



## **System Security Configuration Guide for Cisco NCS 5500 Series Routers, IOS XR Release 6.5.x**

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## CONTENTS

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### PREFACE

#### **Preface** xi

Changes to This Document xi

Communications, Services, and Additional Information xi

---

### CHAPTER 1

#### **New and Changed Feature Information** 1

System Security Features Added or Modified in IOS XR Release 6.5.x 1

---

### CHAPTER 2

#### **Configuring AAA Services** 3

Overview on AAA Services 3

User, User Groups, and Task Groups 3

User Categories 4

User Groups 5

Task Groups 6

Command Access in XR and Admin Modes 6

Administrative Model 7

Administrative Access 8

AAA Database 8

Remote AAA Configuration 9

AAA Configuration 9

Authentication 10

Password Types 11

AAA Password Security for FIPS Compliance 11

AAA Password Security Policies 12

Task-based Authorization 14

Task IDs 14

General Usage Guidelines for Task IDs 15

Task IDs for TACACS+ and RADIUS Authenticated Users	16
Privilege Level Mapping	16
XML Schema for AAA Services	16
Netconf and Restconf for AAA Services	17
About RADIUS	17
Network Security Situations in Which RADIUS is Unsuitable	18
RADIUS Operation	18
How to Configure AAA Services	19
Prerequisites for Configuring AAA Services	19
Restrictions for Configuring AAA Services	19
Configure Task group	19
Configure User Groups	21
Configure Users	23
Configure AAA Password Policy	24
Configure Router to RADIUS Server Communication	26
Configure RADIUS Dead-Server Detection	29
Configure TACACS+ Server	31
Configure RADIUS Server Groups	33
Configure TACACS+ Server Groups	35
Configure Per VRF TACACS+ Server Groups	37
Create Series of Authentication Methods	39
Create Series of Authorization Methods	40
Create Series of Accounting Methods	43
Generate Interim Accounting Records	45
Apply Method List	46
Enable Accounting Services	47
Configure Login Parameters	48
Task Maps	49
Format of the Task String	49
Model-based AAA	51
Prerequisites for Model Based AAA	51
Initial Operation	52
NACM Configuration Management and Persistence	53
Overview of Configuring NACM	53

Disabling NACM 57

---

**CHAPTER 3**

**Configuring FIPS Mode 59**

- Prerequisites for Configuring FIPS 60
- How to Configure FIPS 60
  - Enable FIPS mode 60
  - Configure FIPS-compliant Keys 61
  - Configure FIPS-compliant Key Chain 62
  - Configure FIPS-compliant Certificates 63
  - Configure FIPS-compliant OSPFv3 64
  - Configure FIPS-compliant SNMPv3 Server 65
  - Configure FIPS-compliant SSH Client and Server 66

---

**CHAPTER 4**

**Implementing Certification Authority Interoperability 69**

- Information About Implementing Certification Authority 69
  - Supported Standards for Certification Authority Interoperability 69
  - Certification Authorities 70
    - Purpose of CAs 70
    - CA Registration Authorities 71
- Prerequisites for Implementing Certification Authority 71
- Restrictions for Implementing Certification Authority 71
- Configure Router Hostname and IP Domain Name 71
- Generate RSA Key Pair 72
- Import Public Key to the Router 73
- Declare Certification Authority and Configure Trusted Point 74
- Authenticate CA 76
- Request Your Own Certificates 77
- Configure Certificate Enrollment Using Cut-and-Paste 77
- Certificate Authority Trust Pool Management 81
  - CA Certificate Bundling in the Trust Pool 81
  - Prerequisites for CA Trust Pool Management 81
  - Restrictions for CA trust pool management 81
  - Updating the CA Trustpool 81
    - Manually Update Certificates in Trust Pool 82

Configuring Optional Trustpool Policy Parameters	83
Handling of CA Certificates appearing both in Trust Pool and Trust Point	84

**CHAPTER 5****Implementing Keychain Management 85**

Implementing Keychain Management	85
Restrictions for Implementing Keychain Management	85
Configure Keychain	85
Configure Tolerance Specification to Accept Keys	87
Configure Key Identifier for Keychain	88
Configure Text for Key String	89
Determine Valid Keys	90
Configure Keys to Generate Authentication Digest for Outbound Application Traffic	91
Configure Cryptographic Algorithm	92
Lifetime of Key	94

**CHAPTER 6****Configure MACSec 95**

Understanding MACsec Encryption	96
MKA Authentication Process	96
MACsec Frame Format	97
Advantages of Using MACsec Encryption	97
Hardware Support for MACsec	98
MACsec PSK	98
Fallback PSK	98
Configuring and Verifying MACsec Encryption	99
Creating a MACsec Keychain	99
Securing the MACsec Pre-shared Key (PSK) Using Type 6 Password Encryption	102
Configuring a Primary Key and Enabling the Type 6 Password Encryption Feature	102
Configuring MACSec Pre-shared Key (PSK)	104
Creating a User-Defined MACsec Policy	105
MACsec SAK Rekey Interval	108
Applying MACsec Configuration on an Interface	109
MACsec Policy Exceptions	110
How to Create MACsec Policy Exception	111
Verifying MACsec Encryption on IOS XR	111

Verifying MACsec Encryption on NCS 5500	118
MACsec SecY Statistics	121
Querying SNMP Statistics Using CLI	121
MACsec SNMP MIB (IEEE8021-SECY-MIB)	122
secyIfTable	123
secyTxSCTable	124
secyTxSatable	124
secyRxSCTable	125
secyRxSatable	125
secyCipherSuiteTable	126
secyTxSAStatsTable	126
secyTxSCStatsTable	126
secyRxSAStatsTable	127
secyRxSCStatsTable	127
secyStatsTable	128
Obtaining the MACsec Controlled Port Interface Index	128
SNMP Query Examples	128
Related Commands for MACsec	129
Global MACsec Shutdown	129
Configure MACsec Shutdown	129
Verify MACsec Shutdown	129
Syslog Messages for MACsec Shutdown	130
<hr/>	
<b>CHAPTER 7</b>	<b>Implementing URPF 131</b>
	Understanding URPF 131
	Configuring URPF Loose Mode 131
<hr/>	
<b>CHAPTER 8</b>	<b>Implementing Management Plane Protection 135</b>
	Implementing Management Plane Protection 135
	Benefits of Management Plane Protection 136
	Restrictions for Implementing Management Plane Protection 136
	Configure Device for Management Plane Protection for Inband Interface 136
	Configure Device for Management Plane Protection for Out-of-band Interface 139
	Information About Implementing Management Plane Protection 143

Peer-Filtering on Interfaces 143

Control Plane Protection 144

Management Plane 144

---

**CHAPTER 9 Traffic Protection for Third-Party Applications 145**

gRPC Protocol 145

Limitations for Traffic Protection for Third-Party Applications 146

Prerequisites for Traffic Protection for Third-Party Applications Over GRPC 146

Configuring Traffic Protection for Third-Party Applications 146

Troubleshooting Traffic Protection for Third-Party Applications 147

---

**CHAPTER 10 Implementing Secure Shell 149**

Information About Implementing Secure Shell 149

SSH Server 150

SSH Client 150

SFTP Feature Overview 151

RSA Based Host Authentication 152

RSA Based User Authentication 152

SSHv2 Client Keyboard-Interactive Authentication 153

Prerequisites for Implementing Secure Shell 154

Restrictions for Implementing Secure Shell 154

Configure SSH 155

Configure SSH Client 158

Multi-channeling in SSH 160

Configure Client for Multiplexing 161

---

**CHAPTER 11 Implementing Lawful Intercept 163**

Information About Lawful Intercept Implementation 163

Prerequisites for Implementing Lawful Intercept 164

Restrictions for Implementing Lawful Intercept 164

Lawful Intercept Topology 166

Benefits of Lawful Intercept 166

Installing Lawful Intercept (LI) Package 167

Installing and Activating the LI Package 167



Deactivating the LI RPM	167
How to Configure SNMPv3 Access for Lawful Intercept	168
Disabling SNMP-based Lawful Intercept	168
Configuring the Inband Management Plane Protection Feature	168
Enabling the Lawful Intercept SNMP Server Configuration	169
Additional Information on Lawful Intercept	169
Interception Mode	169
Data Interception	169
Scale or Performance Values	170
Intercepting IPv4 and IPv6 Packets	170
Lawful Intercept Filters	170
Encapsulation Type Supported for Intercepted Packets	171
High Availability for Lawful Intercept	171
Preserving TAP and MD Tables during RP Fail Over	171
Replay Timer	172





## Preface



**Note** This product has reached end-of-life status. For more information, see the [End-of-Life and End-of-Sale Notices](#).

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 and NCS 560 Series Routers*.

The preface contains the following sections:

- [Changes to This Document, on page xi](#)
- [Communications, Services, and Additional Information, on page xi](#)

## Changes to This Document

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

**Table 1: Changes to This Document**

Date	Summary
March 2019	Initial release of this document.

## 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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### **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.



# CHAPTER 1

## 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 6.5.x](#), on page 1

### System Security Features Added or Modified in IOS XR Release 6.5.x

Feature	Description	Changed in Release	Where Documented
Support for multiple prefixes on MPP for TPA feature	Multiple prefixes are now supported on the MPP for TPA feature.	Release 6.5.2	<a href="#">Traffic Protection for Third-Party Applications</a> , on page 145
IS-IS Authentication with Keychain	New cryptographic algorithms such as, AES-128-CMAC-96, HMAC-SHA-256, and HMAC-SHA1-96 are added under keychain infra as part of this feature. These algorithms provide more secured authentication.	Release 6.5.1	<i>Implementing Keychain Management</i> chapter <a href="#">Configure Cryptographic Algorithm</a> , on page 92
OSPF Authentication with Keychain	New cryptographic algorithms such as, HMAC-SHA-256 and HMAC-SHA1-96 are added under keychain infra as part of this feature. These algorithms provide more secured authentication.	Release 6.5.1	<i>Implementing Keychain Management</i> chapter <a href="#">Configure Cryptographic Algorithm</a> , on page 92





## 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.

### Feature History for Configuring AAA Services

Release	Modification
Release 6.0	This feature was introduced.

- [Overview on AAA Services, on page 3](#)
- [How to Configure AAA Services, on page 19](#)

## Overview on 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 chassis 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.
- **maintenance:** Has the ability to display, configure and execute commands for network, files and user-related entities.
- **netadmin:** Has the ability to control and monitor all system and network parameters.
- **operator:** A demonstration group with basic privileges.
- **provisioning:** Has the ability to display and configure network, files and user-related entities.
- **read-only-tg:** Has the ability to perform any show command, but no configuration ability.
- **retrieve:** Has the ability to display network, files and user-related information.
- **root-lr:** Has the ability to control and monitor the specific secure domain router.
- **serviceadmin:** Service administration tasks, for example, Session Border Controller (SBC).
- **sysadmin:** Has the ability to control and monitor all system parameters but cannot configure network protocols.

To verify the individual permissions of a user group, assign the group to a user and execute the **show user tasks** command.

### 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.

XR Task or Group	Sysadmin VM Group	Access	Example
root-lr	Root-system group	Full access to the system configuration.	<pre>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   inc root-lr Mon Nov  3 13:49:06.495 UTC Task:                root-lr  : READ    WRITE EXECUTE             DEBUG (reserved)</pre> <pre>RP/0/RP0/CPU0:ios#admin sysadmin-vm:0_RP0# show aaa user-group Mon Nov  3 13:48:00.790 UTC User group : root-system</pre>

XR Task or Group	Sysadmin VM Group	Access	Example
Admin-r/w/x/d	Admin-r	Read only commands on Sysadmin VM	<pre> 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 </pre>
Netadmin or sysadmin group  Admin-r/ wx /d, aaa -r/w/x/d	Aaa -r and admin -r	Read only commands on Sysadmin VM	<pre> 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   inc aaa Mon Nov 3 13:45:00.999 UTC Task:                aaa : READ RP/0/RP0/CPU0:ios#show user tasks   inc admin Mon Nov 3 13:45:09.567 UTC Task:                admin : READ  RP/0/RP0/CPU0:ios#admin Mon Nov 3 13:46:21.183 UTC netadmin 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 13:44:23.939 UTC User group : admin-r,aaa-r sysadmin-vm:0_RP0# </pre>

## 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.




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

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- 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 these:

- 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.
- Make sure to allow local fallback when configuring AAA. See, [Create Series of Authorization Methods, on page 40](#).
- If you prefer to commit the configuration on a trial basis for a specified time, you may do so by using the **commit confirmed** command, instead of direct **commit**.

## 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.




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**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.

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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.

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## 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)




---

**Note** If the system rejects the authorization request and the user gets locked out, you can try to rollback the previous configuration or remove the problematic AAA configuration through auxiliary port. To log in to the auxiliary port, use the local username and password; not the tacacs+ server credentials. The **config\_rollback -n 0x1** command can be used to rollback the previous configuration. If you are not able to access the auxiliary port, a router reload might be required in such scenarios.

---

## 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 passed to it by the applications. The role of an authenticated user is determined by the group (or groups) to which the user belongs. (A user can be a member of one or more user groups.)

### Authentication of 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** for choosing the authentication method. The **remote** method list is configured using the **aaa authentication login remote method1 method2...** command.

### Authentication of 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 of Secure Domain Router User

Secure domain router user authentication is similar to owner secure domain router user authentication. If the user is not found to be a member of the designated owner secure domain router user group, the user is authenticated as a 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.

