx SC Option(s): Protect-Frames Always-Include-SCI
- Security Policy: MUST SECURE
- Sectag offset: 8
- Rx SC 1
  - Rx SCI: 001de5e9b1bf0019
  - Peer MAC: 00:1d:e5:e9:b1:bf
  - Stale: NO
  - SAK Data
    - SAK[0]: ***
    - SAK Len: 32
    - HashKey[0]: ***
    - HashKey Len: 16
    - Conf offset: 30
    - Cipher Suite: GCM-AES-XPN-256
    - CtxSalt[0]: 83 c3 7b ad 7b 6f 63 16 09 8f f3 d2
    - Rx SA Program Req[0]: 2015 Oct 09 15:20:53.082
    - Tx SA Program Req[0]: 2015 Oct 09 15:20:53.092

- Tx SC 1
  - Tx SCI: 001de5e9aa39001a
  - Active AN: 0
  - Old AN: 255
  - Next PN: 1, 0, 0, 0
  - SAK Data
    - SAK[0]: ***
    - SAK Len: 32
    - HashKey[0]: ***
    - HashKey Len: 16
    - Conf offset: 30
    - Cipher Suite: GCM-AES-XPN-256
    - CtxSalt[0]: 83 c3 7b ae 7b 6f 63 16 09 8f f3 d2
    - Tx SA Program Req[0]: 2015 Oct 09 15:20:55.053
    - Tx SA Program Rsp[0]: 2015 Oct 09 15:20:55.064

The if_handle field provides the IDB instance location.
The Replay window size field displays the configured window size.
The Security Policy field displays the configured security policy.
The Local Mac field displays the MAC address of the router.
The **Peer Mac** field displays the MAC address of the peer. This confirms that a peer relationship has been formed between the two routers.

**Step 2** Use the IDB handle retrieved from Step 1 to verify the platform hardware information.

**Example:**

```plaintext
RP/0/RP0/CPU0:router# show macsec platform hardware
idb location 0/0/CPU0 | b 3480

 if_handle : 0x000003480
 NFPort : 099 [0x063]  
 LdaPort : 016 [0x010] SerdesPort : 000 [0x000]  
 NetSoftPort : 061 [0x03d] SysSoftPort : 062 [0x03e]  
 Active AN : 0x00000000 Idle AN : 0x000000ff  
 Match-All Tx SA : 0x80010001 Match-All Rx SA : 0x00010001  
 Match-All Tx Flow : 0x00000003 Match-All Rx Flow : 0x00000000  
 Bypass Tx SA : 0x80000000 Bypass Rx SA : 0x00000000  
 Tx SA[0] : 0x80020002 Tx Flow[0] : 0x8000000c  
 Rx SA[0] : 0x00020002 Rx Flow[0] : 0x0000000c  
```

**Step 3** Use the Transmitter SA retrieved from Step 2 to verify the MACsec SA information programmed in the hardware.

**Example:**

```plaintext
RP/0/RP0/CPU0:router# show macsec platform hardware sa
0x80020002 interface Fo0/0/0/1/0 location 0/0/CPU0

MACsec HW SA Details:
Action Type : 0x00000003
Direction : Egress
Dest Port : 0x00000000
Conf Offset : 00000030
Drop Type : 0x00000002
Drop NonResvd : 0x00000000
SA In Use : YES
ConfProtect : YES
IncludeSCI : YES
ProtectFrame : YES
UseEs : NO
UseSCB : NO
SCI : 00 1d e5 e9 aa 39 00 05
Replay Window : 64 MacsecCryptoAlgo : 7
Direction : Egress AN : 0
AES Key Len : 256 X-Packet Number : 0x0000000000000000
CtxSalt : f8d88dc3e1c5e6a94ea2299
```

The output displays the details of the encryption, such as the AES key, the Auth key, and other parameters.

**Step 4** Verify the MACsec Secure Channel (SC) information programmed in the hardware.

**Example:**

```plaintext
```

System Security Configuration Guide for Cisco NCS 5500 Series Routers, IOS XR Release 6.3.x
MACsec HW Cfg Details:
Mode : 0x5
Counter Clear on Read : 0x0
SA Fail Mask : 0xffffffff
Global SecFail Mask : 0xffffffff
Latency : 0xff
StaticBypass : 0x0
Should secure : 0x0
Global Frame Validation : 0x2
Ctrl Pkt CC Bypass : 0x1
NonCtrl Pkt CC Bypass : 0x1
Sequence Number Threshold : 0xbfffffb8
Sequence Number Threshold 64bit : 0x000002fffffffffd
Non Matching Non Control Pkts Programming
  Untagged : Bypass: 0x0 DestPort : 0x2, DropType : 0x2
  Tagged : Bypass: 0x0 DestPort : 0x2, DropType : 0x2
  BadTagged : Bypass: 0x0 DestPort : 0x2, DropType : 0x2
  KayTagged : Bypass: 0x0 DestPort : 0x2, DropType : 0x2
Non Matching Control Pkts Programming
  Untagged : Bypass: 0x1 DestPort : 0x2, DropType : 0xffffffff
  Tagged : Bypass: 0x0 DestPort : 0x2, DropType : 0x2
  BadTagged : Bypass: 0x0 DestPort : 0x2, DropType : 0x2
  KayTagged : Bypass: 0x0 DestPort : 0x2, DropType : 0x2

This completes the verification of MACsec encryption on the router hardware.

This completes the configuration and verification of MACsec encryption.

**MACsec SecY Statistics**

The following methods are used to query MACsec SecY statistics such as, encryption, decryption, and the hardware statistics.

- CLI
- SNMP MIB

**Querying SNMP Statistics Using CLI**

The following example shows how to query SNMP statistics using a CLI. Use the `show macsec secy statistics interface interface name` command to display the MACsec SecY statistics details.

```
Router# show macsec secy statistics interface GigabitEthernet 0/1/0/0 SC
Interface Statistics
  InPktsUnTagged : 0
  InPktsNoTag : 1
  InPktsBadTag : 2
  InPktsUnknownSCI : 3
  InPktsNoSCI : 4
  InPktsOverrun : 5
  InOctetsValidated : 6
```
### SC Statistics

**TxSC Statistics**
- OutPktsProtected: 12
- OutPktsEncrypted: 13
- OutOctetsProtected: 14
- OutOctetsEncrypted: 15
- OutPktsTooLong: 16

**TxSA Statistics**
- **TxSA 0:**
  - OutPktsProtected: 17
  - OutPktsEncrypted: 18
  - NextPN: 19
- **TxSA 1:**
  - OutPktsProtected: 20
  - OutPktsEncrypted: 21
  - NextPN: 22
- **TxSA 2:**
  - OutPktsProtected: 23
  - OutPktsEncrypted: 24
  - NextPN: 25
- **TxSA 3:**
  - OutPktsProtected: 26
  - OutPktsEncrypted: 27
  - NextPN: 28

### RxSC Statistics

**RxSC Statistics**
- RxSC 1: 0
- InPktsUnchecked: 29
- InPktsDelayed: 30
- InPktsLate: 31
- InPktsOK: 32
- InPktsInvalid: 33
- InPktsNotValid: 34
- InPktsNotUsingSA: 35
- InPktsUnusedSA: 36
- InPktsUntaggedHit: 37
- InOctetsValidated: 38
- InOctetsDecrypted: 39

### RxSA Statistics

**RxSA Statistics**
- RxSA 0:
  - InPktsUnusedSA: 44
  - InPktsNotUsingSA: 43
  - InPktsNotValid: 42
  - InPktsInvalid: 41
  - InPktsOK: 40
  - NextPN: 45
- **RxSA 1:**
  - InPktsUnusedSA: 50
  - InPktsNotUsingSA: 49
  - InPktsNotValid: 48
  - InPktsInvalid: 47
  - InPktsOK: 46
  - NextPN: 51
- **RxSA 2:**
  - InPktsUnusedSA: 56
  - InPktsNotUsingSA: 55
  - InPktsNotValid: 54
  - InPktsInvalid: 53
  - InPktsOK: 52
  - NextPN: 57
The IEEE8021-SECY-MIB provides Simple Network Management Protocol (SNMP) access to the MAC security entity (SecY) MIB running with IOS XR MACsec-enabled line cards. The IEEE8021-SECY-MIB is used to query on the SecY data, encryption, decryption, and the hardware statistics. The SecY MIB data is queried only on the Controlled Port.

The object ID of the IEEE8021-SECY-MIB is 1.0.8802.1.1.3. The IEEE8021-SECY-MIB contains the following tables that specifies the detailed attributes of the MACsec Controlled Port interface index.

Table 4: IEEE8021-SECY-MIB Table

<table>
<thead>
<tr>
<th>Tables</th>
<th>OID</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyIfTable</td>
<td>1.0.8802.1.1.3.1.1.1</td>
</tr>
<tr>
<td>secyTxSCTable</td>
<td>1.0.8802.1.1.3.1.1.2</td>
</tr>
<tr>
<td>secyTxSATable</td>
<td>1.0.8802.1.1.3.1.1.3</td>
</tr>
<tr>
<td>secyRxSCTable</td>
<td>1.0.8802.1.1.3.1.1.4</td>
</tr>
<tr>
<td>secyRxSATable</td>
<td>1.0.8802.1.1.3.1.1.5</td>
</tr>
<tr>
<td>secyCipherSuiteTable</td>
<td>1.0.8802.1.1.3.1.1.6</td>
</tr>
<tr>
<td>secyTxSASStatsTable</td>
<td>1.0.8802.1.1.3.1.2.1</td>
</tr>
<tr>
<td>secyTxSCSStatsTable</td>
<td>1.0.8802.1.1.3.1.2.2</td>
</tr>
<tr>
<td>secyRxSASStatsTable</td>
<td>1.0.8802.1.1.3.1.2.3</td>
</tr>
<tr>
<td>secyRxSCSStatsTable</td>
<td>1.0.8802.1.1.3.1.2.4</td>
</tr>
<tr>
<td>secyStatsTable</td>
<td>1.0.8802.1.1.3.1.2.5</td>
</tr>
</tbody>
</table>

For more information, see the SecY IEEE MIB at the following URL:

**secyIfTable**

The following table represents the system level information for each interface supported by the MAC security entity. The index tuple for this table is secyIfInterfaceIndex.
Table 5: secyIfTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyIfInterfaceIndex</td>
<td>1.0.8802.1.1.3.1.1.1.1.1</td>
</tr>
<tr>
<td>secyIfMaxPeerSCs</td>
<td>1.0.8802.1.1.3.1.1.1.1.2</td>
</tr>
<tr>
<td>secyIfRxMaxKeys</td>
<td>1.0.8802.1.1.3.1.1.1.1.3</td>
</tr>
<tr>
<td>secyIfTxMaxKeys</td>
<td>1.0.8802.1.1.3.1.1.1.1.4</td>
</tr>
<tr>
<td>secyIfProtectFramesEnable</td>
<td>1.0.8802.1.1.3.1.1.1.1.5</td>
</tr>
<tr>
<td>secyIfValidateFrames</td>
<td>1.0.8802.1.1.3.1.1.1.1.6</td>
</tr>
<tr>
<td>secyIfReplayProtectEnable</td>
<td>1.0.8802.1.1.3.1.1.1.1.7</td>
</tr>
<tr>
<td>secyIfReplayProtectWindow</td>
<td>1.0.8802.1.1.3.1.1.1.1.8</td>
</tr>
<tr>
<td>secyIfCurrentCipherSuite</td>
<td>1.0.8802.1.1.3.1.1.1.1.9</td>
</tr>
<tr>
<td>secyIfAdminPt2PtMAC</td>
<td>1.0.8802.1.1.3.1.1.1.1.10</td>
</tr>
<tr>
<td>secyIfOperPt2PtMAC</td>
<td>1.0.8802.1.1.3.1.1.1.1.11</td>
</tr>
<tr>
<td>secyIfIncludeSCIEnable</td>
<td>1.0.8802.1.1.3.1.1.1.1.12</td>
</tr>
<tr>
<td>secyIfUseESEnable</td>
<td>1.0.8802.1.1.3.1.1.1.1.13</td>
</tr>
<tr>
<td>secyIfUseSCBEnable</td>
<td>1.0.8802.1.1.3.1.1.1.1.14</td>
</tr>
</tbody>
</table>

secyTxSCTable

The following table provides information about the status of each transmitting SC supported by the MAC security entity. The index tuple for this table is secyIfInterfaceIndex.

Table 6: secyTxSCTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyTxSCI</td>
<td>1.0.8802.1.1.3.1.1.2.1.1</td>
</tr>
<tr>
<td>secyTxSCState</td>
<td>1.0.8802.1.1.3.1.1.2.1.2</td>
</tr>
<tr>
<td>secyTxSCEncodingSA</td>
<td>1.0.8802.1.1.3.1.1.2.1.3</td>
</tr>
<tr>
<td>secyTxSCEncipheringSA</td>
<td>1.0.8802.1.1.3.1.1.2.1.4</td>
</tr>
<tr>
<td>secyTxSCCreatedTime</td>
<td>1.0.8802.1.1.3.1.1.2.1.5</td>
</tr>
<tr>
<td>secyTxSCStartedTime</td>
<td>1.0.8802.1.1.3.1.1.2.1.6</td>
</tr>
<tr>
<td>secyTxSCStoppedTime</td>
<td>1.0.8802.1.1.3.1.1.2.1.7</td>
</tr>
</tbody>
</table>
secyTxSATable

The following table provides information about the status of each transmitting SA supported by the MAC security entity. The index tuple for this table is: {secyIfInterfaceIndex, secyTxSA}.

Table 7: secyTxSATable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyTxSA</td>
<td>1.0.8802.1.1.3.1.1.3.1.1</td>
</tr>
<tr>
<td>secyTxSASState</td>
<td>1.0.8802.1.1.3.1.1.3.1.2</td>
</tr>
<tr>
<td>secyTxSANextPN</td>
<td>1.0.8802.1.1.3.1.1.3.1.3</td>
</tr>
<tr>
<td>secyTxSAConfidentiality</td>
<td>1.0.8802.1.1.3.1.1.3.1.4</td>
</tr>
<tr>
<td>secyTxSASAKUnchanged</td>
<td>1.0.8802.1.1.3.1.1.3.1.5</td>
</tr>
<tr>
<td>secyTxSACreatedTime</td>
<td>1.0.8802.1.1.3.1.1.3.1.6</td>
</tr>
<tr>
<td>secyTxSASTartedTime</td>
<td>1.0.8802.1.1.3.1.1.3.1.7</td>
</tr>
<tr>
<td>secyTxSAStoppedTime</td>
<td>1.0.8802.1.1.3.1.1.3.1.8</td>
</tr>
</tbody>
</table>

secyRxSCTable

The following table provides information about the status of each receiving SC supported by the MAC security entity. The index tuple for this table is: {secyIfInterfaceIndex, secyRxSCI}.

Table 8: secyRxSCTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyRxSCI</td>
<td>1.0.8802.1.1.3.1.1.4.1.1</td>
</tr>
<tr>
<td>secyRxSCState</td>
<td>1.0.8802.1.1.3.1.1.4.1.2</td>
</tr>
<tr>
<td>secyRxSCCurrentSA</td>
<td>1.0.8802.1.1.3.1.1.4.1.3</td>
</tr>
<tr>
<td>secyRxSCCreatedTime</td>
<td>1.0.8802.1.1.3.1.1.4.1.4</td>
</tr>
<tr>
<td>secyRxSCStartedTime</td>
<td>1.0.8802.1.1.3.1.1.4.1.5</td>
</tr>
<tr>
<td>secyRxSCStoppedTime</td>
<td>1.0.8802.1.1.3.1.1.4.1.6</td>
</tr>
</tbody>
</table>

secyRxSATable

The following table provides information about the status of each receiving SA supported by the MAC security entity. The index tuple for this table is: {secyIfInterfaceIndex, secyRxSCI, secyRxSA}. 
Table 9: secyRxSATable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyRxSA</td>
<td>1.0.8802.1.1.3.1.1.5.1.1</td>
</tr>
<tr>
<td>secyRxSAState</td>
<td>1.0.8802.1.1.3.1.1.5.1.2</td>
</tr>
<tr>
<td>secyRxSANextPN</td>
<td>1.0.8802.1.1.3.1.1.5.1.3</td>
</tr>
<tr>
<td>secyRxSASAKUnchanged</td>
<td>1.0.8802.1.1.3.1.1.5.1.4</td>
</tr>
<tr>
<td>secyRxSACreatedTime</td>
<td>1.0.8802.1.1.3.1.1.5.1.5</td>
</tr>
<tr>
<td>secyRxSAStartedTime</td>
<td>1.0.8802.1.1.3.1.1.5.1.6</td>
</tr>
<tr>
<td>secyRxSAStoppedTime</td>
<td>1.0.8802.1.1.3.1.1.5.1.7</td>
</tr>
</tbody>
</table>

secyCipherSuiteTable

The following table is a list of selectable cipher suites for the MAC security entity. The index tuple for this table is: {secyCipherSuiteIndex}.

Table 10: secyCipherSuiteTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyCipherSuiteIndex</td>
<td>1.0.8802.1.1.3.1.1.6.1.1</td>
</tr>
<tr>
<td>secyCipherSuiteId</td>
<td>1.0.8802.1.1.3.1.1.6.1.2</td>
</tr>
<tr>
<td>secyCipherSuiteName</td>
<td>1.0.8802.1.1.3.1.1.6.1.3</td>
</tr>
<tr>
<td>secyCipherSuiteCapability</td>
<td>1.0.8802.1.1.3.1.1.6.1.4</td>
</tr>
<tr>
<td>secyCipherSuiteProtection</td>
<td>1.0.8802.1.1.3.1.1.6.1.5</td>
</tr>
<tr>
<td>secyCipherSuiteProtectionOffset</td>
<td>1.0.8802.1.1.3.1.1.6.1.6</td>
</tr>
<tr>
<td>secyCipherSuiteDataLengthChange</td>
<td>1.0.8802.1.1.3.1.1.6.1.7</td>
</tr>
<tr>
<td>secyCipherSuiteICVLength</td>
<td>1.0.8802.1.1.3.1.1.6.1.8</td>
</tr>
<tr>
<td>secyCipherSuiteRowStatus</td>
<td>1.0.8802.1.1.3.1.1.6.1.9</td>
</tr>
</tbody>
</table>

secyTxSAStatsTable

The following table that contains the statistics objects for each transmitting SA in the MAC security entity.

Table 11: secyTxSAStatsTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyTxSAStatsProtectedPks</td>
<td>1.0.8802.1.1.3.1.2.1.1.1</td>
</tr>
</tbody>
</table>
secyTxSCStatsTable

The following table that contains the statistics objects for each transmitting SC in the MAC security entity.

Table 12: secyTxSCStatsTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyTxSAStatsEncryptedPkts</td>
<td>1.0.8802.1.1.3.1.2.1.1.2</td>
</tr>
<tr>
<td>secyTxSCStatsProtectedPkts</td>
<td>1.0.8802.1.1.3.1.2.2.1.1</td>
</tr>
<tr>
<td>secyTxSCStatsEncryptedPkts</td>
<td>1.0.8802.1.1.3.1.2.2.1.4</td>
</tr>
<tr>
<td>secyTxSCStatsOctetsProtected</td>
<td>1.0.8802.1.1.3.1.2.2.1.10</td>
</tr>
<tr>
<td>secyTxSCStatsOctetsEncrypted</td>
<td>1.0.8802.1.1.3.1.2.2.1.11</td>
</tr>
</tbody>
</table>

secyRxSAStatsTable

The following table that contains the statistics objects for each receiving SA in the MAC security entity.