## AAA Password Security for FIPS Compliance

Cisco IOS XR Software introduces advanced AAA password strengthening policy and security mechanism to store, retrieve and provide rules or policy to specify user passwords. This password policy is applicable

only for local users, and not for remote users whose profile information are stored in a third party AAA server. This policy is not applicable to secrets of the user. If both secret and password are configured for a user, then secret takes precedence, and password security policy does not have any effect on authentication or change of password for such users. This AAA password security policy works as such for Cisco IOS XR platforms. Whereas, this feature is supported only on XR VM, for Cisco IOS XR 64 bit platforms and Cisco NCS 5500 Series Routers.

### High Availability for AAA Password Security Policy

The AAA password policy configurations and username configurations remain intact across RP failovers or process restarts in the system. The operational data such as, lifetime of the password and lockout time of the user are not stored on system database or disk. Hence, those are not restored across RP failovers or process restarts. Users start afresh on the active RP or on the new process. Hence, users who were locked out before RP failover or process restart are able to login immediately after the failover or restart.

To configure AAA password policy, see [Configure AAA Password Policy, on page 24](#).

## AAA Password Security Policies

AAA password security for FIPS compliance consists of these policies:

### Password Composition Policy

Passwords can be composed by any combination of upper and lower case alphabets, numbers and special characters that include: "!", "@", "#", "\$", "%", "^", "&", "\*", "(", and ")". Security administrator can also set the types and number of required characters that comprise the password, thereby providing more flexibility for password composition rules. The minimum number of character change required between passwords is 4, by default. There is no restriction on the upper limit of the number of uppercase, lowercase, numeric and special characters.

### Password Length Policy

The administrator can set the minimum and maximum length of the password. The minimum configurable length in password policy is 2, and the maximum length is 253.

### Password Lifetime Policy

The administrator can configure a maximum lifetime for the password, the value of which can be specified in years, months, days, hours, minutes and seconds. The configured password never expires if this parameter is not configured. The configuration remains intact even after a system reload. But, the password creation time is updated to the new time whenever the system reboots. For example, if a password is configured with a life time of one month, and if the system reboots on 29<sup>th</sup> day, then the password is valid for one more month after the system reboot. Once the configured lifetime expires, further action is taken based on the password expiry policy (see the section on Password Expiry Policy).

### Password Expiry Policy

If the password credential of a user who is trying to login is already expired, then the following actions occur:

- User is prompted to set the new password after successfully entering the expired password.
- The new password is validated against the password security policy.



- If the new password matches the password security policy, then the AAA data base is updated and authentication is done with the new password.
- If the new password is not compliant with the password security policy, then the attempt is considered as an authentication failure and the user is prompted again to enter a new password. The max limit for such attempts is in the control of login clients and AAA does not have any restrictions for that.

As part of password expiry policy, if the life time is not yet configured for a user who has already logged in, and if the security administrator configures the life time for the same user, then the life time is set in the database. The system checks for password expiry on the subsequent authentication of the same user.

Password expiry is checked only during the authentication phase. If the password expires after the user is authenticated and logged in to the system, then no action is taken. The user is prompted to change the password only during the next authentication of the same user.

Debug logs and syslog are printed for the user password expiry only when the user attempts to login. This is a sample syslog in the case of password expiry:

```
RP/0/RSP1/CPU0:Jun 21 09:13:34.241 : locald_DSC[308]: %SECURITY-LOCALD-5-USER_PASSWD_EXPIRED
:
Password for user 'user12' has expired.
```

### Password Change Policy

Users cannot change passwords at will. A password change is triggered in these scenarios:

- When the security administrator needs to change the password
- When the user is trying to get authenticated using a profile and the password for the profile is expired
- When the security administrator modifies the password policy which is associated to the user, and does not immediately change the password according to the policy

You can use the **show configuration failed** command to display the error messages when the password entered does not comply with the password policy configurations.

When the security administrator changes the password security policy, and if the existing profile does not meet the password security policy rules, no action is taken if the user has already logged in to the system. In this scenario, the user is prompted to change the password when he tries to get authenticated using the profile which does not meet the password security rules.

When the user is changing the password, the lifetime of the new password remains same as that of the lifetime that was set by the security administrator for the old profile.

When password expires for non-interactive clients (such as dot1x), an appropriate error message is sent to the clients. Clients must contact the security administrator to renew the password in such scenarios.

### Service Provision after Authentication

The basic AAA local authentication feature ensures that no service is performed before a user is authenticated.

### User Re-authentication Policy

A user is re-authenticated when he changes the password. When a user changes his password on expiry, he is authenticated with the new password. In this case, the actual authentication happens based on the previous credential, and the new password is updated in the database.

### User Authentication Lockout Policy

AAA provides a configuration option, **authen-max-attempts**, to restrict users who try to authenticate using invalid login credentials. This option sets the maximum number of permissible authentication failure attempts for a user. The user gets locked out when he exceeds this maximum limit, until the lockout timer ( **lockout-time**) is expired. If the user attempts to login in spite of being locked out, the lockout expiry time keep advancing forward from the time login was last attempted.

This is a sample syslog when user is locked out:

```
RP/0/RSP1/CPU0:Jun 21 09:21:28.226 : locald_DSC[308]: %SECURITY-LOCALD-5-USER_PASSWD_LOCKED
:
User 'user12' is temporarily locked out for exceeding maximum unsuccessful logins.
```

This is a sample syslog when user is unlocked for authentication:

```
RP/0/RSP1/CPU0:Jun 21 09:14:24.633 : locald_DSC[308]: %SECURITY-LOCALD-5-USER_PASSWD_UNLOCKED
:
User 'user12' is unlocked for authentications.
```

### Password Policy Creation, Modification and Deletion

Security administrators having write permission for AAA tasks are allowed to create password policy. Modification is allowed at any point of time, even when the policy is associated to a user. Deletion of password policy is not allowed until the policy is un-configured from the user.

After the modification of password policy associated with a user, security administrator can decide if he wants to change passwords of associated users complying to the password policy. Based on this, there are two scenarios:

- If the administrator configures the password, then the user is not prompted to change the password on next login.
- If the administrator does not configure the password, then the user is prompted to change the password on next login.

In either of the above cases, at every password expiry interval, the user is prompted to change the password on next login.

Debug messages are printed when password policies are created, modified and deleted.

## 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.



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

**Table 2: Task ID Classes**

Operation	Description
Read	Specifies a designation that permits only a read operation.
Write	Specifies a designation that permits a change operation and implicitly allows a read operation.
Execute	Specifies a designation that permits an access operation; for example ping and Telnet.
Debug	Specifies a designation that permits a debug operation.

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 submenu. 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 `priv_lvl` 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.



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

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## 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:
  - a. ACCEPT—The user is authenticated.
  - a. REJECT—The user is not authenticated and is prompted to reenter the username and password, or access is denied.
  - a. CHALLENGE—A challenge is issued by the RADIUS server. The challenge collects additional data from the user.
  - a. 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.

# How to Configure AAA Services

## 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 16](#)” 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.




---

**Note** 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. Use the **commit** or **end** command.

**DETAILED STEPS****Step 1** **configure****Example:**

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

Enters global configuration mode.

**Step 2** **taskgroup** *taskgroup-name***Example:**

```
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:**

```
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:**

```
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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

---

### 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 submenu. 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. Use the **commit** or **end** command.

## DETAILED STEPS

---

### Step 1 **configure**

#### Example:

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

Enters global configuration mode.

### 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*

#### Example:

```
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 Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.

- **Cancel**—Remains in the configuration session, without committing the configuration changes.

---

## 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. Use the **commit** or **end** command.

### DETAILED STEPS

---

#### Step 1 **configure**

**Example:**

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

Enters global configuration mode.

#### 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 secl
```

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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## Configure AAA Password Policy

To configure the AAA password policy, use the **aaa password-policy** command in the global configuration mode.

### Configuration Example

This example shows how to configure a AAA password security policy, *test-policy*. This *test-policy* is applied to a user by using the **username** command along with **password-policy** option.

```
RP/0/RP0/CPU0:router(config)#aaa password-policy test-policy
RP/0/RP0/CPU0:router(config-aaa)#min-length 8
RP/0/RP0/CPU0:router(config-aaa)#max-length 15
RP/0/RP0/CPU0:router(config-aaa)#lifetime months 3
RP/0/RP0/CPU0:router(config-aaa)#min-char-change 5
```

```
RP/0/RP0/CPU0:router(config-aaa)#authen-max-attempts 3
RP/0/RP0/CPU0:router(config-aaa)#lockout-time days 1
RP/0/RP0/CPU0:router(config-aaa)#commit

RP/0/RP0/CPU0:router(config)#username user1 password-policy test-policy password 0 pwd1
```

## Running Configuration

```
aaa password-policy test-policy
  min-length 8
  max-length 15
  lifetime months 3
  min-char-change 5
  authen-max-attempts 3
  lockout-time days 1
!
```

## Verification

Use this command to get details of the AAA password policy configured in the router:

```
RP/0/RP0/CPU0:router#show aaa password-policy
```

```
Fri Feb  3 16:50:58.086 EDT
Password Policy Name : test-policy
  Number of Users : 1
  Minimum Length : 8
  Maximum Length : 15
  Special Character Len : 0
  Uppercase Character Len : 0
  Lowercase Character Len : 1
  Numeric Character Len : 0
  Policy Life Time :
    seconds : 0
    minutes : 0
    hours : 0
    days : 0
    months : 3
    years : 0
  Lockout Time :
    seconds : 0
    minutes : 0
    hours : 0
    days : 1
    months : 0
    years : 0
  Character Change Len : 5
  Maximum Failure Attempts : 3
```

## Related Topic

- [AAA Password Security for FIPS Compliance, on page 11](#)

## Associated Commands

- `aaa password-policy`

- **show aaa password-policy**
- **username**

## 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.




---

**Note** You can configure both global and per-server timeout, retransmission, and key value commands simultaneously on the same Cisco network access server. If both global and per-server functions are configured on a router, the per-server timer, retransmission, and key value commands override global timer, retransmission, and key value commands.

---

### 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. Use the **commit** or **end** command.
9. **show radius**

## DETAILED STEPS

### Step 1 **configure**

#### Example:

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

Enters global configuration mode.

### 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//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** Use the `commit` or `end` command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 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 downtime 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. Use the **commit** or **end** command.
6. **show radius dead-criteria host** *ip-addr* [**auth-port** *auth-port*] [**acct-port** *acct-port*]

## DETAILED STEPS

**Step 1** **configure****Example:**

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

Enters global configuration mode.

**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.

**Step 3** **radius-server dead-criteria time** *seconds***Example:**

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

Establishes the time for the dead-criteria conditions for a RADIUS server to be marked as dead.

**Step 4** **radius-server dead-criteria tries** *tries***Example:**

```
RP/0/RP0/CPU0:router(config)# radius-server dead-criteria tries 4
```

Establishes the number of tries for the dead-criteria conditions for a RADIUS server to be marked as dead.

**Step 5** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 6** **show radius dead-criteria host** *ip-addr* [**auth-port** *auth-port*] [**acct-port** *acct-port*]

**Example:**

```
RP/0/RP0/CPU0:router# show radius dead-criteria host 172.19.192.80
```

(Optional) Displays dead-server-detection information that has been requested for a RADIUS server at the specified IP address.

## 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. Use the **commit** or **end** command.
9. **show tacacs**

### DETAILED STEPS

**Step 1** **configure****Example:**

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

Enters global configuration mode.

**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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## Step 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. Use the **commit** or **end** command.
7. **show radius server-groups** [*group-name* [**detail**]]

**DETAILED STEPS****Step 1** **configure****Example:**

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

Enters global configuration mode.

**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
```

Configures 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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 7** **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* section).

### 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. Use the **commit** or **end** command.
8. **show tacacs server-groups**

## DETAILED STEPS

### Step 1 **configure**

#### Example:

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

Enters global configuration mode.

### 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

- You can configure a maximum of 10 private TACACS+ servers.
- 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 Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.



**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

#### Step 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
!
server-private 10.1.1.2 port 49
key 7 05080F1C2243
!
server-private 2001:db8:1::1 port 49
key 7 045802150C2E
!
server-private 2001:db8:1::2 port 49
key 7 13061E010803
!
!

```

## Verify Per VRF TACACS+ Server Groups

```

Router#show tacacs
Fri Sep 27 11:14:34.991 UTC

Server: 10.1.1.1/49 vrf=test-vrf [private]
opens=0 closes=0 aborts=0 errors=0
packets in=0 packets out=0
status=up single-connect=false family=IPv4

Server: 10.1.1.2/49 vrf=test-vrf [private]
opens=0 closes=0 aborts=0 errors=0
packets in=0 packets out=0
status=up single-connect=false family=IPv4

Server: 2001:db8:1::1/49 vrf=test-vrf [private]
opens=0 closes=0 aborts=0 errors=0
packets in=0 packets out=0
status=up single-connect=false family=IPv6

Server: 2001:db8:1::2/49 vrf=test-vrf [private]
opens=0 closes=0 aborts=0 errors=0
packets in=0 packets out=0
status=up single-connect=false family=IPv6

```

## Associated Commands

- **server-private**
- **vrf**

## 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. Use the **commit** or **end** command.
4. Repeat Step 1 through Step 3 for every authentication method list to be configured.

## DETAILED STEPS

---

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

**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
  - **group named-group**—Use a named subset of TACACS+ or RADIUS servers for authentication
  - **local**—Use a local username or password database for authentication
  - **line**—Use line password or user group for authentication
- The example specifies the **default** method list to be used for authentication.

**Step 3** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 4** Repeat Step 1 through Step 3 for every authentication method list to be configured.

---

## 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.



**Note** To avoid lockouts in user authorization, make sure to allow local fallback (by configuring the **local** option for **aaa authorization** command) when configuring AAA. For example, **aaa authorization commands default tacacs+ local**.

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.



**Note** If you have configured AAA authorization to be subjected to TACACS+ authorization, then you must ensure that the server group is configured (use the **aaa group server tacacs+** command for this) for that TACACS+ server. Else, authorization fails.

For example,

```
aaa authorization exec default group test_tacacs+ local
aaa authorization commands default group test_tacacs+
aaa group server tacacs+ test_tacacs+ <===
```

## SUMMARY STEPS

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

## DETAILED STEPS

---

### Step 1 **configure**

#### Example:

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

Enters global configuration mode.

### Step 2 **aaa authorization {commands | eventmanager | exec | network} {default | list-name} {none | local | group {tacacs+ | radius | group-name}}**

#### Example:

```
RP/0//CPU0: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.