Table 13: secyRxSAStatsTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyRxSAStatsUnusedSAPkts</td>
<td>1.0.8802.1.1.3.1.2.3.1.1</td>
</tr>
<tr>
<td>secyRxSAStatsNoUsingSAPkts</td>
<td>1.0.8802.1.1.3.1.2.3.1.4</td>
</tr>
<tr>
<td>secyRxSAStatsNotValidPkts</td>
<td>1.0.8802.1.1.3.1.2.3.1.13</td>
</tr>
<tr>
<td>secyRxSAStatsInvalidPkts</td>
<td>1.0.8802.1.1.3.1.2.3.1.16</td>
</tr>
<tr>
<td>secyRxSAStatsOKPkts</td>
<td>1.0.8802.1.1.3.1.2.3.1.25</td>
</tr>
</tbody>
</table>

secyRxSCStatsTable

The following table that contains the statistics objects for each receiving SC in the MAC security entity.
Table 14: secyRxSCStatsTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyRxSCStatsUnusedSAPkts</td>
<td>1.0.8802.1.1.3.1.2.4.1.1</td>
</tr>
<tr>
<td>secyRxSCStatsNoUsingSAPkts</td>
<td>1.0.8802.1.1.3.1.2.4.1.2</td>
</tr>
<tr>
<td>secyRxSCStatsLatePkts</td>
<td>1.0.8802.1.1.3.1.2.4.1.3</td>
</tr>
<tr>
<td>secyRxSCStatsNotValidPkts</td>
<td>1.0.8802.1.1.3.1.2.4.1.4</td>
</tr>
<tr>
<td>secyRxSCStatsInvalidPkts</td>
<td>1.0.8802.1.1.3.1.2.4.1.5</td>
</tr>
<tr>
<td>secyRxSCStatsDelayedPkts</td>
<td>1.0.8802.1.1.3.1.2.4.1.6</td>
</tr>
<tr>
<td>secyRxSCStatsUncheckedPkts</td>
<td>1.0.8802.1.1.3.1.2.4.1.7</td>
</tr>
<tr>
<td>secyRxSCStatsOKPkts</td>
<td>1.0.8802.1.1.3.1.2.4.1.8</td>
</tr>
<tr>
<td>secyRxSCStatsOctetsValidated</td>
<td>1.0.8802.1.1.3.1.2.4.1.9</td>
</tr>
<tr>
<td>secyRxSCStatsOctetsDecrypted</td>
<td>1.0.8802.1.1.3.1.2.4.1.10</td>
</tr>
</tbody>
</table>

secyStatsTable

The following table lists the objects for the statistics information of each Secy supported by the MAC security entity.

Table 15: secyStatsTable

<table>
<thead>
<tr>
<th>Object</th>
<th>Object identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>secyStatsTxUntaggedPkts</td>
<td>1.0.8802.1.1.3.1.2.5.1.1</td>
</tr>
<tr>
<td>secyStatsTxTooLongPkts</td>
<td>1.0.8802.1.1.3.1.2.5.1.2</td>
</tr>
<tr>
<td>secyStatsRxUntaggedPkts</td>
<td>1.0.8802.1.1.3.1.2.5.1.3</td>
</tr>
<tr>
<td>secyStatsRxNoTagPkts</td>
<td>1.0.8802.1.1.3.1.2.5.1.4</td>
</tr>
<tr>
<td>secyStatsRxBadTagPkts</td>
<td>1.0.8802.1.1.3.1.2.5.1.5</td>
</tr>
<tr>
<td>secyStatsRxUnknownSCIPkts</td>
<td>1.0.8802.1.1.3.1.2.5.1.6</td>
</tr>
<tr>
<td>secyStatsRxNoSCIPkts</td>
<td>1.0.8802.1.1.3.1.2.5.1.7</td>
</tr>
<tr>
<td>secyStatsRxOverrunPkts</td>
<td>1.0.8802.1.1.3.1.2.5.1.8</td>
</tr>
</tbody>
</table>

Obtaining the MACsec Controlled Port Interface Index

The ifindex of the controlled port can be obtained using the following commands:

- **snmpwalk** command on IfMib[OID: 1.3.6.1.2.1.31.1.1.1]
**SNMP Query Examples**

In the following examples, it is assumed that the configured SNMP community is public, and the management IP of the box is 10.0.0.1.

To perform SNMP walk on the entire SECY MIB for the router, use the following command:

```
$ snmpwalk -v2c -c public 10.0.0.1 1.0.8802.1.1.3
```

To query on the secyTxSCTable to get the TxSCI for interface Gi0/1/0/0, using the ifindex of MACsecControlled0/1/0/0 that is 18, use the following command:

```
snmpget -v2c -c public 10.0.0.1 iso.0.8802.1.1.3.1.1.2.1.1.18
```

**Related Commands for MACsec**

The following commands are available to verify the SNMP results.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>show macsec mka session detail</td>
<td>Displays the details of all MACsec Key Agreement (MKA) sessions on the device.</td>
</tr>
<tr>
<td>show macsec mka interface detail</td>
<td>Verifies the MACsec MKA status on the interface.</td>
</tr>
<tr>
<td>show macsec ea idb interface</td>
<td>Verifies the MACsec encryption and hardware interface descriptor block (IDB) information on the interface.</td>
</tr>
</tbody>
</table>

**Global MACsec Shutdown**

The MACsec shutdown feature allows administrator to disable MACsec and re-enable it without modifying the existing MACsec configuration.

Enabling the `macsec shutdown` command, brings down all MACsec sessions on the MACsec-enabled interfaces and resets ports to non-macsec mode. The already existing MACsec configurations remain unaffected by enabling this feature.

Disabling the `macsec shutdown` command, brings up macsec sessions for the configured interfaces and enforces MACsec policy on the port. This feature is disabled by default.
Configure MACsec Shutdown

The following configuration enables the MACsec shutdown on a chassis:

RP/0/RP0/CPU0:router# configure terminal
RP/0/RP0/CPU0:router(config)# macsec shutdown

Configuring `macsec shutdown` command disables MACsec on all data ports, system wide. Execute `clear` command to erase cached configuration or `commit` command to continue.

Verify MACsec Shutdown

The `show macsec mka session` command displays a shutdown banner indicating that the MACsec shutdown is enabled.

RP/0/RP0/CPU0:router# show macsec mka session
Fri Apr 13 11:56:57.409 IST

********** MACsec shutdown enabled **********

The `show macsec mka interface detail` command displays a shutdown banner and the interface-related information.

RP/0/RP0/CPU0:fretta-2#show macsec mka interface detail
Fri Apr 13 11:57:02.685 IST

********** MACsec shutdown enabled **********

Number of interfaces on node node0_3_CPU0 : 1

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

<table>
<thead>
<tr>
<th>Interface Name</th>
<th>HundredGigE0/3/0/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface Namestring</td>
<td>HundredGigE0/3/0/8</td>
</tr>
<tr>
<td>Interface short name</td>
<td>Hu0/3/0/8</td>
</tr>
<tr>
<td>Interface handle</td>
<td>0x1800170</td>
</tr>
<tr>
<td>Interface number</td>
<td>0x1800170</td>
</tr>
<tr>
<td>Interface MAC</td>
<td>008a.9622.a9d0</td>
</tr>
<tr>
<td>Ethertype</td>
<td>888E</td>
</tr>
<tr>
<td>MACsec Shutdown</td>
<td>TRUE</td>
</tr>
<tr>
<td>Config Received</td>
<td>TRUE</td>
</tr>
<tr>
<td>IM notify Complete</td>
<td>TRUE</td>
</tr>
<tr>
<td>Interface CAPS Add</td>
<td>FALSE</td>
</tr>
<tr>
<td>RxSA CAPS Add</td>
<td>FALSE</td>
</tr>
<tr>
<td>TxSA CAPS Add</td>
<td>FALSE</td>
</tr>
<tr>
<td>MKA PSK Info</td>
<td></td>
</tr>
<tr>
<td>Key Chain Name</td>
<td>kc1</td>
</tr>
<tr>
<td>MKA Cipher Suite</td>
<td>AES-256-CMAC</td>
</tr>
<tr>
<td>CKN</td>
<td>12 34 56</td>
</tr>
<tr>
<td>MKA fallback_PSK Info</td>
<td></td>
</tr>
<tr>
<td>fallback keychain Name</td>
<td>fb1</td>
</tr>
<tr>
<td>MKA Cipher Suite</td>
<td>AES-256-CMAC</td>
</tr>
<tr>
<td>CKN</td>
<td>ff ff ff</td>
</tr>
<tr>
<td>Policy</td>
<td><em>DEFAULT POLICY</em></td>
</tr>
</tbody>
</table>

Syslog Messages for MACsec Shutdown

The following syslog messages are generated when MACsec shutdown is enabled.

System Security Configuration Guide for Cisco NCS 5500 Series Routers, IOS XR Release 6.3.x
Syslog Messages for MACsec Shutdown

%-L2-MKA-5-MACSEC_SHUTDOWN_ENABLED : Shutdown ON, disable MACsec on all MACsec enabled ports
%-L2-MKA-5-SESSION_STOP : (Hu0/3/0/8) MKA session stopped,
  CKN : 123456
%-L2-MKA-4-SESSION_UNSECURED : (Hu0/3/0/8) MKA Session was stopped and is not secured,
  CKN : 123456
%-L2-MKA-5-MACSEC_DISABLED : (Hu0/3/0/8), MACsec disabled (shutdown ON)

The following syslog messages are generated when MACsec shutdown is disabled.
-%L2-MKA-5-MACSEC_SHUTDOWN_DISABLED : Shutdown OFF, resume MACsec on all MACsec enabled ports
-%L2-MKA-5-MACSEC_ENABLED : (Hu0/3/0/8), MACsec enabled with MUST_SECURE
  CKN : 123456
-%L2-MKA-5-SESSION_START : (Hu0/3/0/8) MKA session started
-%L2-MKA-6-MKPDU_ICV_SUCCESS : (Hu0/3/0/8), ICV verification success for
  RxSCI(008a.9600.60b0/0001), CKN(123456)
-%L2-MKA-6-FALLBACK_PSK_MKPDU_ICV_SUCCESS : (Hu0/3/0/8), ICV verification success for
  RxSCI(008a.9600.60b0/0001), CKN(FFFFFF)
-%L2-MKA-5-SESSION_SECURED : (Hu0/3/0/8) MKA session secured
  CKN : 123456
Implementing URPF

This section describes the implementation of URPF.

- Understanding URPF, on page 99
- Configuring URPF Loose Mode, on page 99

Understanding URPF

It has become a commonplace practice for hackers planning a DoS attack to use forged IP addresses (the practice is known as IP address spoofing) and constantly change the source IP address to avoid detection by service providers.

Unicast Reverse Path Forwarding (URPF) is a mechanism for validating the source IP address of packets received on a router. A router configured with URPF performs a reverse path lookup in the FIB table to validate the presence of the source IP address. If the source IP address is listed in the table, then it indicates that the source is reachable and valid. If source IP address cannot be located in the FIB table, the packet is treated as malicious by the router and discarded.

The router supports the use of URPF in loose mode. URPF loose mode is enabled when the router is configured to validate only the prefix of the source IP address in the FIB and not the interface used by the packet to reach the router. By configuring loose mode, legitimate traffic that uses an alternate interface to reach the router is not mistaken to be malicious. URPF loose mode is very useful in multi-homed provider edge networks.

Configuring URPF Loose Mode

This section explains how you can configure URPF loose mode on the router for both IPv4 and IPv6 networks.

Before You Begin

Before you can configure URPF loose mode on a router, you must disable the default scale on the line card, as described in this section.