### Step 3 Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.

- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

---

## 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. Use the **commit** or **end** command.

### DETAILED STEPS

---

#### Step 1 **configure**

##### Example:

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

Enters global configuration mode.

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

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

**Example:**

```
RP/0//CPU0: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.

**Step 3** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.



## 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. Use the **commit** or **end** command.

### DETAILED STEPS

#### Step 1 **configure**

**Example:**

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

Enters global configuration mode.

#### Step 2 **aaa accounting update** {**newinfo** | **periodic** *minutes*}

**Example:**

```
RP/0//CPU0: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 Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.

- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## 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. Use the **commit** or **end** command.

### DETAILED STEPS

#### Step 1 **configure**

##### Example:

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

Enters global configuration mode.

#### Step 2 **line** { **console** | **default** | **template** *template-name*}

##### Example:

```
RP/0//CPU0: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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

---

#### 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. Use the **commit** or **end** command.

### DETAILED STEPS

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

**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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**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. Use the **commit** or **end** command.

**DETAILED STEPS**

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

**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.

**Step 4** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

---

## 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 , ..."
```




---

**Note** 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 = "rwxbgp,#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.



**Note** 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:bjp,#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   EXECUTEDEBUG
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
```

## Model-based AAA

The Network Configuration Protocol (NETCONF) protocol does not provide any standard mechanisms to restrict the protocol operations and content that each user is authorized to access. The NETCONF Access Control Model (NACM) is defined in AAA subsystem to manage access-control for NETCONF/YANG RPC requests.

The NACM module provides the ability to control the manageability activities of NETCONF users on the router. You can manage access privileges, the kind of operations that users can perform, and a history of the operations that were performed on the router. The NACM functionality accounts for all the operations that are performed on the box over the NETCONF interface. This functionality authenticates the user or user groups and authorizes permissions for users to perform the operation.

## Prerequisites for Model Based AAA

Working with the model based AAA feature requires prior understanding of the following :

- NETCONF-YANG

- RFC 6536: Network Configuration Protocol (NETCONF) Access Control Model

## Initial Operation

These are the NACM default values. By default a user is denied write permission, hence you'll not be able to edit the NACM configurations after enabling NACM authorization using AAA command.

```
<enable-nacm>>false</enable-nacm>
<read-default>permit</read-default>
<write-default>deny</write-default>
<exec-default>permit</exec-default>
<enable-external-groups>>true</enable-external-groups>
```

Therefore we recommend to enable NACM after configuring the required NACM configurations, or after changing the default NACM configurations. Here are few sample configurations:



**Note** If `access-denied` message is returned while writing NACM configurations, then NACM authorization can be disabled to edit the NACM configurations.

```
<aaa xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-aaa-lib-cfg">
<usernames xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-aaa-locald-cfg">
<username>
<ordering-index>3</ordering-index>
<name>username</name>
<password>password</password>
  <usergroup-under-usernames>
    <usergroup-under-username>
      <name>root-lr</name>
    </usergroup-under-username>
    <usergroup-under-username>
      <name>cisco-support</name>
    </usergroup-under-username>
  </usergroup-under-usernames>
</username>
</usernames>
</aaa>

<nacm xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-aaa-nacm-cfg">
<read-default>permit</read-default>
<write-default>permit</write-default>
<exec-default>permit</exec-default>
<enable-external-groups>>true</enable-external-groups>
<groups>
  <group>
    <name>nacm_group</name>
    <user-name>lab</user-name>
  </group>
</groups>
<rule-list>
<name>Rule-list-1</name>
<group>Group_nacm_0_test</group>
<rule>
  <name>Rule-1</name>
  <access-operations>read</access-operations>
  <action>permit</action>
  <module-name>ietf-netconf-acm</module-name>
  <rpc-name>edit-config</rpc-name>
  <access-operations>*</access-operations>
  <path>/</path>
```



```

        <action>permit</action>
      </rule>
    </rule-list>
  </nacm>

```

## NACM Configuration Management and Persistence

The NACM configuration can be modified using NETCONF or RESTCONF. In order for a user to be able to access the NACM configuration, they must have explicit permission to do so, that is, through a NACM rule. Configuration under the /nacm subtree persists when the **copy running-config startup-config** EXEC command is issued, or the **cisco-ia:save-config** RPC is issued.

```

<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <save-config xmlns="http://cisco.com/yang/cisco-ia"/>
</rpc>

```

## Overview of Configuring NACM

Here are the steps involved in configuring NACM:

1. Configure all NACM rules
2. Enable NACM
3. Disconnect all active NETCONF sessions
4. Launch new NETCONF session




---

**Note** Enabling or disabling NACM does not affect any existing NETCONF sessions.

---

## NACM Rules

As per the RFC 6536, NACM defines two categories of rules:

- Global Rules—It includes the following:
  - Enable/Disable NACM
  - Read-Default
  - Write-Default
  - Exec-Default
  - Enable External Groups
- Access Control Rules—It includes the following:
  - Module (used along with protocol rule / data node rule)
  - Protocol
  - Data Node

The following table lists the rules and access operations:

Operation	Description
all	Rule is applied to all types of protocol operations
create	Rule is applied to all protocol operations, which create a new data node such as edit-config operation
read	Rule is applied to all protocol operations, which reads the data node such as get, get-config or notification
update	Rule is applied to all protocol operations, which alters a data node such as edit-config operation
exec	Rule is applied to all exec protocol access operations such as action RPC
delete	Rule is applied to all protocol operations that removes a data node



**Note** Before enabling NACM using NETCONF RPC, any user with access to the system can create NACM groups and rules. However, after NACM is enabled, only authorised users can change the NACM configurations.

**Example: Configure Global Rules**

**YANG Data Model:** You must configure NACM groups and NACM rulelist before configuring NACM rules. The following sample configuration shows a NACM group configuration:

```
<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" >
<edit-config>
  <target><candidate/></target>
<config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
  <nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
    <groups>
      <group>
        <name>group1</name>
        <user-name>user1</user-name>
        <user-name>user2</user-name>
        <user-name>user3</user-name>
      </group>
    </groups>
  </nacm>
</config>
</edit-config>
</rpc>
```

The following sample configuration shows a NACM rule list configuration:

```
<rpc
xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"message-id="101">
<edit-config>
  <target>
    <candidate/>
  </target>
<config>
<nacm xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-aaa-nacm-cfg">
  <rulelist-classes>
```

```

    <rulelist-class>
    <ordering-index>1</ordering-index>
    <rulelist-name>GlobalRule</rulelist-name>
    <group-names>
    <group-name>root-system</group-name>
    <group-name>AdminUser</group-name>
    </group-names>
    </rulelist-class>
  </rulelist-classes>
</nacm>
</config>
</edit-config>
</rpc>

```

### Example: Configure NACM Global Rules

#### YANG Data Model:

```

<rpc message-id="101" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" >
<edit-config>
  <target><candidate/></target>
<config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
  <nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
    <read-default>permit</read-default>
    <write-default>permit</write-default>
    <exec-default>permit</exec-default>
    <enable-external-groups>false</enable-external-groups>
  </nacm>
</config>
</edit-config>
</rpc>

```

### Example: Configure Access Control Rules

#### YANG Data Model:

```

<rpc message-id="101"
xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" >
<edit-config>
<target><candidate/></target>
<config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
  <nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
    <rule-list>
      <rule>
        <name>GlobalRule</name>
        <rule>
          <name>rule1</name>
          <module-name>ietf-netconf-acm</module-name>
          <rpc-name>edit-config</rpc-name>
          <access-operations>*</access-operations>
          <action>permit</action>
        </rule>
      </rule>
      <rule>
        <name>rule2</name>
        <module-name>ietf-netconf-acm</module-name>
        <rpc-name>get-config</rpc-name>
        <access-operations>create read update exec</accessoperations>
        <action>permit</action>
      </rule>
    </rule-list>
  </nacm>
</config>

```

```
</edit-config>
</rpc>
```




---

**Note** '\*' refers to all operations.

---

### Example: Configure NACM Data Node Rules

```
<rpc message-id="101"xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" >
<edit-config>
<target><candidate/></target>
  <config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0">
    <nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
      <rule-list>
        <name>GlobalRule</name>
        <rule>
          <name>rule4</name>
          <module-name>*</module-name>
          <path>/nacm/groups/group</path>
          <access-operations>*</access-operations>
          <action>permit</action>
        </rule>
        <rule>
          <name>rule5</name>
          <module-name>ietf-netconf-acm</module-name>
          <path>/nacm/rule-list</path>
          <access-operations>read</access-operations>
          <action>deny</action>
        </rule>
      </rule-list>
    </nacm>
  </config>
</edit-config>
</rpc>
```




---

**Note** '\*' refers to all modules, and all operations.

---

## Enabling NACM

NACM is disabled on the router by default. Users with root-lr or 'aaa' write task privilege users can enable/disable the NACM via CLI.

To enable NACM, use the following command in the Global configuration mode:

```
Router (config) #aaa authorization nacm default local
```

### Verification

Use the **show nacm summary** command to verify the default values after enabling NACM:

```
Router# show nacm summary
Mon Jan 15 16:47:43.549 UTC
NACM SUMMARY
-----
```

```

Enable Nacm : True
Enable External Groups : True
Number of Groups : 0
Number of Users : 0
Number of Rules : 0
Number of Rulelist : 0
Default Read : permit
Default Write : deny
Default Exec : permit
Denied Operations : 0
Denied Data Writes : 0
Denied Notifications : 0

```

### Associated Commands

- Router#**show nacm summary**
- Router#**show nacm users [user-name]**
- Router#**show nacm rule-list [rule-list-name] [rule [rule-name]]**
- Router#**show nacm groups [group-name]secret**

## Verify the NACM Configurations

Use the **show nacm summary** command to verify the NACM configurations:

```

Router# show nacm summary
Mon Jan 15 17:02:46.696 UTC
NACM SUMMARY
-----
Enable Nacm : True
Enable External Groups : True
Number of Groups : 3
Number of Users : 3
Number of Rules : 4
Number of Rulelist : 2
Default Read : permit
Default Write : permit
Default Exec : permit
Denied Operations : 1
Denied Data Writes : 0
Denied Notifications : 0
-----

```

### Associated Commands

- Router#**show nacm summary**
- Router#**show nacm users [user-name]**
- Router#**show nacm rule-list [rule-list-name] [rule [rule-name]]**
- Router#**show nacm groups [group-name]secret**

## Disabling NACM

There are two ways you can disable NACM. Use one of the following commands:

Configuring NACM authorization as none:

```
Router(config)# aaa authorization nacm default none
```

OR

Using no form of AAA authorization command:

```
Router(config)# no aaa authorization nacm default
```

### Verification

Use the **show nacm summary** command to verify the default values after disabling NACM:

```
Router# show nacm summary
```

```
Mon Jan 15 17:02:46.696 UTC
```

```
NACM SUMMARY
```

```
-----  
Enable Nacm : False
```

```
Enable External Groups : True
```

```
Number of Groups : 0
```

```
Number of Users : 0
```

```
Number of Rules : 0
```

```
Number of Rulelist : 0
```

```
Default Read : permit
```

```
Default Write : deny
```

```
Default Exec : permit
```

```
Denied Operations : 0
```

```
Denied Data Writes : 0
```

```
Denied Notifications : 0
```



## CHAPTER 3

# Configuring FIPS Mode

The Federal Information Processing Standard (FIPS) 140-2 is an U.S. and Canadian government certification standard that defines requirements that the cryptographic modules must follow. The FIPS specifies best practices for implementing cryptographic algorithms, handling key material and data buffers, and working with the operating system.

In Cisco IOS XR software, these applications are verified for FIPS compliance:

- Secure Shell (SSH)
- Secure Socket Layer (SSL)
- Transport Layer Security (TLS)
- Internet Protocol Security (IPSec) for Open Shortest Path First version 3 (OSPFv3)
- Simple Network Management Protocol version 3 (SNMPv3)
- AAA Password Security



**Note** Any process that uses any of the following cryptographic algorithms is considered non-FIPS compliant:

- Rivest Cipher 4 (RC4)
- Message Digest (MD5)
- Keyed-Hash Message Authentication Code (HMAC) MD5
- Data Encryption Standard (DES)

The Cisco Common Cryptographic Module (C3M) provides cryptographic services to a wide range of the networking and collaboration products of Cisco. This module provides FIPS-validated cryptographic algorithms for services such as RTP, SSH, TLS, 802.1x, and so on. The C3M provides cryptographic primitives and functions for the users to develop any protocol.

By integrating with C3M, the Cisco IOS-XR software is compliant with the FIPS 140-2 standards and can operate in FIPS mode, level 1 compliance.

- [Prerequisites for Configuring FIPS, on page 60](#)
- [How to Configure FIPS, on page 60](#)

# Prerequisites for Configuring FIPS

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.

## How to Configure FIPS

Perform these tasks to configure FIPS.

### Enable FIPS mode

---

**Step 1** `configure`**Example:**

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

Enters global configuration mode.

**Step 2** `crypto fips-mode`**Example:**

```
Router(config)#crypto fips-mode
```

Enters FIPS configuration mode.

**Note** Stop new incoming SSH sessions while configuring or unconfiguring `crypto fips-mode`. Restart the router upon configuration.

**Step 3** Use the `commit` or `end` command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 4** `show logging`**Example:**