Note

IPv6 uRPF configuration requires the `hw-module fib ipv6 scale internet-optimized-disable` command for all types of cards, both TCAM cards and non-TCAM cards. By default, IPv6 uses internal memory for prefixes. Therefore, you need to configure the `hw-module fib ipv6 scale internet-optimized-disable` command and then reload the line card.
Line cards must be reloaded after disabling the default scale. This is done to ensure that the `hw-module` command configuration takes immediate effect.

On Jericho+ with external TCAM (eTCAM) systems, the dual capacity mode need not be disabled to enable uRPF.

**For all types of line cards with TCAM:**

```
RP/0/RP0/CPU0:router(config)# hw-module tcam fib ipv4 scaledisable
RP/0/RP0/CPU0:router(config)# hw-module fib ipv6 scale internet-optimized-disable
RP/0/RP0/CPU0:router(config)# commit
RP/0/RP0/CPU0:router(config)# end
RP/0/RP0/CPU0:router# reload location all
Proceed with reload? [confirm]
```

**For all types of line cards without TCAM:**

```
RP/0/RP0/CPU0:router(config)# hw-module fib ipv4 scale host-optimized-disable
RP/0/RP0/CPU0:router(config)# hw-module fib ipv6 scale internet-optimized-disable
RP/0/RP0/CPU0:router(config)# commit
RP/0/RP0/CPU0:router(config)# end
RP/0/RP0/CPU0:router# reload location all
Proceed with reload? [confirm]
```

**Configuration**

Use the following configuration to configure URPF loose mode on the router.

**Note**

You must configure both IPv4 and IPv6 commands (as described in this section) for URPF to work.

```
RP/0/RP0/CPU0:router(config)# interface bundle-ether1
RP/0/RP0/CPU0:router(config-if)# ipv4 address 10.0.0.1 255.255.255.0
RP/0/RP0/CPU0:router(config-if)# ipv4 verify unicast source reachable-via any
RP/0/RP0/CPU0:router(config-if)# ipv6 address 2001::1/64
RP/0/RP0/CPU0:router(config-if)# ipv6 verify unicast source reachable-via any
RP/0/RP0/CPU0:router(config-if)# commit
```

**Running Configuration**

Confirm your configuration as shown:

```
RP/0/RP0/CPU0:router(config-if)# show running-config
Thu Jul 27 14:40:38.167 IST
...
interface Bundle-Ether1
  ipv4 address 10.0.0.1 255.255.255.0
  ipv4 verify unicast source reachable-via any
ipv6 address 2001::1/64
  ipv6 verify unicast source reachable-via any
```
You have successfully configured URPF loose mode on the router.
Implementing Management Plane Protection

The Management Plane Protection (MPP) feature provides the capability to restrict the interfaces on which network management packets are allowed to enter a device. The MPP feature allows a network operator to designate one or more router interfaces as management interfaces.

The MPP protection feature, as well as all the management protocols under MPP, are disabled by default. When you configure an interface as either out-of-band or inband, it automatically enables MPP. Consequently, this enablement extends to all the protocols under MPP. If MPP is disabled and a protocol is activated, all interfaces can pass traffic.

When MPP is enabled with an activated protocol, the only default management interfaces allowing management traffic are the route processor (RP) and standby route processor (SRP) Ethernet interfaces. You must manually configure any other interface for which you want to enable MPP as a management interface.

Afterwards, only the default management interfaces and those you have previously configured as MPP interfaces accept network management packets destined for the device. All other interfaces drop such packets. Logical interfaces (or any other interfaces not present on the data plane) filter packets based on the ingress physical interface.

- Implementing Management Plane Protection, on page 103

Implementing Management Plane Protection

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Benefits of Management Plane Protection

Implementing the MPP feature provides the following benefits:

- Greater access control for managing a device than allowing management protocols on all interfaces.
- Improved performance for data packets on non-management interfaces.
- Support for network scalability.
- Simplifies the task of using per-interface access control lists (ACLs) to restrict management access to the device.
- Fewer ACLs are needed to restrict access to the device.
- Prevention of packet floods on switching and routing interfaces from reaching the CPU.

Restrictions for Implementing Management Plane Protection

The following restrictions are listed for implementing Management Plane Protection (MPP):

- Currently, MPP does not keep track of the denied or dropped protocol requests.
- MPP configuration does not enable the protocol services. MPP is responsible only for making the services available on different interfaces. The protocols are enabled explicitly.
- Management requests that are received on inband interfaces are not necessarily acknowledged there.
- Both Route Processor (RP) and distributed route processor (DRP) Ethernet interfaces are by default out-of-band interfaces and can be configured under MPP.
- The changes made for the MPP configuration do not affect the active sessions that are established before the changes.
- Currently, MPP controls only the incoming management requests for protocols, such as TFTP, Telnet, Simple Network Management Protocol (SNMP), Secure Shell (SSH), XML, HTTP and Netconf.
- MPP does not support MIB.

Configure Device for Management Plane Protection for Inband Interface

An inband management interface is a physical or logical interface that processes management packets, as well as data-forwarding packets. An inband management interface is also called a shared management interface. Perform this task to configure a device that you have just added to your network or a device already operating in your network. This task shows how to configure MPP as an inband interface in which Telnet is allowed to access the router only through a specific interface.

Perform the following additional tasks to configure an inband MPP interface in non-default VRF.

- Configure the interface under the non-default inband VRF.
- Configure the global inband VRF.
- In the case of Telnet, configure the Telnet VRF server for the inband VRF.
SUMMARY STEPS

1. configure
2. control-plane
3. management-plane
4. inband
5. interface {type instance | all}
6. allow {protocol | all} [peer]
7. address ipv4 {peer-ip-address | peer ip-address/length}
8. commit
9. show mgmt-plane [inband | out-of-band] [interface {type instance}]

DETAILED STEPS

Step 1 configure
   Example:
   RP/0/RP0/CPU0:router(config)# control-plane
   RP/0/RP0/CPU0:router(config-ctrl)#
   Enters control plane configuration mode.

Step 2 control-plane
   Example:

Step 3 management-plane
   Example:

Step 4 inband
   Example:

Step 5 interface {type instance | all}
   Example:
   RP/0/RP0/CPU0:router(config-mpp-inband)# interface HundredGigE 0/6/0/1
Configure Device for Management Plane Protection for Inband Interface

Step 6  allow {protocol | all} [peer]

Example:

```
RP/0/RP0/CPU0:router(config-mpp-inband-G10_6_0_1)# allow Telnet peer
RP/0/RP0/CPU0:router(config-telnet-peer)#
```

Configures an interface as an inband interface for a specified protocol or all protocols.

- Use the `protocol` argument to allow management protocols on the designated management interface.
  
  - HTTP or HTTPS
  
  - SNMP (also versions)
  
  - Secure Shell (v1 and v2)
  
  - TFTP
  
  - Telnet
  
  - Netconf
  
  - XML

- Use the `all` keyword to configure the interface to allow all the management traffic that is specified in the list of protocols.

- (Optional) Use the `peer` keyword to configure the peer address on the interface.

Step 7  address ipv4 {peer-ip-address | peer ip-address/length}

Example:

```
RP/0/RP0/CPU0:router(config-telnet-peer)# address ipv4 10.1.0.0/16
```

Configures the peer IPv4 address in which management traffic is allowed on the interface.

- Use the `peer-ip-address` argument to configure the peer IPv4 address in which management traffic is allowed on the interface.

- Use the `peer ip-address/length` argument to configure the prefix of the peer IPv4 address.

Step 8  commit

Step 9  show mgmt-plane [inband | out-of-band] [interface {type instance}]

Example:
Configure Device for Management Plane Protection for Out-of-band Interface

Out-of-band refers to an interface that allows only management protocol traffic to be forwarded or processed. An out-of-band management interface is defined by the network operator to specifically receive network management traffic. The advantage is that forwarding (or customer) traffic cannot interfere with the management of the router, which significantly reduces the possibility of denial-of-service attacks.

Out-of-band interfaces forward traffic only between out-of-band interfaces or terminate management packets that are destined to the router. In addition, the out-of-band interfaces can participate in dynamic routing protocols. The service provider connects to the router’s out-of-band interfaces and builds an independent overlay management network, with all the routing and policy tools that the router can provide.

Perform the following tasks to configure an out-of-band MPP interface.

• Configure the interface under the out-of-band VRF.

• Configure the global out-of-band VRF.

• In the case of Telnet, configure the Telnet VRF server for the out-of-band VRF.

SUMMARY STEPS

1. configure
2. control-plane
3. management-plane
4. out-of-band
5. vrf vrf-name
6. interface {type instance | all}
7. allow {protocol | all} [peer]
8. address ipv6 {peer-ip-address | peer ip-address/length}
9. commit
10. show mgmt-plane [inband | out-of-band] [interface {type instance} | vrf]

DETAILED STEPS

Step 1 configure
Step 2 control-plane
Configure Device for Management Plane Protection for Out-of-band Interface

Step 3  management-plane

Example:

RP/0/RP0/CPU0:router(config-ctrl)# management-plane
RP/0/RP0/CPU0:router(config-mpp)#

Configures management plane protection to allow and disallow protocols and enters management plane protection configuration mode.

Step 4  out-of-band

Example:

RP/0/RP0/CPU0:router(config-mpp)# out-of-band
RP/0/RP0/CPU0:router(config-mpp-outband)#

Configures out-of-band interfaces or protocols and enters management plane protection out-of-band configuration mode.

Step 5  vrf vrf-name

Example:

RP/0/RP0/CPU0:router(config-mpp-outband)# vrf target

Configures a Virtual Private Network (VPN) routing and forwarding (VRF) reference of an out-of-band interface.

- Use the vrf-name argument to assign a name to a VRF.

Step 6  interface {type instance | all}

Example:

RP/0/RP0/CPU0:router(config-mpp-outband)# interface HundredGigE 0/6/0/2
RP/0/RP0/CPU0:router(config-mpp-outband-if)#

Configures a specific out-of-band interface, or all out-of-band interfaces, as an out-of-band interface. Use the interface command to enter management plane protection out-of-band configuration mode.

- Use the all keyword to configure all interfaces.

Step 7  allow {protocol | all} [peer]
Implementing Management Plane Protection

Configure Device for Management Plane Protection for Out-of-band Interface

Example:

RP/0/RP0/CPU0:router(config-mpp-outband-if)# allow TFTP peer
RP/0/RP0/CPU0:router(config-tftp-peer)#

Configures an interface as an out-of-band interface for a specified protocol or all protocols.

• Use the protocol argument to allow management protocols on the designated management interface.
  • HTTP or HTTPS
  • SNMP (also versions)
  • Secure Shell (v1 and v2)
  • TFTP
  • Telnet
  • Netconf

• Use the all keyword to configure the interface to allow all the management traffic that is specified in the list of protocols.

• (Optional) Use the peer keyword to configure the peer address on the interface.

Step 8
address ipv6 \{peer-ip-address | peer ip-address/length\}

Example:

RP/0/RP0/CPU0:router(config-tftp-peer)# address ipv6 33::33

Configures the peer IPv6 address in which management traffic is allowed on the interface.

• Use the peer-ip-address argument to configure the peer IPv6 address in which management traffic is allowed on the interface.

• Use the peer ip-address/length argument to configure the prefix of the peer IPv6 address.

Step 9
commit

Step 10
show mgmt-plane \[inband | out-of-band\] \[interface \{type instance\} \| vrf\]

Example:

RP/0/RP0/CPU0:router# show mgmt-plane out-of-band interface HundredGigE 0/6/0/2

Displays information about the management plane, such as type of interface and protocols enabled on the interface.

• (Optional) Use the inband keyword to display the inband management interface configurations that are the interfaces that process management packets as well as data-forwarding packets.

• (Optional) Use the out-of-band keyword to display the out-of-band interface configurations.

• (Optional) Use the interface keyword to display the details for a specific interface.
• (Optional) Use the vrf keyword to display the Virtual Private Network (VPN) routing and forwarding reference of an out-of-band interface.

Example

The following example shows how to configure inband and out-of-band interfaces for a specific IP address under MPP:

```
configure
control-plane
management-plane
inband
  interface all
    allow SSH
!
  interface HundredGigE 0/6/0/0
    allow all
    allow SSH
    allow Telnet peer
    address ipv4 10.1.0.0/16
    !

  interface HundredGigE 0/6/0/1
    allow Telnet peer
    address ipv4 10.1.0.0/16
    !

!
out-of-band
vrf my_out_of_band
  interface HundredGigE 0/6/0/2
    allow TFTP peer
    address ipv6 33::33
    !
    !

show mgmt-plane
Management Plane Protection
inband interfaces
-----------------------------
  interface - HundredGigE0_6_0_0
    ssh configured -
      All peers allowed
telnet configured -
    peer v4 allowed - 10.1.0.0/16
    all configured -
      All peers allowed
  interface - HundredGigE0_6_0_1
    telnet configured -
      peer v4 allowed - 10.1.0.0/16
```
interface - all
   all configured -
      All peers allowed
outband interfaces
----------------------
interface - HundredGigE0_6_0_2
tftp configured -
   peer v6 allowed - 33::33
show mgmt-plane out-of-band vrf
Management Plane Protection -
   out-of-band VRF - my_out_of_band

Information About Implementing Management Plane Protection

Before you enable the Management Plane Protection feature, you should understand the following concepts:

Peer-Filtering on Interfaces

The peer-filtering option allows management traffic from specific peers, or a range of peers, to be configured.

Control Plane Protection

A control plane is a collection of processes that run at the process level on a route processor and collectively provide high-level control for most Cisco software functions. All traffic directly or indirectly destined to a router is handled by the control plane. Management Plane Protection operates within the Control Plane Infrastructure.

Management Plane

The management plane is the logical path of all traffic that is related to the management of a routing platform. One of three planes in a communication architecture that is structured in layers and planes, the management plane performs management functions for a network and coordinates functions among all the planes (management, control, and data). In addition, the management plane is used to manage a device through its connection to the network.

Examples of protocols processed in the management plane are Simple Network Management Protocol (SNMP), Telnet, HTTP, Secure HTTP (HTTPS), SSH, XML and Netconf. These management protocols are used for monitoring and for command-line interface (CLI) access. Restricting access to devices to internal sources (trusted networks) is critical.
Implementing Management Plane Protection

Management Plane
MPP for Third-Party Applications

MPP for Third-Party Applications provides a mechanism for securing management traffic on the router. Without MPP for Third-Party Applications, if the service is enabled, the Cisco IOS XR allows the service traffic to pass through any interface with a network address.

MPP for Third-Party Applications enables to filter the traffic of TPA component. The addition of gRPC component controls the management protocol traffic and supports the management protocols for the TPA. It also helps to control the gRPC application and filter the gRPC traffic through MPP configuration.

MPP for Third-Party Applications helps in rate limiting or throttling the traffic through configuration with the help of LPTS. MPP for Third-Party Applications filters traffic based on the following tuples: address family, vrf, port, interface, local address and remote address.

Note: It is mandatory to configure address family, protocol, local port, vrf and interface or local or remote address. Currently, only the default vrf is supported for TPA configuration.

- gRPC Protocol, on page 113
- Limitations for MPP for TPA, on page 114
- Prerequisites for Traffic Protection for Third-Party Applications Over GRPC, on page 114
- Configuring MPP Over gRPC With TPA, on page 114
- Troubleshooting MPP Over gRPC, on page 115

gRPC Protocol

Google-defined Remote Procedure Calls (gRPC) is an open-source RPC framework. It is based on Protocol Buffers (Protobuf), which is an open source binary serialization protocol. gRPC provides a flexible, efficient, automated mechanism for serializing structured data, like XML, but is smaller and simpler to use. The user needs to define the structure by defining protocol buffer message types in .proto files. Each protocol buffer message is a small logical record of information, containing a series of name-value pairs.

Cisco gRPC Interface Definition Language (IDL) uses a set of supported RPCs such as get-config, merge-config, replace-config, cli-config, delete-config, cli-show, get-models, action-json, commit, and commit-replace. gRPC server runs in Extensible Manageability Services Daemon (emsd) process. gRPC client can be on any machine.

gRPC encodes requests and responses in binary. gRPC is extensible to other content types along with Protobuf. The Protobuf binary data object in gRPC is transported over HTTP/2.
It is recommended to configure TLS before enabling gRPC. Enabling gRPC protocol uses the default HTTP/2 transport with no TLS enabled on TCP. gRPC mandates AAA authentication and authorization for all gRPC requests. If TLS is not configured, the authentication credentials are transferred over the network unencrypted. Non-TLS mode can only be used in secure internal network.

gRPC supports distributed applications and services between a client and server. gRPC provides the infrastructure to build a device management service to exchange configuration and operational data between a client and a server. The structure of the data is defined by YANG models.

Limitations for MPP for TPA

The following limitations are applicable for the MPP for TPA:

- If multiple MPP entries are configured with the combination of same local-port and different remote-addresses or interfaces, then only the latest entry is valid and available.

Prerequisites for Traffic Protection for Third-Party Applications Over GRPC

Ensure that the gRPC is configured.

**gRPC Configuration**

Router(config)# grpc port port-number
Router(config)# grpc no-tls
Router(config-grpc)# commit

**Running Configuration**

Router# show running-config grpc

grpc port 57600
no-tls

Configuring MPP Over gRPC With TPA

The following task shows how to configure MPP over gRPC with TPA.

Router# configure
Router(config)# control-plane
Router(config-ctrl)# management-plane
Router(config-mpp)# tpa
Router(config-mpp-tpa)# vrf default
Router(config-mpp-tpa-vrf)# address-family [ipv4 | ipv6]
Router(config-mpp-tpa-vrf)# allow local-port port-number protocol protocol-number
(interface interface-name) local-address IP local address | remote-address IP remote address]
Running Configuration

Router# show running-config control-plane

control-plane
management-plane
tpa
  vrf default
    address-family ipv4
      allow local-port 57600 protocol tcp interface any remote-address 2.2.2.2/32 local-address 1.1.1.1/32
!
!

For more information on tpa and allow local-port commands, see Management Plane Protection Commands Chapter of the System Security Command Reference for Cisco NCS 5500 Series Routers.

Troubleshooting MPP Over gRPC

The following show command output verifies whether gRPC is configured or not.

Router# show running-config grpc

grpc
  no-tls
!

The following show command output displays the gRPC configuration.

Router# show running-config control-plane

control-plane
management-plane
tpa
  vrf default
    address-family ipv4
      allow local-port 57600 protocol tcp interface mgmtEth 0/RP0/CPU0/0 local-address 1.1.1.1/32 remote-address 2.2.2.2/32
!

gRPC Configuration without MPP

Router# show kim lpts database

State:
  Prog - Programmed in hardware
  Cfg - Configured, not yet programmed
  Ovr - Not programmed, overridden by user configuration
  Intf - Not programmed, interface does not exist

Owner AF Proto State Interface VRF Local ip,port > Remote ip,port
------- -- ----- ----- -------------- ------------- ------------------------------
Linux 2 6 Prog global-vrf any,57600 any,0

Router# show lpts bindings brief | include TPA
0/RP0/CP0/0 TPA LR IPV4 TCP default any any,57600 any

gRPC Configuration with MPP TPA

The following show command output displays the things that are configured in the LPTS database. It also checks if gRPC configuration is owned by Linux without using any filters.
Router# show kim lpts database

State:
Prog - Programmed in hardware
Cfg - Configured, not yet programmed
Ovr - Not programmed, overridden by user configuration
Intf - Not programmed, interface does not exist

<table>
<thead>
<tr>
<th>Owner</th>
<th>AF</th>
<th>Proto</th>
<th>State</th>
<th>Interface</th>
<th>VRF</th>
<th>Local ip,port &gt; Remote ip,port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>2</td>
<td>6</td>
<td>Prog</td>
<td>default</td>
<td></td>
<td>192.168.0.1/32,57600 &gt; 10.0.0.2/32,0</td>
</tr>
<tr>
<td>Linux</td>
<td>2</td>
<td>6</td>
<td>Ovr</td>
<td>global-vrf</td>
<td>any</td>
<td>57600 &gt; any,0</td>
</tr>
</tbody>
</table>

Router# show lpts bindings brief | include TPA

| 0/RP0/CPU0 | TPA | LR IPV4 TCP | default | Mg0/RP0/CPUO/0 | 192.168.0.1,57600 | 10.0.0.2 |

Router# 0/RP0/ADMIN0:Mar 19 15:22:26.837 IST: pm[2433]:
%INFRA-Process_Manager-3-PROCESS_RESTART : Process tams (IID: 0) restarted
Implementing Secure Shell

Secure Shell (SSH) is an application and a protocol that provides a secure replacement to the Berkeley r-tools. The protocol secures sessions using standard cryptographic mechanisms, and the application can be used similarly to the Berkeley `rexe` and `rsh` tools.

Two versions of the SSH server are available: SSH Version 1 (SSHv1) and SSH Version 2 (SSHv2). SSHv1 uses Rivest, Shamir, and Adelman (RSA) keys and SSHv2 uses either Digital Signature Algorithm (DSA) keys or Rivest, Shamir, and Adelman (RSA) keys. Cisco software supports both SSHv1 and SSHv2.