```
Router#show logging
Syslog logging: enabled (0 messages dropped, 0 flushes, 0 overruns)
  Console logging: level debugging, 60 messages logged
```



```

Monitor logging: level debugging, 0 messages logged
Trap logging: level informational, 0 messages logged
Buffer logging: level debugging, 3 messages logged

Log Buffer (9000000 bytes):
<output omitted>

Log Buffer (307200 bytes):

RP/0/RSP0/CPU0:Apr 16 12:48:17.736 : cepki[433]: The configuration setting for FIPS mode has been
modified. The system must be reloaded to finalize this configuration change. Please refer to the IOS
XR System Security Configuration Guide, Federal Information Process Standard(FIPS) Overview section
when modifying the FIPS mode setting.
RP/0/RSP0/CPU0:Apr 16 12:48:17.951 : config[65757]: %MGBL-CONFIG-6-DB_COMMIT :
Configuration committed by user 'lab'. Use 'show configuration commit changes 1000000002' to view
the changes.
RP/0/RSP0/CPU0:Apr 16 12:48:23.988 : config[65757]: %MGBL-SYS-5-CONFIG_I : Configured from console
by lab

....
....
....

```

Displays the contents of logging buffers.

**Note** Use the **show logging | i fips** command to filter FIPS specific logging messages.

#### Step 5 reload location all

##### Example:

```
Router#reload location all
```

Reloads a node or all nodes on a single chassis or multishelf system.

## Configure FIPS-compliant Keys

Perform these steps to configure the FIPS-compliant keys:



**Note** The crypto keys are auto-generated at the time of router boot up. You need to perform these steps to generate the keys only if the keys are missing under some scenarios.

### Before you begin

Refer the configuration steps in the [Enable FIPS mode, on page 60](#) section for enabling the FIPS mode.

#### Step 1 crypto key generate rsa [usage-keys | general-keys] key label

##### Example:

```
Router#crypto key generate rsa general-keys rsakeypair
```

Generate a RSA key pair. Ensure that all the key pairs meet the FIPS requirements. The RSA key sizes allowed under FIPS mode are 2048, 3072 and 4096.

The option **usage-keys** generates separate RSA key pairs for signing and encryption. The option **general-keys** generates a general-purpose RSA key pair for signing and encryption.

To delete the RSA key pair, use the **crypto key zeroize rsa** *keypair-label* command.

## Step 2 **crypto key generate dsa**

### Example:

```
Router#crypto key generate dsa
```

Generate a DSA key pair if required. Ensure that all the key pairs meet the FIPS requirements. The DSA key size allowed under FIPS mode is 2048.

To delete the DSA key pair, use the **crypto key zeroize dsa** *keypair-label* command.

## Step 3 **crypto key generate ecdsa**

### Example:

```
Router#crypto key generate ecdsa
```

Generate a ECDSA key pair if required. Ensure that all the key pairs meet the FIPS requirements. The ECDSA key sizes allowed under FIPS mode are **nistp256**, **nistp384** and **nistp512**.

To delete the DSA key pair, use the **crypto key zeroize ecdsa** *keypair-label* command.

## Step 4 **show crypto key mypubkey rsa**

### Example:

```
Router#show crypto key mypubkey rsa
```

Displays the existing RSA key pairs

## Step 5 **show crypto key mypubkey dsa**

### Example:

```
Router#show crypto key mypubkey dsa
```

Displays the existing DSA key pairs

# Configure FIPS-compliant Key Chain

Perform these steps to configure the FIPS-compliant key chain:

## Before you begin

Refer the configuration steps in the [Enable FIPS mode, on page 60](#) section for enabling the FIPS mode.

## Step 1 **configure**

### Example:

```
Router#configure
```

Enters the global configuration mode.

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

**Example:**

```
Router(config)#key chain mykeychain
```

Creates a key chain.

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

**Example:**

```
Router(config-mykeychain)#key 1
```

Creates a key in the key chain.

**Step 4** **cryptographic-algorithm** {**HMAC-SHA1-20** | **SHA-1**}

**Example:**

```
Router(config-mykeychain-1)#cryptographic-algorithm HMAC-SHA1-20
```

Configures the cryptographic algorithm for the key chain. Ensure that the key chain configuration always uses SHA-1 as the hash or keyed hash message authentication code (hmac) algorithm.

**Step 5** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## Configure FIPS-compliant Certificates

Perform these steps to configure the FIPS-compliant certificates:

### Before you begin

Refer the configuration steps in the [Enable FIPS mode, on page 60](#) section for enabling the FIPS mode.

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

**Step 2** **crypto ca trustpoint** *ca-name key label*

**Example:**

```
Router(config)#crypto ca trustpoint msiox rsakeypair
```

Configures the trustpoint by utilizing the desired RSA keys.

Ensure that the certificates meet the FIPS requirements for key length and signature hash or encryption type.

**Note** The minimum key length for RSA or DSA key is 1024 bits. The required hash algorithm is SHA-1-20.

**Step 3** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 4** **show crypto ca certificates**

**Example:**

```
Router#show crypto ca certificates
```

Displays the information about the certificate

#### What to do next

For more information about certification authority and requesting router certificates, see the *Implementing Certification Authority* chapter in this guide.

## Configure FIPS-compliant OSPFv3

Perform these steps to configure the FIPS-compliant OSPFv3:

#### Before you begin

Refer the configuration steps in the [Enable FIPS mode, on page 60](#) section for enabling the FIPS mode.

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

**Step 2** **router ospfv3 process name**

**Example:**

```
Router(config)#router ospfv3 ospfname
```

Configures the OSPFv3 process.

**Step 3**     **area** *id***Example:**

```
Router(config-ospfv3)#area 1
```

Configures the OSPFv3 area ID. The ID can either be a decimal value or an IP address.

**Step 4**     **authentication**{ **disable** | **ipsec spi** *spi-value* **sha1** [**clear** | **password**] *password*}**Example:**

```
Router(config-ospfv3-ar)#authentication ipsec spi 256 sha1 password pa1
```

Enables authentication for OSPFv3. Note that the OSPFv3 configuration supports only SHA-1 for authentication.

**Note**     IPSec is supported only for Open Shortest Path First version 3 (OSPFv3).

**Step 5**     **exit****Example:**

```
Router(config-ospfv3-ar)#exit
```

Exits OSPFv3 area configuration and enters the OSPFv3 configuration mode.

**Step 6**     **encryption**{ **disable** | {**ipsec spi** *spi-value* **esp** {**3des** | **aes** [**192** | **256**] [**clear** | **password**] *encrypt-password*} [**authentication** **sha1** [**clear** | **password**] *auth-password*] } }**Example:**

```
Router(config-ospfv3)#encryption ipsec spi 256 esp 3des password pwd
```

Encrypts and authenticates the OSPFv3 packets. Ensure that the OSPFv3 configuration uses the following for encryption in the configuration.

- 3DES: Specifies the triple DES algorithm.
- AES: Specifies the Advanced Encryption Standard (AES) algorithm.

Ensure that SHA1 is chosen if the authentication option is specified.

**Step 7**     Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## Configure FIPS-compliant SNMPv3 Server

Perform these steps to configure the FIPS-compliant SNMPv3 server:

**Before you begin**

Refer the configuration steps in the [Enable FIPS mode, on page 60](#) section for enabling the FIPS mode.

**Step 1** **configure****Example:**

```
Router#configure
```

Enters the global configuration mode.

**Step 2** **snmp-server user** *username groupname {v3 [ auth sha {clear | encrypted} auth-password [priv {3des | aes { 128 | 192 | 256} } {clear | encrypted} priv-password]] } [SDROwner | SystemOwner] access-list-name***Example:**

```
Router(config)#snmp-server user user1 g v3 auth sha clear pass priv aes 128 clear privp
```

Configures the SNMPv3 server.

**Step 3** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## Configure FIPS-compliant SSH Client and Server

Perform these steps to configure the FIPS-compliant SSH Client and the Server:

**Before you begin**

Refer the configuration steps in the [Enable FIPS mode, on page 60](#) section for enabling the FIPS mode.

**Step 1** **ssh** {*ipv4-address* | *ipv6-address*} **cipher** **aes** {**128-CTR** | **192-CTR** | **256-CTR**} **username** *username***Example:**

```
Router#ssh 192.0.2.1 cipher aes 128-CTR username user1
```

Starts an SSH session to the server using the FIPS-approved ciphers. Ensure that the SSH client is configured only with the FIPS-approved ciphers. AES(Advanced Encryption Standard)-CTR (Counter mode) is the FIPS-compliant cipher algorithm with key lengths of 128, 192 and 256 bits.

**Step 2** **configure****Example:**

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

Enters global configuration mode.

### Step 3 **ssh server v2**

#### **Example:**

```
Router(config)#ssh server v2
```

Configures the SSH server.

The supported key exchange algorithms are:

- diffie-hellman-group14-sha1
- ecdh-sha2-nistp256
- ecdh-sha2-nistp384
- ecdh-sha2-nistp521

The supported cipher algorithms are:

- aes128-ctr
- aes192-ctr
- aes256-ctr
- aes128-gcm
- aes256-gcm

The supported HMAC algorithms are:

- hmac-sha2-512
- hmac-sha2-256
- hmac-sha1

### Step 4 Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
  - **No** —Exits the configuration session without committing the configuration changes.
  - **Cancel** —Remains in the configuration session, without committing the configuration changes.
-







## CHAPTER 4

# 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.

### Feature History for Implementing Certification Authority Interoperability

Release	Modification
Release 6.0	This feature was introduced.

- [Information About Implementing Certification Authority](#), on page 69
- [Prerequisites for Implementing Certification Authority](#), on page 71
- [Restrictions for Implementing Certification Authority](#), on page 71
- [Configure Router Hostname and IP Domain Name](#), on page 71
- [Generate RSA Key Pair](#), on page 72
- [Import Public Key to the Router](#), on page 73
- [Declare Certification Authority and Configure Trusted Point](#), on page 74
- [Authenticate CA](#), on page 76
- [Request Your Own Certificates](#), on page 77
- [Configure Certificate Enrollment Using Cut-and-Paste](#), on page 77
- [Certificate Authority Trust Pool Management](#), on page 81

## 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.
- **Public-Key Cryptography Standard #10 (PKCS #10)**—A standard syntax from RSA Data Security Inc. for certificate requests.
- **RSA keys**—RSA is the public key cryptographic system developed by Ron Rivest, Adi Shamir, and Leonard Adelman. RSA keys come in pairs: one public key and one private key.
- **SSL**—Secure Socket Layer protocol.
- **X.509v3 certificates**—Certificate support that allows the IPsec-protected network to scale by providing the equivalent of a digital ID card to each device. When two devices want to communicate, they exchange digital certificates to prove their identity (thus removing the need to manually exchange public keys with each peer or specify a shared key at each peer). These certificates are obtained from a CA. X.509 as part of the X.500 standard of the ITU.

## 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

Some CAs have a registration authority (RA) as part of their implementation. An RA is essentially a server that acts as a proxy for the CA so that CA functions can continue when the CA is offline.

# 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. Use the **commit** or **end** command.

## DETAILED STEPS

---

### Step 1 **configure**

#### Example:

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

Enters global configuration mode.

### 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 Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
  - **No** —Exits the configuration session without committing the configuration changes.
  - **Cancel** —Remains in the configuration session, without committing the configuration changes.
- 

## 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. **rsa-keypair keypair-label**
8. Use the **commit** or **end** command.

**DETAILED STEPS**

**Step 1** configure

**Example:**

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

Enters global configuration mode.

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

**Example:**

```
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.

**Note** If you want to do certificate enrolment when the server or destination is in a VRF, use the following command after step 2 to configure the VRF:

```
Router(config-trustp)# vrf vrf-name
```

### Step 3 enrollment url CA-URL

**Example:**

```
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.

**Note** If you want to do certificate enrolment when the destination URL is in a VRF, use the following command instead:

```
Router(config-trustp)# enrollment url tftp-address;vrf-name/ca-name
```

### Step 4 query url LDAP-URL

**Example:**

```
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:**

```
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:**

```
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:**

```
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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## 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. Use the **commit** or **end** command.
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****Example:**

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

Enters global configuration mode.

**Step 2** **crypto ca trustpoint** *ca-name***Example:**

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

**Step 3** enrollment terminal**Example:**

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

Specifies manual cut-and-paste certificate enrollment.

**Step 4** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**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 7979D262 B35465A6 1D3B70D1 36ACAFBD 7F91D5A0 CFB0EE91 B9D52C69
7CAF89ED F66A6A58 89EEF776 A03916CB 3663FB17 B7DBEBF8 1C54AF7F 293F3004
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 DF8ADB7F 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 82](#) 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 url`
3. `show crypto ca trustpool policy`

### DETAILED STEPS

	Command or Action	Purpose
<b>Step 1</b>	<b>crypto ca trustpool import url clean</b> <b>Example:</b> RP/0/RSP0/CPU0:IMC0#crypto ca trustpool import url clean	(Optional) Manually removes all downloaded CA certificates. This command is run in the EXEC mode.
<b>Step 2</b>	<b>crypto ca trustpool import url url</b> <b>Example:</b> RP/0/RSP0/CPU0:IMC0#crypto ca trustpool import url http://www.cisco.com/security/pki/trs/ios.p7b	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.

	Command or Action	Purpose
Step 3	<p><b>show crypto ca trustpool policy</b></p> <p><b>Example:</b></p> <pre>RP/0/RSP0/CPU0:IMC0#show crypto ca trustpool  Trustpool: Built-In ===== CA certificate   Serial Number   : 5F:F8:7B:28:2B:54:DC:8D:42:A3:15:B5:68:C9:AD:FF   Subject:     CN=Cisco Root CA 2048,O=Cisco Systems   Issued By      :     CN=Cisco Root CA 2048,O=Cisco Systems   Validity Start : 20:17:12 UTC Fri May 14 2004   Validity End   : 20:25:42 UTC Mon May 14 2029   SHA1 Fingerprint:     DE990CED99E0431F60EDC3937E7CD5BF0ED9E5FA  Trustpool: Built-In ===== CA certificate   Serial Number   : 2E:D2:0E:73:47:D3:33:83:4B:4F:DD:0D:D7:B6:96:7E   Subject:     CN=Cisco Root CA M1,O=Cisco   Issued By      :     CN=Cisco Root CA M1,O=Cisco   Validity Start : 20:50:24 UTC Tue Nov 18 2008   Validity End   : 21:59:46 UTC Fri Nov 18 2033   SHA1 Fingerprint:     45AD6BB499011BB4E84E84316A81C27D89EE5CE7</pre>	Displays the CA trust pool certificates of the router in a verbose format.

## 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

	Command or Action	Purpose
Step 1	<p><b>configure</b></p> <p><b>Example:</b></p> <pre>RP/0/RP0/CPU0:router# configure</pre>	Enters global configuration mode.

	Command or Action	Purpose
<b>Step 2</b>	<b>crypto ca trustpool policy</b> <b>Example:</b> RP/0/RSP0/CPU0:IMC0(config)#crypto ca trustpool policy RP/0/RSP0/CPU0:IMC0(config-trustpool)#	Enters ca-trustpool configuration mode where commands can be accessed to configure CA trustpool policy parameters.
<b>Step 3</b>	<b>cabundle url URL</b> <b>Example:</b> RP/0/RSP0/CPU0:IMC0(config-trustpool)#cabundle url http://www.cisco.com/security/pki/crl/crca2048.crl	Specifies the URL from which the CA trustpool certificate bundle is downloaded.
<b>Step 4</b>	<b>crl optional</b> <b>Example:</b> RP/0/RSP0/CPU0:IMC0(config-trustpool)#crl optional	Disables 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).
<b>Step 5</b>	<b>description LINE</b> <b>Example:</b> RP/0/RSP0/CPU0:IMC0(config-trustpool)#description Trustpool for Test.	

## 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.





## CHAPTER 5

# 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 85](#)

## 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.

## 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. Use the **commit** or **end** command.
4. **show key chain** *key-chain-name*

### DETAILED STEPS

---

**Step 1**     **configure**

**Example:**

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

Enters global configuration mode.

**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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 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. Use the **commit** or **end** command.

### DETAILED STEPS

---

#### Step 1 **configure**

**Example:**

```
RP/0/RP0/CPU0:router# configure
Enters global configuration mode.
```

#### 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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## 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. Use the **commit** or **end** command.

### DETAILED STEPS

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

**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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

---

## 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. Use the **commit** or **end** command.

### DETAILED STEPS

---

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

**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
```

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

Creates a key for the keychain.

**Step 4** **key-string** [**clear** | **password**] *key-string-text*

**Example:**

```
RP/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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## 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. Use the **commit** or **end** command.

### DETAILED STEPS

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

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

Creates a key for the keychain.

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

**Example:**

```
RP/0/RP0/CPU0:router(config-isis-keys)# key 8
RP/0/RP0/CPU0:router(config-isis-keys-0x8)# accept-lifetime 1:00:00 october 24 2005 infinite
```

(Optional) Specifies the validity of the key lifetime in terms of clock time.

**Step 5** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## 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. Use the **commit** or **end** command.

**DETAILED STEPS**

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

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

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
RP/0/RP0/CPU0:router(config-isis-keys-0x8)# send-lifetime 1:00:00 october 24 2005 infinite
```

(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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

---

## 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 | AES-128-CMAC-96 | HMAC-SHA-256 | HMAC-SHA1-96]
5. Use the **commit** or **end** command.

## DETAILED STEPS

---

### Step 1 **configure**

#### Example:

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

Enters global configuration mode.

### 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 | AES-128-CMAC-96 | HMAC-SHA-256 | HMAC-SHA1-96]

#### 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
- HMAC-SHA-256
- HMAC-SHA1-96
- AES-128-CMAC-96

The routing protocols each support a different set of cryptographic algorithms:

- Border Gateway Protocol (BGP) supports HMAC-MD5, HMAC-SHA1-12, HMAC-SHA1-96 and AES-128-CMAC-96.
- Intermediate System-to-Intermediate System (IS-IS) supports HMAC-MD5, SHA-1, MD5, AES-128-CMAC-96, HMAC-SHA-256, HMAC-SHA1-12, HMAC-SHA1-20, and HMAC-SHA1-96.
- Open Shortest Path First (OSPF) supports MD5, HMAC-MD5, HMAC-SHA-256, HMAC-SHA1-12, HMAC-SHA1-20, and HMAC-SHA1-96.

**Step 5** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

## 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.



**Note** 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 6

# 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	Release	Modification
	Release 6.1.3	This feature is introduced for physical interfaces and bundle member interfaces.
	Release 6.3.3	Introduced the support for global MACsec shutdown.
	Release 6.3.3	Introduced the support for MACsec SAK rekey interval.

- [Understanding MACsec Encryption, on page 96](#)
- [MKA Authentication Process, on page 96](#)
- [MACsec Frame Format, on page 97](#)
- [Advantages of Using MACsec Encryption, on page 97](#)
- [Hardware Support for MACsec, on page 98](#)
- [MACsec PSK, on page 98](#)
- [Fallback PSK, on page 98](#)
- [Configuring and Verifying MACsec Encryption , on page 99](#)
- [Creating a MACsec Keychain, on page 99](#)
- [Creating a User-Defined MACsec Policy, on page 105](#)
- [Applying MACsec Configuration on an Interface, on page 109](#)
- [MACsec Policy Exceptions, on page 110](#)
- [Verifying MACsec Encryption on IOS XR, on page 111](#)
- [Verifying MACsec Encryption on NCS 5500, on page 118](#)
- [MACsec SecY Statistics, on page 121](#)
- [Global MACsec Shutdown, on page 129](#)

## 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.

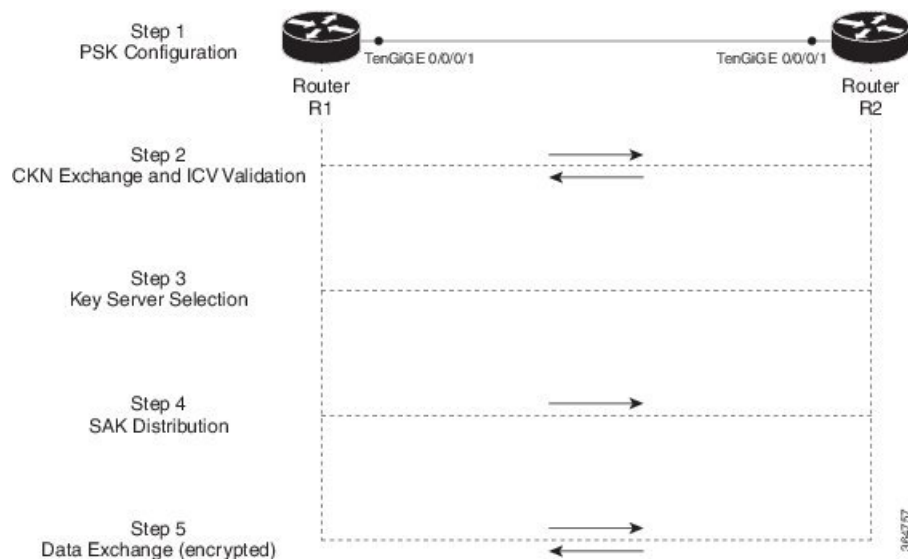
MACsec secures data on physical media, making it impossible for data to be compromised at higher layers. As a result, MACsec encryption takes priority over any other encryption method such as IPsec and SSL at higher layers. MACsec is configured on the Customer Edge (CE) router interfaces that connect 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).

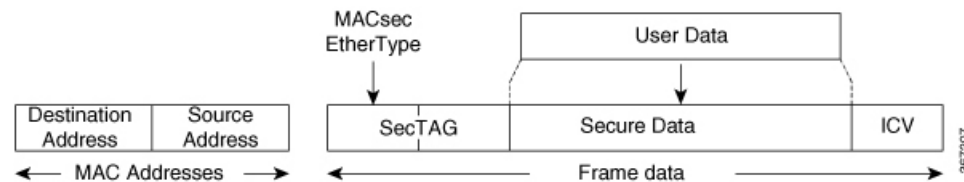
**Step 4:** A security association is formed between the peers. The key server generates and distributes the Secure Association Key (SAK) to the key client (peer). Each secure channel is supported by an overlapped sequence of Security Associations (SA). Each SA uses a new Secure Association Key (SAK).

**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.

# Hardware Support for MACsec

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




---

**Note** MACsec is supported only on the QSFP28 or SFP28 ports (in 10G to 100G speeds, and not 1G speed).

---

## Release History for MACSec Hardware Support

*Table 3: Release History for MACSec Hardware Support*

# 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 110](#) of the [Applying MACsec Configuration on an Interface, on page 109](#) 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 110](#) of the [Applying MACsec Configuration on an Interface, on page 109](#) 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.

MACsec Keychain Keyword	Description
Key	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.
Key-string	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).
Lifetime	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 <i>infinite</i> .

### Guidelines for Configuring MACsec Keychain

MACsec keychain management has the following configuration guidelines:

- To establish MKA session, ensure that the MACsec key (CKN) and key-string (CAK) match at both ends.

- 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.
- With NC55-MPA-12T-S MPA, you might experience a traffic drop in these scenarios:
  - A commit replace scenario where multiple MACsec configurations are applied across ports.
  - A process restart (say, in a SMU installation scenario) which results in MACsec rekeying on all the ports.
  - If there are multiple MACsec ports with the same rekey timeout.

## SUMMARY STEPS

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

**Step 2** Enter the MACsec mode.

**Example:**

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

**Step 3** 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 4** 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 123456781234567812345678123456781234567812345678123456781234567812345678 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 5** 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 macsec mka session** command does not display any information. If you run the **show macsec mka interface detail** command, the output displays **\*\*\* No Active Keys Present \*\*\*** in the PSK information.

**Step 6** Commit your configuration.

**Example:**

```
RP/0/RP0/CPU0:router(config-mac_chain-MacSec-1234abcd5678)#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 primary 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 primary 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 primary key is configured. The Type 6 Password Encryption is currently available on NCS-55A1-36H-SE-S Router.

## Configuring a Primary Key and Enabling the Type 6 Password Encryption Feature

You can configure a primary 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

	Command or Action	Purpose
Step 1	key config-key password-encryption [delete] Example:	Configuring a Primary Key

	Command or Action	Purpose
	<p>Configuring a Primary Key</p> <pre>Router# key config-key password-encryption New password Requirements: Min-length 6, Max-length 64 Characters restricted to [A-Z][a-z][0-9] Enter new key : Enter confirm key :</pre> <p><b>Example:</b></p> <p>Modifying the Primary Key</p> <pre>Router# key config-key password-encryption New password Requirements: Min-length 6, Max-length 64 Characters restricted to [A-Z][a-z][0-9] Enter old key : Enter new key : Enter confirm key :</pre> <p><b>Example:</b></p> <p>Deleting the Primary Key</p> <pre>Router# key config-key password-encryption delete</pre>	<p>Configures a primary key to be used with the Type 6 password encryption feature. The primary key can contain between 6 and 64 alphanumeric characters.</p> <p><b>Modifying the Primary Key</b></p> <p>If a primary key is already configured, you are prompted to enter the current primary key before entering a new primary key.</p> <p>Modifying a primary key would re-encrypt all the existing Type 6 format key strings with the new primary key. If Type 6 key strings are present, ensure that the <b>password6 configuration aes</b> command is present to enable re-encryption with the new primary key. Otherwise, the primary key update operation fails.</p> <p><b>Deleting the Primary Key</b></p> <p>You can use the <b>delete</b> form of this command to delete the primary key at any time.</p> <p><b>Note</b> Before deleting the primary key, <b>password6 encryption aes</b> command needs to be disabled using the <b>no password6 encryption aes</b> command followed by configuring the commit command.</p> <p><b>Caution</b> Primary key deletion would bring down MACSec traffic if MKA sessions were up with Type 6 keys. To avoid traffic disruptions, configure a new set of PSK key pairs [key (CKN) and key string (CAK)] with latest timestamps with the lifetime of infinite validity on both the peers and ensure the successful CAK rekey to the newly configured CKN and CAK.</p>
<b>Step 2</b>	<p><b>configure terminal</b></p> <p><b>Example:</b></p> <pre>Router# configure terminal Router(config)#</pre>	Enters global configuration mode.
<b>Step 3</b>	<p><b>[no] password6 encryption aes</b></p> <p><b>Example:</b></p> <pre>Router(config)# password6 encryption aes</pre>	<p>Enables or disables the Type 6 password encryption feature.</p> <p>If you enable the Type 6/AES password encryption feature before configuring a primary key, password encryption will not take place.</p>
<b>Step 4</b>	<p><b>commit</b></p> <p><b>Example:</b></p> <pre>Router(config)# commit</pre>	Use the <b>commit</b> 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 primary 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

	Command or Action	Purpose
Step 1	<b>configure terminal</b> <b>Example:</b> <pre>Router# configure terminal Router(config)#</pre>	Enters global configuration mode.
Step 2	<b>key chain</b> <i>key chain name</i> <b>macsec</b> <b>Example:</b> <pre>Router(config)# key chain kcl macsec Router(config-kcl-MacSec)#</pre>	Configures a key chain with the MACsec submode.
Step 3	<b>key</b> <i>hex string of even length and max 64 bytes</i> <b>Example:</b> <pre>Router(config-kcl-MacSec)# key 1111 Router(config-kcl-MacSec-1111)#</pre>	Configures MACsec CKN as hex string of even length upto 64 bytes.  <b>Caution</b> Configuring a hex string of odd number length exits from the MACsec submode. In that case, repeat from Step2 to enter the MACsec submode again.
Step 4	<b>key-string</b> <i>hex string of length 32 bytes or 64 bytes</i> <b>cryptographic-algorithm</b> { <b>aes-128-cmac</b>   <b>aes-256-cmac</b> } <b>Example:</b> Configuring 32 byte hex CAK	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).

	Command or Action	Purpose
	<pre>Router(config-kcl-MacSec-1111)# key-string 12345678901234567890123456789022 cryptographic-algorithm aes-128-cmac</pre> <p><b>Example:</b></p> <p>Configuring 64 byte hex CAK</p> <pre>Router(config-kcl-MacSec-1111)# key-string 1234567890123456789012345678902212345678901234567890123456789022</pre> <pre>cryptographic-algorithm aes-256-cmac</pre>	
<b>Step 5</b>	<p><b>lifetime</b> <i>{hh:mm:ss} {1-31} month year infinite</i></p> <p><b>Example:</b></p> <pre>Router(config-kcl-MacSec-1111)# lifetime 00:00:00 1 january 2017 infinite</pre>	<p>Configures a valid lifetime for MACsec PSK.</p> <p><b>Note</b> Without configuring a valid lifetime, MACsec PSK will be an inactive key.</p>
<b>Step 6</b>	<p><b>commit</b></p> <p><b>Example:</b></p> <pre>Router(config)# commit</pre>	<p>Use the <b>commit</b> command to save the configuration changes to the running configuration file and remain within the configuration session.</p>
<b>Step 7</b>	<p><b>show running-config key chain</b> <i>keychain name</i></p> <p><b>Example:</b></p> <pre>Router# show running-config key chain kcl key chain kcl  macsec   key 1111   key-string password6  5d63525a58594657565e6845446842465965554862424c5  95d696554694a424c59655f504a575e6648484c484b4646 535d49675e535a60644e6045654a655f666858414142 cryptographic-algorithm aes-128-cmac lifetime 00:00:00 january 01 2017 infinite  ! ! !</pre>	<p>[Optional] Displays the Type 6 encrypted key string.</p>

### Example

## 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
```