This module describes how to implement Secure Shell.

Feature History for Implementing Secure Shell

<table>
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<th>Modification</th>
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- Implementing Secure Shell, on page 117

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Two versions of the SSH server are available: SSH Version 1 (SSHv1) and SSH Version 2 (SSHv2). SSHv1 uses Rivest, Shamir, and Adelman (RSA) keys and SSHv2 uses either Digital Signature Algorithm (DSA) keys or Rivest, Shamir, and Adelman (RSA) keys. Cisco software supports both SSHv1 and SSHv2.

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</table>
Prerequisites for Implementing Secure Shell

The following prerequisites are required to implement Secure Shell:

- Download the required image on your router. The SSH server and SSH client require you to have a crypto package (data encryption standard [DES], 3DES and AES) from Cisco downloaded on your router.
- Configure user authentication for local or remote access. You can configure authentication with or without authentication, authorization, and accounting (AAA).
- AAA authentication and authorization must be configured correctly for Secure Shell File Transfer Protocol (SFTP) to work.

Restrictions for Implementing Secure Shell

The following are some basic SSH restrictions and limitations of the SFTP feature:

- In order for an outside client to connect to the router, the router needs to have an RSA (for SSHv1 or SSHv2) or DSA (for SSHv2) key pair configured. DSA and RSA keys are not required if you are initiating an SSH client connection from the router to an outside routing device. The same is true for SFTP: DSA and RSA keys are not required because SFTP operates only in client mode.
- In order for SFTP to work properly, the remote SSH server must enable the SFTP server functionality. For example, the SSHv2 server is configured to handle the SFTP subsystem with a line such as
  
  /etc/ssh2/sshd2_config
  
  - subsystem-sftp /usr/local/sbin/sftp-server

  The SFTP server is usually included as part of SSH packages from public domain and is turned on by default configuration.
- SFTP is compatible with ssh server version OpenSSH_2.9.9p2 or higher.
- RSA-based user authentication is supported in the SSH and SFTP servers. The support however, is not extended to the SSH client.
- Execution shell and SFTP are the only applications supported.
- The SFTP client does not support remote filenames containing wildcards (* ?, []). The user must issue the sftp command multiple times or list all of the source files from the remote host to download them on to the router. For uploading, the router SFTP client can support multiple files specified using a wildcard provided that the issues mentioned in the first through third bullets in this section are resolved.
- The cipher preference for the SSH server follows the order AES128, AES192, AES256, and, finally, 3DES. The server rejects any requests by the client for an unsupported cipher, and the SSH session does not proceed.
- Use of a terminal type other than vt100 is unsupported, and the software generates a warning message in this case.
- Password messages of “none” are unsupported on the SSH client.
- Because the router infrastructure does not provide support for UNIX-like file permissions, files created on the local device lose the original permission information. For files created on the remote file system, the file permission adheres to the umask on the destination host and the modification and last access times are the time of the copy.
Configure SSH

Perform this task to configure SSH.

For SSHv1 configuration, Step 1 to Step 4 are required. For SSHv2 configuration, Step to Step 4 are optional.

SUMMARY STEPS

1. configure
2. hostname hostname
3. domain name domain-name
4. commit
5. crypto key generate rsa [usage keys | general-keys] [keypair-label]
6. crypto key generate dsa
7. configure
8. ssh timeout seconds
9. Do one of the following:
   • ssh server [vrf vrf-name]
   • ssh server v2
10. commit
11. show ssh
12. show ssh session details

DETAILED STEPS

Step 1 configure
Step 2 hostname hostname

Example:

RP/0/RP0/CPU0:router# config mode
RP/0/RP0/CPU0:router(config)# hostname router1

Configures a hostname for your router.

Step 3 domain name domain-name

Example:

RP/0/RP0/CPU0:router(config)# domain name cisco.com

Defines a default domain name that the software uses to complete unqualified host names.

Step 4 commit
Step 5 crypto key generate rsa [usage keys | general-keys] [keypair-label]

Example:

RP/0/RP0/CPU0:router# crypto key generate rsa general-keys
Generates an RSA key pair. The RSA key modulus can be in the range of 512 to 4096 bits.

- To delete the RSA key pair, use the `crypto key zeroize rsa` command.
- This command is used for SSHv1 only.

**Step 6**

`crypto key generate dsa`

**Example:**

```
RP/0/RP0/CPU0:router# crypto key generate dsa
```

Enables the SSH server for local and remote authentication on the router. The supported key sizes are: 512, 768 and 1024 bits.

- The recommended minimum modulus size is 1024 bits.
- Generates a DSA key pair.

To delete the DSA key pair, use the `crypto key zeroize dsa` command.

- This command is used only for SSHv2.

**Step 7**

`configure`

**Example:**

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

Enters mode.

**Step 8**

`ssh timeout seconds`

**Example:**

```
RP/0/RP0/CPU0:router(config)# ssh timeout 60
```

(Optional) Configures the timeout value for user authentication to AAA.

- If the user fails to authenticate itself to AAA within the configured time, the connection is aborted.
- If no value is configured, the default value of 30 seconds is used. The range is from 5 to 120.

**Step 9**

Do one of the following:

- `ssh server [vrf vrf-name]`
- `ssh server v2`

**Example:**

```
RP/0/RP0/CPU0:router(config)# ssh server v2
```

(Optional) Brings up an SSH server using a specified VRF of up to 32 characters. If no VRF is specified, the default VRF is used.

To stop the SSH server from receiving any further connections for the specified VRF, use the `no` form of this command. If no VRF is specified, the default is assumed.

**Note** The SSH server can be configured for multiple VRF usage.
• (Optional) Forces the SSH server to accept only SSHv2 clients if you configure the SSHv2 option by using the `ssh server v2` command. If you choose the `ssh server v2` command, only the SSH v2 client connections are accepted.

**Step 10**
commit

**Step 11**
show ssh

**Example:**

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

(Optional) Displays all of the incoming and outgoing SSHv1 and SSHv2 connections to the router.

**Step 12**
show ssh session details

**Example:**

```
RP/0/RP0/CPU0:router# show ssh session details
```

(Optional) Displays a detailed report of the SSHv2 connections to and from the router.

---

**Configure SSH Client**

Perform this task to configure an SSH client.

**SUMMARY STEPS**

1. configure
2. ssh client knownhost device :/filename
3. commit
4. ssh {ipv4-address | ipv6-address | hostname} [username user-cipher | source-interface type instance]

**DETAILED STEPS**

**Step 1**
configure

**Step 2**
`ssh client knownhost device :/filename`

**Example:**

```
RP/0/RP0/CPU0:router(config)# ssh client knownhost slot1:/server_pubkey
```

(Optional) Enables the feature to authenticate and check the server public key (pubkey) at the client end.

**Note**

The complete path of the filename is required. The colon (:) and slash mark (/) are also required.

**Step 3**
commit

**Step 4**
`ssh {ipv4-address | ipv6-address | hostname} [username user-cipher | source-interface type instance]`

Enables an outbound SSH connection.
• To run an SSHv2 server, you must have a VRF. This may be the default or a specific VRF. VRF changes are applicable only to the SSH v2 server.

• The SSH client tries to make an SSHv2 connection to the remote peer. If the remote peer supports only the SSHv1 server, the peer internally spawns an SSHv1 connection to the remote server.

• The cipher des option can be used only with an SSHv1 client.

• The SSHv1 client supports only the 3DES encryption algorithm option, which is still available by default for those SSH clients only.

• If the hostname argument is used and the host has both IPv4 and IPv6 addresses, the IPv6 address is used.

• If you are using SSHv1 and your SSH connection is being rejected, the reason could be that the RSA key pair might have been zeroed out or that you have not successfully generated an RSA key pair for your router. Another reason could be that the SSH server to which the user is connecting to using SSHv1 client does not accept SSHv1 connections. Make sure that you have specified a hostname and domain. Then use the crypto key generate rsa command to generate an RSA host-key pair, and then enable the SSH server.

• If you are using SSHv2 and your SSH connection is being rejected, the reason could be that the DSA, RSA host-key pair might have been zeroed out. Make sure you follow similar steps as mentioned above to generate the required host-key pairs, and then enable the SSH server.

• When configuring the RSA or DSA key pair, you might encounter the following error messages:

  • No hostname specified

  You must configure a hostname for the router using the hostname command.

  • No domain specified

  You must configure a host domain for the router using the domain-name command.

• The number of allowable SSH connections is limited to the maximum number of virtual terminal lines configured for the router. Each SSH connection uses a vty resource.

• SSH uses either local security or the security protocol that is configured through AAA on your router for user authentication. When configuring AAA, you must ensure that the console is not running under AAA by applying a keyword in the global configuration mode to disable AAA on the console.

  **Note**

  If you are using Putty version 0.63 or higher to connect to the SSH client, set the 'Chokes on PuTTYs SSH2 winadj request' option under SSH > Bugs in your Putty configuration to 'On.' This helps avoid a possible breakdown of the session whenever some long output is sent from IOS XR to the Putty client.

Configuring Secure Shell

The following example shows how to configure SSHv2 by creating a hostname, defining a domain name, enabling the SSH server for local and remote authentication on the router by generating a DSA
key pair, bringing up the SSH server, and saving the configuration commands to the running configuration file.

After SSH has been configured, the SFTP feature is available on the router.

```
custom
hostname router1
domain name cisco.com
exit
crypto key generate rsa/dsa
custom
configure
ssh server
end
```

### Information About Implementing Secure Shell

To implement SSH, you should understand the following concepts:

**SSH Server**

The SSH server feature enables an SSH client to make a secure, encrypted connection to a Cisco router. This connection provides functionality that is similar to that of an inbound Telnet connection. Before SSH, security was limited to Telnet security. SSH allows a strong encryption to be used with the Cisco software authentication. The SSH server in Cisco software works with publicly and commercially available SSH clients.

**SSH Client**

The SSH client feature is an application running over the SSH protocol to provide device authentication and encryption. The SSH client enables a Cisco router to make a secure, encrypted connection to another Cisco router or to any other device running the SSH server. This connection provides functionality that is similar to that of an outbound Telnet connection except that the connection is encrypted. With authentication and encryption, the SSH client allows for a secure communication over an insecure network.

The SSH client works with publicly and commercially available SSH servers. The SSH client supports the ciphers of AES, 3DES, message digest algorithm 5 (MD5), SHA1, and password authentication. User authentication is performed in the Telnet session to the router. The user authentication mechanisms supported for SSH are RADIUS, TACACS+, and the use of locally stored usernames and passwords.