**Note** We recommend to change the offset value of the **conf-offset** *<offset\_value>* command (MACsec encryption command) in Cisco NCS 5500 fixed port routers only when the port is in **admin down** state (that is, when the interface is shut down). Changing the offset value otherwise may result in traffic loss.

**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 4: MACsec Security Policies**

MKA		Secured MKA Session	Unsecured MKA Session
Security Policy	Must-secure	Encrypted traffic	Traffic drop (no Tx and no Rx)
	Should-secure	Encrypted traffic	Plain text or unencrypted traffic

**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 mpl
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       : mpl
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-XPB-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.
- 

## MACsec SAK Rekey Interval

From Cisco IOS XR Software Release 6.3.3 and later, you can set a timer value to rekey the MACsec secure association key (SAK) at a specified interval. This periodic refresh of SAK ensures that data encryption key is frequently updated. The configuration is effective on the node acting as a key server.

To set the rekey interval, use the **sak-rekey-interval** command in macsec-policy configuration mode. The timer ranges from 60 to 2,592,000 seconds, the default being OFF.



### Configuration Example

```
Router#configure
Router(config)#macsec-policy test-policy
Router(config-macsec-policy)#sak-rekey-interval 120
Router(config-macsec-policy)#commit
```

### Running Configuration

```
macsec-policy test-policy
  sak-rekey-interval 120
!
```

### Associated Command

sak-rekey-interval

## 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.

### Before you begin



---

**Note** Under the IS-IS instance, use the **lsp-mtu** command to configure the maximum transmission unit (MTU) size of link-state packets (LSPs) on each router where MACsec is enabled. The LSP MTU should be set to 32 bytes less than the interface MTU, to account for MACsec overhead.

---

### 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:**

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

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
```

## MACsec Policy Exceptions

By default, the MACsec security policy uses **must-secure** option, that mandates data encryption. Hence, the packets cannot be sent in clear-text format. To optionally bypass the MACsec encryption or decryption for Link Aggregation Control Protocol (LACP) packets, and to send the packets in clear-text format, use the **policy-exception lACP-in-clear** command in macsec-policy configuration mode. This functionality is beneficial in scenarios such as, in a network topology with three nodes, where bundles are terminated at the middle node, whereas MACsec is terminated at the end nodes.

This MACsec policy exception is also beneficial in interoperability scenarios where the node at the other end expects the data packets to be in clear text.

## How to Create MACsec Policy Exception

### Configuration Example

Using the **policy-exception** command:

```
Router#configure
Router(config)#macsec-policy test-macsec-policy
Router(config-macsec-policy)#policy-exception lacp-in-clear
Router(config-macsec-policy)#commit
```

### Running Configuration

With the **policy-exception** command:

```
Router#show run macsec-policy test-macsec-policy
macsec-policy test-macsec-policy
  policy-exception lacp-in-clear
  security-policy should-secure
  include-icv-indicator
  sak-rekey-interval seconds 120
!
```

### Associated Commands

- **policy-exception lacp-in-clear**

## 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-XP  0             64      30
            N-256
```

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
```

```
=====
Interface   Status   Cipher Suite   KeyChain
=====
Fo0/0/0/1/0 Secured  GCM-AES-XP-256 mac_chain
```

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

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

```
=====
Interface      Local-TxSCI      # Peers      Status      Key-Server
=====
Fo0/0/0/1/0    d46d.5023.3709/0001    1            Secured      YES
```

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**.

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: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          : 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)

```

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:router#show macsec mka session
```

```
NODE: node0_0_CPU0
```

```
=====
```



```

Local Tx-SCI                : 008a.96d6.194c/0001
Local Tx-SSCI              : 2
Interface MAC Address      : 008a.96d6.194c
MKA Port Identifier       : 1
Interface Name            : Hu0/2/0/11
CAK Name (CKN)           : 2111
CA Authentication Mode    : PRIMARY-PSK
Keychain                  : test1
Member Identifier (MI)    : 69B39E87B3CBA673401E9891
Message Number (MN)      : 352
Authenticator            : NO
Key Server                : YES
MKA Cipher Suite         : AES-128-CMAC
Configured MACSec Cipher Suite : GCM-AES-XPB-128
Key Distribution Mode     : SAK

Latest SAK Status        : Rx & Tx
Latest SAK AN           : 0
Latest SAK KI (KN)     : 69B39E87B3CBA673401E989100000001 (1)
Old SAK Status          : FIRST-SAK
Old SAK AN              : 0
Old SAK KI (KN)        : FIRST-SAK (0)

SAK Transmit Wait Time  : 0s (Not waiting for any peers to respond)
SAK Retire Time         : 0s (No Old SAK to retire)
Time to SAK Rekey       : 456s
Time to exit suspension : NA

MKA Policy Name         : P12
Key Server Priority     : 20
Delay Protection        : TRUE
Replay Window Size     : 100
Include ICV Indicator   : TRUE
Confidentiality Offset  : 0
Algorithm Agility      : 80C201
SAK Cipher Suite       : 0080C20001000003 (GCM-AES-XPB-128)
MACsec Capability      : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired         : YES

# of MACsec Capable Live Peers      : 1
# of MACsec Capable Live Peers Responded : 1

# of MACSec Suspended Peers         : 0

Live Peer List:
-----
      MI                MN                Rx-SCI                SSCI  KS-Priority
-----
42A78BD6243539E917B8C6B2    290    7061.7bea.1df4/0001    1        20

Potential Peer List:
-----
      MI                MN                Rx-SCI                SSCI  KS-Priority
-----

Suspended Peer List:
-----
      Rx-SCI                SSCI
-----

Peers Status:
Last Tx MKPDU      : 2021 May 18 13:23:29.588
Peer Count         : 1

```

```

RxSCI           : 70617BEA1DF40001
MI              : 42A78BD6243539E917B8C6B2
Peer CAK        : Match
Latest Rx MKPDU : 2021 May 18 13:23:29.847

```

## MKA Detailed Status for MKA Session

=====

**Status: Active** - Marked Peer as Live (Waiting for SAK generation/distribution)

```

Local Tx-SCI           : 008a.96d6.194c/0001
Local Tx-SSCI          : 2
Interface MAC Address   : 008a.96d6.194c
MKA Port Identifier     : 1
Interface Name          : Hu0/2/0/11
CAK Name (CKN)         : 2000
CA Authentication Mode  : FALLBACK-PSK
Keychain                : test1f
Member Identifier (MI)  : 8F59AD6021FA3E2D5F9E6231
Message Number (MN)    : 350
Authenticator          : NO
Key Server              : YES
MKA Cipher Suite       : AES-128-CMAC
Configured MACSec Cipher Suite : GCM-AES-XPN-128
Key Distribution Mode   : SAK

Latest SAK Status      : Rx & Tx
Latest SAK AN          : 0
Latest SAK KI (KN)    : 69B39E87B3CBA673401E989100000001 (1)
Old SAK Status         : FIRST-SAK
Old SAK AN             : 0
Old SAK KI (KN)       : FIRST-SAK (0)

SAK Transmit Wait Time : 0s (Not waiting for any peers to respond)
SAK Retire Time        : 0s (No Old SAK to retire)
Time to SAK Rekey      : 456s
Time to exit suspension : NA

MKA Policy Name        : P12
Key Server Priority     : 20
Delay Protection        : TRUE
Replay Window Size     : 100
Include ICV Indicator  : TRUE
Confidentiality Offset : 0
Algorithm Agility      : 80C201
SAK Cipher Suite       : 0080C20001000003 (GCM-AES-XPN-128)
MACsec Capability      : 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired         : YES

# of MACsec Capable Live Peers      : 1
# of MACsec Capable Live Peers Responded : 0

# of MACSec Suspended Peers         : 0

```

## Live Peer List:

```

-----
MI              MN              Rx-SCI          SSCI  KS-Priority
-----
1BB9428C721F6EE3E538C942  288      7061.7bea.1df4/0001  1      20

```

## Potential Peer List:

```

-----
MI              MN              Rx-SCI          SSCI  KS-Priority
-----

```



Suspended Peer List:

```
-----
      Rx-SCI          SSCI
-----
```

Peers Status:

```
Last Tx MKPDU      : 2021 May 18 13:23:29.587
Peer Count         : 1
```

```
RxSCI              : 70617BEA1DF40001
MI                 : 1BB9428C721F6EE3E538C942
Peer CAK           : Match
Latest Rx MKPDU    : 2021 May 18 13:23:29.847
```

RP/0/RP0/CPU0:router#

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 Fo0/0/0/1/0
```

```

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-XPB-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
Rx SA Program Rsp[0]: 2015 Oct 09 15:20:53.092

Tx SC
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-XPB-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 **Reply 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:**

```

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

if_handle : 0x00003480
NPPort : 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 : 0x80000003 Match-All Rx Flow : 0x00000003
Bypass Tx SA : 0x80000000 Bypass Rx SA : 0x00000000
Tx SA[0] : 0x80020002 Tx Flow[0] : 0x8000000c
Tx SA[1] : 0xffffffff Tx Flow[1] : 0xffffffff
Tx SA[2] : 0xffffffff Tx Flow[2] : 0xffffffff
Tx SA[3] : 0xffffffff Tx Flow[3] : 0xffffffff
Rx SA[0] : 0x00020002 Rx Flow[0] : 0x0000000c
Rx SA[1] : 0xffffffff Rx Flow[1] : 0xffffffff
Rx SA[2] : 0xffffffff Rx Flow[2] : 0xffffffff
Rx SA[3] : 0xffffffff Rx Flow[3] : 0xffffffff

```

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

**Example:**

```
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 : f8d88dc3e1c5e6a94ca2299
```

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:**

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

MACsec HW Cfg Details:
Mode : 0x5
Counter Clear on Read : 0x0
SA Fail Mask : 0xffff
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 : 0xbfffffff8
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
  InOctetsDecrypted  : 7
  OutPktsUntagged    : 8
  OutPktsTooLong     : 9
  OutOctetsProtected : 10
  OutOctetsEncrypted : 11
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 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 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
RxSA 3:
  InPktsUnusedSA       : 62
  InPktsNotUsingSA     : 61
  InPktsNotValid       : 60
  InPktsInvalid        : 59
  InPktsOK             : 58
  NextPN               : 63

```




---

**Note** Ideally, while displaying the MACsec SecY statistics, the hardware does not account the MKPDUs (MACsec control plane packets) in the *InPktsNoTag* counter. Whereas, for NC55-MPA-12T-S MPA, the MKPDU packets are considered as untagged packets, and are accounted in the *InPktsNoTag* counter. Hence, unlike for other PIDs, the *InPktsNoTag* counter increments for incoming MKPDUs in addition to untagged packets, for both Should-Secure and Must-Secure policy modes.

---

## MACsec SNMP MIB (IEEE8021-SECY-MIB)

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 5: IEEE8021-SECY-MIB Table

Tables	OID
secyIfTable	1.0.8802.1.1.3.1.1.1
secyTxSCTable	1.0.8802.1.1.3.1.1.2
secyTxSatable	1.0.8802.1.1.3.1.1.3
secyRxSCTable	1.0.8802.1.1.3.1.1.4
secyRxSatable	1.0.8802.1.1.3.1.1.5
secyCipherSuiteTable	1.0.8802.1.1.3.1.1.6
secyTxSAStatsTable	1.0.8802.1.1.3.1.2.1
secyTxSCStatsTable	1.0.8802.1.1.3.1.2.2
secyRxSAStatsTable	1.0.8802.1.1.3.1.2.3
secyRxSCStatsTable	1.0.8802.1.1.3.1.2.4
secyStatsTable	1.0.8802.1.1.3.1.2.5

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

<http://www.ieee802.org/1/files/public/MIBs/IEEE8021-SECY-MIB-200601100000Z.txt>

## 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 6: secyIfTable

Object	Object identifier
secyIfInterfaceIndex	1.0.8802.1.1.3.1.1.1.1
secyIfMaxPeerSCs	1.0.8802.1.1.3.1.1.1.1.2
secyIfRxMaxKeys	1.0.8802.1.1.3.1.1.1.1.3
secyIfTxMaxKeys	1.0.8802.1.1.3.1.1.1.1.4
secyIfProtectFramesEnable	1.0.8802.1.1.3.1.1.1.1.5
secyIfValidateFrames	1.0.8802.1.1.3.1.1.1.1.6
secyIfReplayProtectEnable	1.0.8802.1.1.3.1.1.1.1.7
secyIfReplayProtectWindow	1.0.8802.1.1.3.1.1.1.1.8
secyIfCurrentCipherSuite	1.0.8802.1.1.3.1.1.1.1.9

Object	Object identifier
secyIfAdminPt2PtMAC	1.0.8802.1.1.3.1.1.1.1.10
secyIfOperPt2PtMAC	1.0.8802.1.1.3.1.1.1.1.11
secyIfIncludeSCIEnable	1.0.8802.1.1.3.1.1.1.1.12
secyIfUseESEnable	1.0.8802.1.1.3.1.1.1.1.13
secyIfUseSCBEnable	1.0.8802.1.1.3.1.1.1.1.14

## 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 7: secyTxSCTable**

Object	Object identifier
secyTxSCI	1.0.8802.1.1.3.1.1.2.1.1
secyTxSCState	1.0.8802.1.1.3.1.1.2.1.2
secyTxSCEncodingSA	1.0.8802.1.1.3.1.1.2.1.3
secyTxSCEncipheringSA	1.0.8802.1.1.3.1.1.2.1.4
secyTxSCCreatedTime	1.0.8802.1.1.3.1.1.2.1.5
secyTxSCStartedTime	1.0.8802.1.1.3.1.1.2.1.6
secyTxSCStoppedTime	1.0.8802.1.1.3.1.1.2.1.7

## 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 8: secyTxSatable**

Object	Object identifier
secyTxSA	1.0.8802.1.1.3.1.1.3.1.1
secyTxSAState	1.0.8802.1.1.3.1.1.3.1.2
secyTxSANextPN	1.0.8802.1.1.3.1.1.3.1.3
secyTxSAConfidentiality	1.0.8802.1.1.3.1.1.3.1.4
secyTxSASAKUnchanged	1.0.8802.1.1.3.1.1.3.1.5



Object	Object identifier
secyTxSACreatedTime	1.0.8802.1.1.3.1.1.3.1.6
secyTxSASharedTime	1.0.8802.1.1.3.1.1.3.1.7
secyTxSAShoppedTime	1.0.8802.1.1.3.1.1.3.1.8

## 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 9: secyRxSCTable**

Object	Object identifier
secyRxSCI	1.0.8802.1.1.3.1.1.4.1.1
secyRxSCState	1.0.8802.1.1.3.1.1.4.1.2
secyRxSCCurrentSA	1.0.8802.1.1.3.1.1.4.1.3
secyRxSCCreatedTime	1.0.8802.1.1.3.1.1.4.1.4
secyRxSCStartedTime	1.0.8802.1.1.3.1.1.4.1.5
secyRxSCStoppedTime	1.0.8802.1.1.3.1.1.4.1.6

## 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 10: secyRxSatable**

Object	Object identifier
secyRxSA	1.0.8802.1.1.3.1.1.5.1.1
secyRxSAState	1.0.8802.1.1.3.1.1.5.1.2
secyRxSANextPN	1.0.8802.1.1.3.1.1.5.1.3
secyRxSASAKUnchanged	1.0.8802.1.1.3.1.1.5.1.4
secyRxSACreatedTime	1.0.8802.1.1.3.1.1.5.1.5
secyRxSAStartedTime	1.0.8802.1.1.3.1.1.5.1.6
secyRxSAShoppedTime	1.0.8802.1.1.3.1.1.5.1.7

## 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 11: secyCipherSuiteTable**

Object	Object identifier
secyCipherSuiteIndex	1.0.8802.1.1.3.1.1.6.1.1
secyCipherSuiteId	1.0.8802.1.1.3.1.1.6.1.2
secyCipherSuiteName	1.0.8802.1.1.3.1.1.6.1.3
secyCipherSuiteCapability	1.0.8802.1.1.3.1.1.6.1.4
secyCipherSuiteProtection	1.0.8802.1.1.3.1.1.6.1.5
secyCipherSuiteProtectionOffset	1.0.8802.1.1.3.1.1.6.1.6
secyCipherSuiteDataLengthChange	1.0.8802.1.1.3.1.1.6.1.7
secyCipherSuiteICVLength	1.0.8802.1.1.3.1.1.6.1.8
secyCipherSuiteRowStatus	1.0.8802.1.1.3.1.1.6.1.9

## secyTxSAStatsTable

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

**Table 12: secyTxSAStatsTable**

Object	Object identifier
secyTxSAStatsProtectedPkts	1.0.8802.1.1.3.1.2.1.1.1
secyTxSAStatsEncryptedPkts	1.0.8802.1.1.3.1.2.1.1.2
secyTxSCStatsProtectedPkts	1.0.8802.1.1.3.1.2.2.1.1
secyTxSCStatsEncryptedPkts	1.0.8802.1.1.3.1.2.2.1.4
secyTxSCStatsOctetsProtected	1.0.8802.1.1.3.1.2.2.1.10
secyTxSCStatsOctetsEncrypted	1.0.8802.1.1.3.1.2.2.1.11

## secyTxSCStatsTable

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

Table 13: secyTxSCStatsTable

Object	Object identifier
secyTxSCStatsProtectedPkts	1.0.8802.1.1.3.1.2.2.1.1
secyTxSCStatsEncryptedPkts	1.0.8802.1.1.3.1.2.2.1.4
secyTxSCStatsOctetsProtected	1.0.8802.1.1.3.1.2.2.1.10
secyTxSCStatsOctetsEncrypted	1.0.8802.1.1.3.1.2.2.1.11

## secyRxSASStatsTable

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

Table 14: secyRxSASStatsTable

Object	Object identifier
secyRxSASStatsUnusedSAPkts	1.0.8802.1.1.3.1.2.3.1.1
secyRxSASStatsNoUsingSAPkts	1.0.8802.1.1.3.1.2.3.1.4
secyRxSASStatsNotValidPkts	1.0.8802.1.1.3.1.2.3.1.13
secyRxSASStatsInvalidPkts	1.0.8802.1.1.3.1.2.3.1.16
secyRxSASStatsOKPkts	1.0.8802.1.1.3.1.2.3.1.25

## secyRxSCStatsTable

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

Table 15: secyRxSCStatsTable

Object	Object identifier
secyRxSCStatsUnusedSAPkts	1.0.8802.1.1.3.1.2.4.1.1
secyRxSCStatsNoUsingSAPkts	1.0.8802.1.1.3.1.2.4.1.2
secyRxSCStatsLatePkts	1.0.8802.1.1.3.1.2.4.1.3
secyRxSCStatsNotValidPkts	1.0.8802.1.1.3.1.2.4.1.4
secyRxSCStatsInvalidPkts	1.0.8802.1.1.3.1.2.4.1.5
secyRxSCStatsDelayedPkts	1.0.8802.1.1.3.1.2.4.1.6
secyRxSCStatsUncheckedPkts	1.0.8802.1.1.3.1.2.4.1.7
secyRxSCStatsOKPkts	1.0.8802.1.1.3.1.2.4.1.8
secyRxSCStatsOctetsValidated	1.0.8802.1.1.3.1.2.4.1.9

Object	Object identifier
secyRxSCStatsOctetsDecrypted	1.0.8802.1.1.3.1.2.4.1.10

## secyStatsTable

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

**Table 16: secyStatsTable**

Object	Object identifier
secyStatsTxUntaggedPkts	1.0.8802.1.1.3.1.2.5.1.1
secyStatsTxTooLongPkts	1.0.8802.1.1.3.1.2.5.1.2
secyStatsRxUntaggedPkts	1.0.8802.1.1.3.1.2.5.1.3
secyStatsRxNoTagPkts	1.0.8802.1.1.3.1.2.5.1.4
secyStatsRxBadTagPkts	1.0.8802.1.1.3.1.2.5.1.5
secyStatsRxUnknownSCIPkts	1.0.8802.1.1.3.1.2.5.1.6
secyStatsRxNoSCIPkts	1.0.8802.1.1.3.1.2.5.1.7
secyStatsRxOverrunPkts	1.0.8802.1.1.3.1.2.5.1.8

## 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]

```
rtr1.0/1/CPU0/ $ snmpwalk -v2c -c public 10.0.0.1 1.3.6.1.2.1.31.1.1.1.1
SNMPv2-SMI::mib-2.31.1.1.1.1.3 = STRING: "GigabitEthernet0/1/0/0"
SNMPv2-SMI::mib-2.31.1.1.1.1.18 = STRING: "MACSecControlled0/1/0/0"
SNMPv2-SMI::mib-2.31.1.1.1.1.19 = STRING: "MACSecUncontrolled0/1/0/0"
```

- **show snmp interface** command

```
Router#show snmp interface
ifName : GigabitEthernet0/1/0/0 ifIndex : 3
ifName : MACSecControlled0/1/0/0 ifIndex : 18
ifName : MACSecUncontrolled0/1/0/0 ifIndex : 19
```

## 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.

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

## 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
```



### Warning

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
```

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

## Syslog Messages for MACsec Shutdown

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

```
%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
%L2-MKA-5-SESSION_START             : (Hu0/3/0/8) MKA session started
CKN                                 : 123456
%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
```



## CHAPTER 7

# Implementing URPF

---

This section describes the implementation of URPF.

- [Understanding URPF, on page 131](#)
- [Configuring URPF Loose Mode, on page 131](#)

## 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.

---



**Note** The **hw-module fib ipv4 scale internet-optimized** command and **hw-module fib ipv6 scale internet-optimized** command are deprecated from Cisco IOS XR Software Release 7.3.1 and Release 7.4.1, respectively. Hence, if you are upgrading a router (where these configurations are already existing) to Release 7.3.1 or Release 7.4.1 or later, you might see a corresponding warning message stating so.



**Note** Line cards must be reloaded after disabling the default scale. This is done to ensure that the **hw-module** command configuration takes immediate effect.



**Note** On NCS55Ax systems with external TCAM (eTCAM), 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.





## CHAPTER 8

# 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 135](#)

## Implementing Management Plane Protection

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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.

## 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. Use the **commit** or **end** command.
9. **show mgmt-plane** [**inband** | **out-of-band**] [**interface** {*type instance*}]

## DETAILED STEPS

### Step 1 **configure**

**Example:**

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

Enters global configuration mode.

### Step 2 **control-plane**

**Example:**

```
RP/0/RP0/CPU0:router(config)# control-plane  
RP/0/RP0/CPU0:router(config-ctrl)#
```

Enters control plane configuration mode.

### 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 **inband**

**Example:**

```
RP/0/RP0/CPU0:router(config-mpp)# inband  
RP/0/RP0/CPU0:router(config-mpp-inband)#
```

Configures an inband interface and enters management plane protection inband configuration mode.

**Step 5** `interface {type instance | all}`**Example:**

```
RP/0/RP0/CPU0:router(config-mpp-inband)# interface HundredGigE 0/6/0/1
RP/0/RP0/CPU0:router(config-mpp-inband-Gi0_6_0_1)#
```

Configures a specific inband interface, or all inband interfaces. Use the **interface** command to enter management plane protection inband interface configuration mode.

- Use the **all** keyword to configure all interfaces.