The SSH client supports setting DSCP value in the outgoing packets.

```
ssh client dscp <value from 0 – 63>
```

If not configured, the default DSCP value set in packets is 16 (for both client and server).

The SSH client supports the following options:

- **DSCP**—DSCP value for SSH client sessions.

  ```
  RP/0/5/CPU0:1#configure
  RP/0/5/CPU0:1(config)#ssh ?
  client    Provide SSH client service
  server    Provide SSH server service
  timeout    Set timeout value for SSH
  RP/0/5/CPU0:1(config)#ssh client ?
  ```

- **Knownhost**—Enable the host pubkey check by local database.
- **Source-interface**—Source interface for SSH client sessions.
SSH also supports remote command execution as follows:

```
RP/0/5/CPU0:router#ssh ?
A.B.C.D IPv4 (A.B.C.D) address
WORD Hostname of the remote node
X:X::X IPv6 (A:B:C:D...:D) address
vrf vrf table for the route lookup
source-interface Specify source interface
username Accept userid for authentication
<cr>
```

```
RP/0/5/CPU0:router#ssh 1.1.1.1
RP/0/5/CPU0:router#ssh 1.1.1.1 ?
cipher Accept cipher type
command Specify remote command (non-interactive)
source-interface Specify source interface
username Accept userid for authentication
<cr>
```

```
RP/0/5/CPU0:router#ssh 12.28.46.6 username admin command "show redundancy sum"
Password:
```

```
Wed Jan 9 07:05:27.997 PST
Active Node Standby Node
---------- ----------
0/4/CPU0 0/5/CPU0 (Node Ready, NSR: Not Configured)
```

```
RP/0/5/CPU0:router#
```

**SFTP Feature Overview**

SSH includes support for standard file transfer protocol (SFTP), a new standard file transfer protocol introduced in SSHv2. This feature provides a secure and authenticated method for copying router configuration or router image files.

The SFTP client functionality is provided as part of the SSH component and is always enabled on the router. Therefore, a user with the appropriate level can copy files to and from the router. Like the `copy` command, the `sftp` command can be used only in XR EXEC mode.
The SFTP client is VRF-aware, and you may configure the secure FTP client to use the VRF associated with a particular source interface during connections attempts. The SFTP client also supports interactive mode, where the user can log on to the server to perform specific tasks via the Unix server.

The SFTP Server is a sub-system of the SSH server. In other words, when an SSH server receives an SFTP server request, the SFTP API creates the SFTP server as a child process to the SSH server. A new SFTP server instance is created with each new request.

The SFTP requests for a new SFTP server in the following steps:

- The user runs the `sftp` command with the required arguments
- The SFTP API internally creates a child session that interacts with the SSH server
- The SSH server creates the SFTP server child process
- The SFTP server and client interact with each other in an encrypted format
- The SFTP transfer is subject to LPTS policer "SSH-Known". Low policer values will affect SFTP transfer speeds

---

**Note**

In IOS-XR SW release 4.3.1 onwards the default policer value for SSH-Known has been reset from 2500pps to 300pps. Slower transfers are expected due to this change. You can adjust the lpts policer value for this punt cause to higher values that will allow faster transfers.

When the SSH server establishes a new connection with the SSH client, the server daemon creates a new SSH server child process. The child server process builds a secure communications channel between the SSH client and server via key exchange and user authentication processes. If the SSH server receives a request for the sub-system to be an SFTP server, the SSH server daemon creates the SFTP server child process. For each incoming SFTP server subsystem request, a new SSH server child and a SFTP server instance is created. The SFTP server authenticates the user session and initiates a connection. It sets the environment for the client and the default directory for the user.

Once the initialization occurs, the SFTP server waits for the SSH_FXP_INIT message from the client, which is essential to start the file communication session. This message may then be followed by any message based on the client request. Here, the protocol adopts a 'request-response' model, where the client sends a request to the server; the server processes this request and sends a response.

The SFTP server displays the following responses:

- Status Response
- Handle Response
- Data Response
- Name Response

---

**Note**

The server must be running in order to accept incoming SFTP connections.
RSA Based Host Authentication

Verifying the authenticity of a server is the first step to a secure SSH connection. This process is called the host authentication, and is conducted to ensure that a client connects to a valid server.

The host authentication is performed using the public key of a server. The server, during the key-exchange phase, provides its public key to the client. The client checks its database for known hosts of this server and the corresponding public-key. If the client fails to find the server's IP address, it displays a warning message to the user, offering an option to either save the public key or discard it. If the server's IP address is found, but the public-key does not match, the client closes the connection. If the public key is valid, the server is verified and a secure SSH connection is established.

The IOS XR SSH server and client had support for DSA based host authentication. But for compatibility with other products, like IOS, RSA based host authentication support is also added.

RSA Based User Authentication

One of the method for authenticating the user in SSH protocol is RSA public-key based user authentication. The possession of a private key serves as the authentication of the user. This method works by sending a signature created with a private key of the user. Each user has a RSA keypair on the client machine. The private key of the RSA keypair remains on the client machine.

The user generates an RSA public-private key pair on a unix client using a standard key generation mechanism such as ssh-keygen. The max length of the keys supported is 4096 bits, and the minimum length is 512 bits. The following example displays a typical key generation activity:

```
bash-2.05b$ ssh-keygen -b 1024 -t rsa
Generating RSA private key, 1024 bit long modulus
```

The public key must be in base64 encoded (binary) format for it to be imported correctly into the box. You can use third party tools available on the Internet to convert the key to the binary format.

Once the public key is imported to the router, the SSH client can choose to use the public key authentication method by specifying the request using the “-o” option in the SSH client. For example:

```
client$ ssh -o PreferredAuthentications=publickey 1.2.3.4
```

If a public key is not imported to a router using the RSA method, the SSH server initiates the password based authentication. If a public key is imported, the server proposes the use of both the methods. The SSH client then chooses to use either method to establish the connection. The system allows only 10 outgoing SSH client connections.

Currently, only SSH version 2 and SFTP server support the RSA based authentication.

Note

The preferred method of authentication would be as stated in the SSH RFC. The RSA based authentication support is only for local authentication, and not for TACACS/RADIUS servers.

Authentication, Authorization, and Accounting (AAA) is a suite of network security services that provide the primary framework through which access control can be set up on your Cisco router or access server.
SSHv2 Client Keyboard-Interactive Authentication

An authentication method in which the authentication information is entered using a keyboard is known as keyboard-interactive authentication. This method is an interactive authentication method in the SSH protocol. This type of authentication allows the SSH client to support different methods of authentication without having to be aware of their underlying mechanisms.

Currently, the SSHv2 client supports the keyboard-interactive authentication. This type of authentication works only for interactive applications.

---

**Note**

The password authentication is the default authentication method. The keyboard-interactive authentication method is selected if the server is configured to support only the keyboard-interactive authentication.
Implementing Secure Shell

SSHv2 Client Keyboard-Interactive Authentication
CHAPTER 10

Implementing Lawful Intercept

Lawful intercept is the lawfully authorized interception and monitoring of communications of an intercept subject. Service providers worldwide are legally required to assist law enforcement agencies in conducting electronic surveillance in both circuit-switched and packet-mode networks.

Only authorized service provider personnel are permitted to process and configure lawfully authorized intercept orders. Network administrators and technicians are prohibited from obtaining knowledge of lawfully authorized intercept orders, or intercepts in progress. Error messages or program messages for intercepts installed in the router are not displayed on the console.

Lawful Intercept is not a part of the Cisco IOS XR software by default. You have to install it separately by installing and activating.

For more information about activating and deactivating the Lawful Intercept package, see the Installing Lawful Intercept (LI) Package, on page 133 section.

Information About Lawful Intercept Implementation

Cisco lawful intercept is based on RFC3924 architecture and SNMPv3 provisioning architecture. SNMPv3 addresses the requirements to authenticate data origin and ensure that the connection from the router to the Mediation Device (MD) is secure. This ensures that unauthorized parties cannot forge an intercept target.

Lawful intercept offers these capabilities:

- SNMPv3 lawful intercept provisioning interface
- Lawful intercept MIB: CISCO-TAP2-MIB, version 2
- CISCO-IP-TAP-MIB manages the Cisco intercept feature for IP and is used along with CISCO-TAP2-MIB to intercept IP traffic
Prerequisites for Implementing Lawful Intercept

Lawful intercept implementation requires that these prerequisites are met:

• The router is used as content Intercept Access Point (IAP) router in lawful interception operation.

• **Provisioned Router**—The router must be already provisioned.

  **Tip**
  For the purpose of lawful intercept taps, provisioning a loopback interface has advantages over other interface types.

• **Management Plane Configured to Enable SNMPv3**—Allows the management plane to accept SNMP commands, so that the commands go to the interface (preferably, a loopback interface) on the router. This allows the mediation device (MD) to communicate with a physical interface.

• **VACM Views Enabled for SNMP Server**—View-based access control model (VACM) views must be enabled on the router.

• **Provisioned MD**—For detailed information, see the vendor documentation associated with your MD.

• **QoS Peering**—QoS peering must be enabled on the router for Lawful Intercept to work.

  **Note**
  The Lawful Intercept feature has no intersection with the QoS feature on the router. Enabling the QoS peering profile with `hw-module profile qos ingress-model peering` command on all the required line cards, allows QoS and Lawful intercept to allocate hardware resources.

• The MD uses the **CISCO-TAP2-MIB** to set up communications between the router acting as the content IAP, and the MD. The MD uses the **CISCO-IP-TAP-MIB** to set up the filter for the IP addresses and port numbers to be intercepted.

• The MD can be located anywhere in the network but must be reachable from the content IAP router, which is being used to intercept the target. MD should be reachable only from global routing table and not from VRF routing table.

Restrictions for Implementing Lawful Intercept

The following restrictions are applicable for Lawful Intercept:

• Lawful Intercept shares a pool of 16 unique source IP addresses with tunnel-ip. The combined configuration of GRE tunnel-ips and the MDs (the cTap2MediationSrcInterface field) shall not yield
more than 16 unique source IPs. Note that when configuring the MD, if the value 0 is passed in for the cTap2MediationSrcInterface field, it will be resolved into a source IP address, which is the egress IP to the MD destination.

• Lawful intercept is supported only to match pure IP over Ethernet packets.

• Only 250 MDs and 500 Taps on IPv4 are supported.

• One Tap-to-multiple MDs is not supported.

• After the route processor reload or fail-over, the MD and Tap configuration must be re-provisioned.