**Step 6** `allow {protocol | all} [peer]`**Example:**

```
RP/0/RP0/CPU0:router(config-mpp-inband-Gi0_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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 9** **show mgmt-plane [inband | out-of-band] [interface {type instance}]**

**Example:**

```
RP/0/RP0/CPU0:router# show mgmt-plane inband interface HundredGigE 0/6/0/1
```

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.

---

## 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. Use the **commit** or **end** command.
10. **show mgmt-plane** [**inband** | **out-of-band**] [**interface** *{type instance}* | **vrf**]

## DETAILED STEPS

---

### Step 1 **configure**

#### Example:

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

Enters global configuration mode.

### Step 2 **control-plane**

#### Example:

```
RP/0/RP0/CPU0:router(config)# control-plane
RP/0/RP0/CPU0:router(config-ctrl)#
```

Enters control plane configuration mode.

### 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**]

**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** Use the **commit** or **end** command.

**commit**—Saves the configuration changes and remains within the configuration session.

**end**—Prompts user to take one of these actions:

- **Yes**—Saves configuration changes and exits the configuration session.
- **No**—Exits the configuration session without committing the configuration changes.
- **Cancel**—Remains in the configuration session, without committing the configuration changes.

**Step 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.



## CHAPTER 9

# Traffic Protection for Third-Party Applications

Traffic Protection for Third-Party Applications provides a mechanism for securing management traffic on the router. Without Traffic Protection 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.



**Note** Prior to Cisco IOS XR Release 6.5.2, Traffic Protection for Third-Party Applications was termed as MPP for Third-Party Applications.

Traffic Protection for Third-Party Applications helps in rate limiting or throttling the traffic through configuration with the help of LPTS. Traffic Protection 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, and vrf, as well as at least one of interface or local or remote address.

- [gRPC Protocol, on page 145](#)
- [Limitations for Traffic Protection for Third-Party Applications, on page 146](#)
- [Prerequisites for Traffic Protection for Third-Party Applications Over GRPC, on page 146](#)
- [Configuring Traffic Protection for Third-Party Applications, on page 146](#)
- [Troubleshooting Traffic Protection for Third-Party Applications, on page 147](#)

## 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.

**Note**

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 Traffic Protection for Third-Party Applications

The following limitations are applicable for the Traffic Protection for Third-Party Applications:

- If the TPA entry is configured with only the active RP management interface and redundancy switchover is performed, the gRPC connection fails.

## 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 Traffic Protection for Third-Party Applications

The following task shows how to configure traffic protection for third-party applications

```
RP/0/0/CPU0:ios#configure
RP/0/0/CPU0:ios(config)#tpa
RP/0/0/CPU0:ios(config-tpa)#vrf default
RP/0/0/CPU0:ios(config-tpa-vrf)#address-family ipv4
RP/0/0/CPU0:ios(config-tpa-vrf-afi)#protection
```

```
RP/0/0/CPU0:ios(config-tpa-vrf-afi-prot)#allow protocol tcp local-port port-number
remote-address IP remote address interface interface-name local-address IP local address
```

### Running Configuration

```
Router# show running-config
tpa
vrf default
address-family ipv4
protection
allow protocol tcp local-port 57600 remote-address 10.0.0.2/32 local-address 192.168.0.1/32
allow protocol tcp local-port 57600 remote-address 10.0.1.0/24 local-address 192.168.0.1/32
allow protocol tcp local-port 57600 remote-address 10.0.2.0/24 local-address 192.168.0.1/32
address-family ipv6
protection
allow protocol tcp local-port 57600 remote-address 2001:DB8::1/128 local-address
2001:DB8:0:ABCD::1/128
allow protocol tcp local-port 57600 remote-address 2001:DB8::2/128 local-address
2001:DB8:0:ABCD::1/128
allow protocol tcp local-port 57600 remote-address 2001:DB8::3/128 local-address
2001:DB8:0:ABCD::1/128
!
!
!
!
```

## Troubleshooting Traffic Protection for Third-Party Applications

The following show command output verifies whether TPA is configured or not.

```
Router# show running-config grpc

grpc
no-tls
!
```

The following show command output displays the TPA configuration.

```
Router# show running-config tpa

tpa
vrf default
address-family ipv4
allow local-port 57600 protocol tcp inter mgmtEth 0/RP0/CPU0/0 local-address
192.168.0.1/32 remote-address 10.0.0.2/32
!
```

### gRPC Configuration without TPA

```
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/CPU0 TPA LR IPV4 TCP default any any,57600 any
```

### gRPC Configuration with 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
```

Owner	AF	Proto	State	Interface	VRF	Local ip,port	>	Remote ip,port
Client	2	6	Prog		default	192.168.0.1/32,57600	>	10.0.0.2/32,0
Linux	2	6	Ovr		global-vrf	any,57600	>	any,0

```
Router# show lpts bindings brief | include TPA
```

```
0/RP0/CPU0 TPA LR IPV4 TCP default Mg0/RP0/CPU0/0 192.168.0.1,57600 10.0.0.2
```

```
Router#
```

```
Router# 0/RP0/ADMIN0:Mar 19 15:22:26.837 IST: pm[2433]:
```

```
%INFRA-Process_Manager-3-PROCESS_RESTART : Process tams (IID: 0) restarted
```





# CHAPTER 10

## 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 **rexec** 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.



**Note** Any reference to CiscoSSH in this chapter implies OpenSSH-based implementation of SSH that is available on this platform from Cisco IOS XR Software Release 7.3.2 and later. CiscoSSH replaces Cisco IOS XR SSH, which is the older SSH implementation that existed prior to this release.

For more information, see the *CiscoSSH* section later in this chapter.

### Feature History for Implementing Secure Shell

Release	Modification
Release 6.0	This feature was introduced.

- [Information About Implementing Secure Shell, on page 149](#)
- [Prerequisites for Implementing Secure Shell, on page 154](#)
- [Restrictions for Implementing Secure Shell, on page 154](#)
- [Configure SSH, on page 155](#)
- [Configure SSH Client, on page 158](#)
- [Multi-channeling in SSH, on page 160](#)

## 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:router#configure
RP/0/5/CPU0:router(config)#ssh ?
  client  Provide SSH client service
  server  Provide SSH server service
  timeout Set timeout value for SSH
RP/0/5/CPU0:router(config)#ssh client ?
```

- **Knownhost**—Enable the host pubkey check by local database.
- **Source-interface**—Source interface for SSH client sessions.

```
RP/0/5/CPU0:router(config)#ssh client source-interface ?
ATM                ATM Network Interface(s)
BVI                Bridge-Group Virtual Interface
Bundle-Ether       Aggregated Ethernet interface(s)
CEM                Circuit Emulation interface(s)
GigabitEthernet    GigabitEthernet/IEEE 802.3 interface(s)
IMA                ATM Network Interface(s)
IMtestmain         IM Test Interface
Loopback           Loopback interface(s)
MgmtEth            Ethernet/IEEE 802.3 interface(s)
Multilink          Multilink network interface(s)
Null               Null interface
PFItestmain        PFI Test Interface
PFItestnothw       PFI Test Not-HW Interface
PW-Ether           PWHE Ethernet Interface
PW-IW              PWHE VC11 IP Interworking Interface
Serial             Serial network interface(s)
VASILeft           VASI Left interface(s)
VASIRight          VASI Right interface(s)
test-bundle-channel Aggregated Test Bundle interface(s)
```

```

tunnel-ipsec      IPSec Tunnel interface(s)
tunnel-mte        MPLS Traffic Engineering P2MP Tunnel interface(s)
tunnel-te         MPLS Traffic Engineering Tunnel interface(s)
tunnel-tp         MPLS Transport Protocol Tunnel interface
RP/0/5/CPU0:router(config)#ssh client source-interface
RP/0/5/CPU0:router(config)#

```

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
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) formats for it to be imported correctly into the router.



---

**Note** 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.

---

## 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 sftp 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 not supported, and the software generates a warning message in this case.
- Password messages of “none” are unsupported on the SSH client.
- Files created on the local device lose the original permission information because the router infrastructure does not provide support for UNIX-like file permissions. 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.



**Note** For SSHv1 configuration, Step 1 to Step 4 are required. For SSHv2 configuration, Step 4 to Step 6 are optional.

### SUMMARY STEPS

1. **configure**
2. **hostname** *hostname*
3. **domain name** *domain-name*
4. Use the **commit** or **end** command.
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. Use the **commit** or **end** command.
11. **show ssh**
12. **show ssh session details**

### DETAILED STEPS

**Step 1** **configure**

**Example:**

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

Enters global configuration mode.

**Step 2** **hostname** *hostname*

**Example:**

```
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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 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 terminated.
- 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** Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

**Step 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. Use the **commit** or **end** command.
4. **ssh** {*ipv4-address* | *ipv6-address* | *hostname*} [ **username** *user-* **cipher** | **source-interface** *type instance*]

## DETAILED STEPS

### Step 1 **configure**

#### Example:

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

Enters global configuration mode.

### 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 Use the **commit** or **end** command.

**commit** —Saves the configuration changes and remains within the configuration session.

**end** —Prompts user to take one of these actions:

- **Yes** — Saves configuration changes and exits the configuration session.
- **No** —Exits the configuration session without committing the configuration changes.
- **Cancel** —Remains in the configuration session, without committing the configuration changes.

### Step 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.

```
configure
hostname router1
```

```
domain name cisco.com
exit
crypto key generate rsa/dsa
configure
ssh server
end
```

## Multi-channeling in SSH

The multi-channeling (also called multiplexing) feature on the Cisco IOS XR software server allows you to establish multiple channels over the same TCP connection. Thus, rather than opening a new TCP socket for each SSH connection, all the SSH connections are multiplexed into one TCP connection. For example, with multiplexing support on your XR software server, on a single SSH connection you can simultaneously open a pseudo terminal, remotely execute a command and transfer a file using any file transfer protocol. Multiplexing offers the following benefits:

- You are required to authenticate only once at the time of creating the session. After that, all the SSH clients associated with a particular session use the same TCP socket to communicate to the server.
- Saves time consumed otherwise wasted in creating a new connection each time.

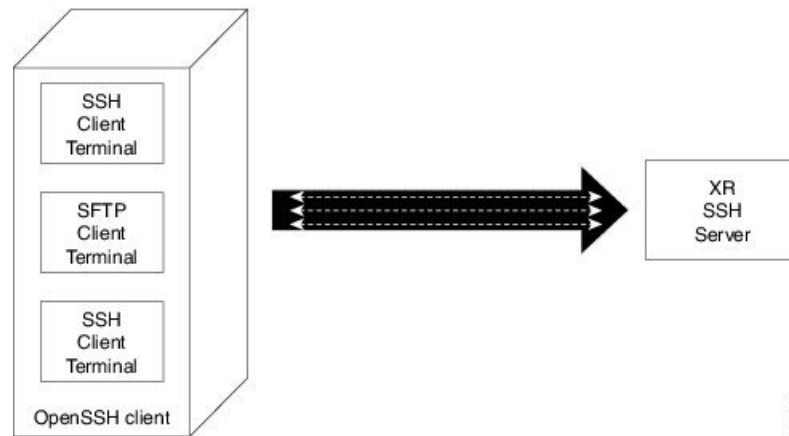
Multiplexing is enabled by default in the Cisco IOS XR software server. If your client supports multiplexing, you must explicitly set up multiplexing on the client for it to be able to send multi-channel requests to the server. You can use OpenSSH, Putty, Perl, WinSCP, Putty, FileZilla, TTSSH, Cygwin or any other SSH-based tool to set up multiplexing on the client. [Configure Client for Multiplexing, on page 161](#) provides an example of how you can configure the client for multiplexing using OpenSSH.

### Restrictions for Multi-channeling Over SSH

- Do not use client multiplexing for heavy transfer of data as the data transfer speed is limited by the TCP speed limit. Hence, for a heavy data transfer it is advised that you run multiple SSH sessions, as the TCP speed limit is per connection.
- Client multiplexing must not be used for more than 15 concurrent channels per session simultaneously.
- You must ensure that the first channel created at the time of establishing the session is always kept alive in order for other channels to remain open.
- The **line template default session-limit** command is not supported for SSH.

### Client and Server Interaction Over Multichannel Connection

The following figure provides an illustration of a client-server interaction over a SSH multichannel connection.



As depicted in the illustration,

- The client multiplexes the collection of channels into a single connection. This allows different operations to be performed on different channels simultaneously. The dotted lines indicate the different channels that are open for a single session.
- After receiving a request from the client to open up a channel, the server processes the request. Each request to open up a channel represents the processing of a single service.



**Note** The Cisco IOS XR software supports server-side multiplexing only.

## Configure Client for Multiplexing

The SSH client opens up one TCP socket for all the connections. In order to do so, the client multiplexes all the connections into one TCP connection. Authentication happens only once at the time of creating the session. After that, all the SSH clients associated with the particular session uses the same TCP socket to communicate to the server. Use the following steps to configure client multiplexing using OpenSSH:

1. Edit the `ssh_config` file.

Open the `ssh_config` file with your favorite text editor to configure values for session multiplexing. The system-wide SSH configuration file is located under `/etc/ssh/ssh_config`. The user configuration file is located under `~/.ssh/config` or `$HOME/.ssh/config`.

2. Add entries **ControlMaster auto** and **ControlPath**

Add the entry `ControlMaster auto` and `ControlPath` to the `ssh_config` file, save it and exit.

- `ControlMaster` determines whether SSH will listen for control connections and what to do about them. Setting the `ControlMaster` to 'auto' creates a primary session automatically but if there is a primary session already available, subsequent sessions are automatically multiplexed.
- `ControlPath` is the location for the control socket used by the multiplexed sessions. Specifying the `ControlPath` ensures that any time a connection to a particular server uses the same specified primary connection.

Example:

```
Host *
ControlMaster auto
ControlPath ~/.ssh/tmp/%r@%h:%p
```

**3.** Create a temporary folder.

Create a temporary directory inside the `/.ssh` folder for storing the control sockets.



## CHAPTER 11

# 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 167](#) section.

- [Information About Lawful Intercept Implementation, on page 163](#)
- [Prerequisites for Implementing Lawful Intercept, on page 164](#)
- [Restrictions for Implementing Lawful Intercept, on page 164](#)
- [Lawful Intercept Topology, on page 166](#)
- [Benefits of Lawful Intercept, on page 166](#)
- [Installing Lawful Intercept \(LI\) Package, on page 167](#)
- [How to Configure SNMPv3 Access for Lawful Intercept, on page 168](#)
- [Additional Information on Lawful Intercept, on page 169](#)

## 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

- IPv4 user datagram protocol (UDP) encapsulation to the MD
- Replication and forwarding of intercepted packets to the MD
- Supports the NCS55-36x100 and NCS55-18H18F line cards

## 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.  
In Cisco IOS XR Release 6.5.x and later, QoS peering is not required.
- 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



- 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



---

**Note** You might experience interface or protocol flaps while uninstalling or deactivating the LI RPM. Hence, we recommend you to perform this activity during a maintenance window.

---

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
```




---

**Note** 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.




---

**Note** 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.

```
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-ctr)# exit
router(config)# exit
router# show mgmt-plane inband interface loopback0
Management Plane Protection - inband interface
interface - Loopback0
    snmp configured -
All peers allowed
router(config)# commit
```

## 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 support 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.



---

**Note** 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.



---

**Note** 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.

---