• Only IPv4 MD is supported.

• The path to the MD must have the ARP resolved. Any other traffic or protocol will trigger ARP.

• MD next-hop must have ARP resolved. Any other traffic or protocol will trigger ARP.

• In Cisco IOS XR Release 6.3.x, QoS peering must be enabled for QoS to work.

• Lawful Intercept has no intersection with the GRE Tunnel feature, except that they allocate hardware resources (16 unique egress IP addresses) from the same pool. In the normal case, the egress interface for the LI packets is decided by the forwarding algorithm. No resource is needed from that unique address pool. However, if the Lawful Intercept configuration mandates that the Lawful Intercept packets have to egress through a certain interface (the cTap2MediationSrcInterface field in the MD configuration), then the forwarding module must be configured so that the packets go out through that interface. In that case a resource must be allocated from the unique address pool. If GRE uses up all resources, then LI does not work.

• Lawful Intercept Stats is not supported.

• Even though the original packets can be fragmented, the LI packets cannot be fragmented. The MTU of the egress interface to the MD must be large enough to support the size of the packets captured.

• Lawful intercept does not provide support for these features on the router:
  • IPv4/IPv6 multicast tapping
  • IPv6 MD encapsulation
  • Per interface tapping
  • Tagged packet tapping
  • Replicating a single tap to multiple MDs
  • Tapping L2 flows
  • RTP encapsulation
  • Lawful Intercept and SPAN on the same interface

**Lawful Intercept Topology**

This figure shows intercept access points and interfaces in a lawful intercept topology for both voice and data interception.
Benefits of Lawful Intercept

Lawful intercept has the following benefits:

• Allows multiple LEAs to run a lawful intercept on the same Router without each other's knowledge.
• Does not affect subscriber services on the router.
• Supports wiretaps in both the input and output direction.
• Supports wiretaps of Layer 3 traffic.
• Cannot be detected by the target.
• Uses Simple Network Management Protocol Version 3 (SNMPv3) and security features such as the View-based Access Control Model (SNMP-VACM-MIB) and User-based Security Model (SNMP-USM-MIB) to restrict access to lawful intercept information and components.
• Hides information about lawful intercepts from all but the most privileged users. An administrator must set up access rights to enable privileged users to access lawful intercept information.
Installing Lawful Intercept (LI) Package

As LI is not a part of the Cisco IOS XR image by default, you need to install it separately.

Installing and Activating the LI Package

Use the `show install committed` command in EXEC mode to verify the committed software packages.

To install the Lawful Intercept (LI) package, you must install and activate the .

Configuration

```
Router# install add source tftp://223.255.254.252/auto/tftp-sjc-users/username/
Router# install activate
Router# install commit
```

Verification

```
Router# show install active
Node 0/RP0/CPU0 [RP]
  Boot Partition: xr_lv0
  Active Packages: 2

Node 0/0/CPU0 [LC]
  Boot Partition: xr_lcp_lv0
  Active Packages: 2
```

Deactivating the LI RPM

To uninstall the Lawful Intercept package, deactivate as shown in the following steps:

Configuration

```
Router# install deactivate
Router# install commit
Router# install remove
Router# show install committed
```

How to Configure SNMPv3 Access for Lawful Intercept

Perform these procedures to configure SNMPv3 for the purpose of Lawful Intercept enablement:

Disabling SNMP-based Lawful Intercept

Lawful Intercept is enabled by default on the router after installing and activating the .

• To disable Lawful Intercept, enter the `lawful-intercept disable` command in global configuration mode.
• To re-enable it, use the no form of this command.

Disabling SNMP-based Lawful Intercept: Example

Router# configure
Router(config)# lawful-intercept disable

The lawful-intercept disable command is available on the router, only after installing and activating the. All SNMP-based taps are dropped when lawful intercept is disabled.

Configuring the Inband Management Plane Protection Feature

If MPP was not earlier configured to work with another protocol, then ensure that the MPP feature is also not configured to enable the SNMP server to communicate with the mediation device for lawful interception. In such cases, MPP must be configured specifically as an inband interface to allow SNMP commands to be accepted by the router, using a specified interface or all interfaces.

Ensure this task is performed, even if you have recently migrated to Cisco IOS XR Software from Cisco IOS, and you had MPP configured for a given protocol.

For lawful intercept, a loopback interface is often the choice for SNMP messages. If you choose this interface type, you must include it in your inband management configuration.

Example: Configuring the Inband Management Plane Protection Feature

This example illustrates how to enable the MPP feature, which is disabled by default, for the purpose of lawful intercept.

You must specifically enable management activities, either globally or on a per-inband-port basis, using this procedure. To globally enable inbound MPP, use the keyword all with the interface command, rather than use a particular interface type and instance ID with it.

Example: Configuring the Inband Management Plane Protection Feature

```
router# configure
router(config)# control-plane
router(config-ctrl)# management-plane
router(config-mpp)# inband
router(config-mpp-inband)# interface loopback0
router(config-mpp-inband-Loopback0)# allow snmp
router(config-mpp-inband-Loopback0)# commit
router(config-mpp-inband-Loopback0)# exit
router(config-mpp-inband)# exit
router(config-mpp)# exit
router(config-ctrl)# exit
router(config)# exit
router# show mgmt-plane inband interface loopback0
Management Plane Protection - inband interface
interface - Loopback0
  snmp configured -
```
Enabling the Lawful Intercept SNMP Server Configuration

The following SNMP server configuration tasks enable the Cisco LI feature on a router running Cisco IOS XR Software by allowing the MD to intercept data sessions.

Configuration

```
router(config)# snmp-server engineID local 00:00:00:09:00:00:00:a1:61:6c:20:56
router(config)# snmp-server host 1.75.55.1 traps version 3 priv user-name udp-port 4444
router(config)# snmp-server user user-name li-group v3 auth md5 clear lab priv des56 clear lab
router(config)# snmp-server view li-view ciscoTap2MIB included
router(config)# snmp-server view li-view ciscoIpTapMIB included
router(config)# snmp-server view li-view snmp included
router(config)# snmp-server view li-view ifMIB included
router(config)# snmp-server view li-view 1.3.6.1.6.3.1.1.4.1 included
router(config)# snmp-server group li-group v3 auth read li-view write li-view notify li-view
```

Note

SNMP configuration must be removed while deactivating the LI RPM.

Additional Information on Lawful Intercept

Interception Mode

The lawful intercept operates in the Global LI mode.

In this mode, the taps are installed on all the line cards in the ingress direction. The lawful intercept is available on line cards where QoS peering is enabled. With the global tap, the traffic for the target can be intercepted regardless of ingress point. Only the tap that has wild cards in the interface field is supported.

Data Interception

Data are intercepted in this manner:

- The MD initiates communication content intercept requests to the content IAP router using SNMPv3.
- The content IAP router intercepts the communication content, replicates it, and sends it to the MD in IPv4 UDP format.
- Intercepted data sessions are sent from the MD to the collection function of the law enforcement agency, using a supported delivery standard for lawful intercept.

Information About the MD

The MD performs these tasks:
• Activates the intercept at the authorized time and removes it when the authorized time period elapses.

• Periodically audits the elements in the network to ensure that:
  • only authorized intercepts are in place.
  • all authorized intercepts are in place.

Scale or Performance Values

The router supports the following scalability and performance values for lawful intercept:

• IPv4, or IPv6, or a combination of IPv4 and IPv6, lawful intercept tap limit is up to a maximum of 500 taps.

• The scale decreases, if port ranges are used in the taps.

• The IPv6 entries consume double the memory of the IPv4 entries. Hence, the IPv6 scale will reduce to half of the IPv4 scale.

• A maximum of 250 IPv4 MDs are supported.

• Interception rate is 1 Gbps best effort per Linecard NPU.

Intercepting IPv4 and IPv6 Packets

This section provides details for intercepting IPv4 and IPv6 packets supported on the router.

Lawful Intercept Filters

The following filters are supported for classifying a tap:

• IP address type

• Destination address

• Destination mask

• Source address

• Source mask

• ToS (Type of Service) and ToS mask

• L4 Protocol

• Destination port with range

• Source port with range

• VRF (VPN Routing and Forwarding)

Note

Flow-id and interface filters are not supported.
Encapsulation Type Supported for Intercepted Packets

Intercepted packets mapping the tap are replicated, encapsulated, and then sent to the MD. IPv4 and IPv6 packets are encapsulated using IPv4 UDP encapsulation. The replicated packets are forwarded to MD using UDP as the content delivery protocol.

The intercepted packet gets a new UDP header and IPv4 header. Information for IPv4 header is derived from MD configuration. Apart from the IP and UDP headers, a 4-byte channel identifier (CCCID) is also inserted after the UDP header in the packet. The router does not support forwarding the same replicated packets to multiple MDs.

Encapsulation types, such as RTP and RTP-NOR, are not supported.

High Availability for Lawful Intercept

High availability for lawful intercept provides operational continuity of the TAP flows and provisioned MD tables to reduce loss of information due to route processor fail over (RPFO).

To achieve continuous interception of a stream, when RP fail over is detected; MDs are required to re-provision all the rows relating to CISCO-TAP2-MIB and CISCO-IP-TAP-MIB to synchronize database view across RP and MD.

Preserving TAP and MD Tables during RP Fail Over

At any point in time, MD has the responsibility to detect the loss of the taps via SNMP configuration process.

After RPFO is completed, MD should re-provision all the entries in the stream tables, MD tables, and IP taps with the same values they had before fail over. As long as an entry is re-provisioned in time, existing taps will continue to flow without any loss.

The following restrictions are listed for re-provisioning MD and tap tables with respect to behavior of SNMP operation on citapStreamEntry, cTap2StreamEntry, cTap2MediationEntry MIB objects:

- After RPFO, table rows that are not re-provisioned, shall return NO_SUCH_INSTANCE value as result of SNMP Get operation.
- Entire row in the table must be created in a single configuration step, with exactly same values as before RPFO, and with the rowStatus as CreateAndGo. Only exception is the cTap2MediationTimeout object, that should reflect valid future time.

Replay Timer

The replay timer is an internal timeout that provides enough time for MD to re-provision tap entries while maintaining existing tap flows. It resets and starts on the active RP when RPFO takes place. The replay timer is a factor of number of LI entries in router with a minimum value of 10 minutes.

After replay timeout, interception stops on taps that are not re-provisioned.

In case high availability is not required, MD waits for entries to age out after fail over. MD cannot change an entry before replay timer expiry. It can either reinstall taps as is, and then modify; or wait for it to age out.