



Cisco Nexus 3000 Series NX-OS Security Configuration Guide, Release 6.x

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CHAPTER 1

New and Changed Information

This chapter contains the following sections:

- [New and Changed Information, on page 1](#)

New and Changed Information

The following table provides an overview of the significant changes to this guide for this current release. The table does not provide an exhaustive list of all changes made to the configuration guide or of the new features in this release.

Feature	Description	Added or Changed in Release	Where Documented
Secure Login Enhancements	You can now enhance the security of a router by configuring options to automatically block further login attempts during a possible denial-of-service (DoS) attack.	6.0(2)U6(7)	Secure Login Enhancements, on page 20
Redirect HTTP methods	You can now intercept and redirect the specific HTTP methods to a server connected to specific port.	6.0(2)U5(1)	Configuring ACL Using HTTP Methods to Redirect Requests, on page 149
LOU Thresholds	You can configure the LOU threshold to conserve the LOU registers and use TCAMs for expansions based on the threshold values.	6.0(2)U5(1)	Configuring the LOU Threshold, on page 154

New and Changed Information

Feature	Description	Added or Changed in Release	Where Documented
IP-in-IP Decapsulation Enabled	Cisco Nexus 3000 Series switch drops all the packets when feature tunnel is not configured and also when the tunnel is configured but the tunnel interface is not configured or the tunnel interface is in shut down state.	6.0(2)U5(1)	Guidelines and Limitations for CoPP, on page 220 CoPP Configuration Examples, on page 229
Egress RACLs on L3 Port Channels	Added the limitation that you cannot configure egress RACLs on L3 Port Channels.	6.0(2)U5(1)	Guidelines and Limitations for ACLs, on page 137
Source IP Address Configuration	You can now configure source IP addresses for RADIUS, TACACS, SSH, and Telnet	6.0(2)U4(1)	Configuring the SSH Source Interface, on page 66 Configuring the Telnet Source Interface, on page 73
CoPP	Added descriptions of static CoPP classes.	6.0(2)U4(1)	Static CoPP Classes, on page 216
Consistency Checker	The RACL consistency checker was introduced to compare the hardware and software configuration for consistency and display the results.	6.0(2)U2(1)	Triggering the RACL Consistency Checker, on page 148
ACL Logging	ACL logging allows you to monitor flows that hit specific access control lists.	6.0(2)U2(1)	Configuring Access Control Lists, on page 131
Support for DHCPv6 relay	The DHCPv6 relay agent forwards DHCPv6 configurations between source and destination ports.	6.0(2)U1(2)	Configuring DHCP Snooping, on page 163



CHAPTER 2

Overview

The Cisco NX-OS software supports security features that can protect your network against degradation or failure and also against data loss or compromise resulting from intentional attacks and from unintended but damaging mistakes by well-meaning network users.

- [Authentication, Authorization, and Accounting, on page 3](#)
- [RADIUS and TACACS+ Security Protocols, on page 4](#)
- [SSH and Telnet, on page 4](#)
- [IP ACLs, on page 5](#)

Authentication, Authorization, and Accounting

Authentication, authorization, and accounting (AAA) is an architectural framework for configuring a set of three independent security functions in a consistent, modular manner.

Authentication

Provides the method of identifying users, including login and password dialog, challenge and response, messaging support, and, depending on the security protocol that you select, encryption. Authentication is the way a user is identified prior to being allowed access to the network and network services. You configure AAA authentication by defining a named list of authentication methods and then applying that list to various interfaces.

Authorization

Provides the method for remote access control, including one-time authorization or authorization for each service, per-user account list and profile, user group support, and support of IP, IPX, ARA, and Telnet.

Remote security servers, such as RADIUS and TACACS+, authorize users for specific rights by associating attribute-value (AV) pairs, which define those rights, with the appropriate user. AAA authorization works by assembling a set of attributes that describe what the user is authorized to perform. These attributes are compared with the information contained in a database for a given user, and the result is returned to AAA to determine the user's actual capabilities and restrictions.

Accounting

Provides the method for collecting and sending security server information used for billing, auditing, and reporting, such as user identities, start and stop times, executed commands (such as PPP), number of packets, and number of bytes. Accounting enables you to track the services that users are accessing, as well as the amount of network resources that they are consuming.



Note You can configure authentication outside of AAA. However, you must configure AAA if you want to use RADIUS or TACACS+, or if you want to configure a backup authentication method.

Related Topics

[Configuring AAA](#)

RADIUS and TACACS+ Security Protocols

AAA uses security protocols to administer its security functions. If your router or access server is acting as a network access server, AAA is the means through which you establish communication between your network access server and your RADIUS or TACACS+ security server.

The chapters in this guide describe how to configure the following security server protocols:

RADIUS

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

TACACS+

A security application implemented through AAA that provides a centralized validation of users who are attempting to gain access to a router or network access server. TACACS+ services are maintained in a database on a TACACS+ daemon running, typically, on a UNIX or Windows NT workstation. TACACS+ provides for separate and modular authentication, authorization, and accounting facilities.

Related Topics

[Configuring RADIUS](#)

[Configuring TACACS+, on page 45](#)

SSH and Telnet

You can use the Secure Shell (SSH) server to enable an SSH client to make a secure, encrypted connection to a Cisco NX-OS device. SSH uses strong encryption for authentication. The SSH server in the Cisco NX-OS software can interoperate with publicly and commercially available SSH clients.

The SSH client in the Cisco NX-OS software works with publicly and commercially available SSH servers.

The Telnet protocol enables TCP/IP connections to a host. Telnet allows a user at one site to establish a TCP connection to a login server at another site and then passes the keystrokes from one device to the other. Telnet can accept either an IP address or a domain name as the remote device address.

Related Topics

[Configuring SSH and Telnet, on page 61](#)

IP ACLs

IP ACLs are ordered sets of rules that you can use to filter traffic based on IPv4 information in the Layer 3 header of packets. Each rule specifies a set of conditions that a packet must satisfy to match the rule. When the Cisco NX-OS software determines that an IP ACL applies to a packet, it tests the packet against the conditions of all rules. The first match determines whether a packet is permitted or denied, or if there is no match, the Cisco NX-OS software applies the applicable default rule. The Cisco NX-OS software continues processing packets that are permitted and drops packets that are denied.

Related Topics

[Configuring IP ACLs](#)



CHAPTER 3

Configuring Authentication, Authorization, and Accounting

This chapter contains the following sections:

- [Information About AAA, on page 7](#)
- [Prerequisites for Remote AAA, on page 11](#)
- [Guidelines and Limitations for AAA, on page 11](#)
- [Configuring AAA, on page 11](#)
- [Monitoring and Clearing the Local AAA Accounting Log , on page 24](#)
- [Verifying the AAA Configuration, on page 24](#)
- [Configuration Examples for AAA, on page 25](#)
- [Default AAA Settings, on page 25](#)

Information About AAA

AAA Security Services

The authentication, authorization, and accounting (AAA) features allows you to verify the identity of, grant access to, and track the actions of users who manage Cisco Nexus devices. The Cisco Nexus device supports Remote Access Dial-In User Service (RADIUS) or Terminal Access Controller Access Control device Plus (TACACS+) protocols.

Based on the user ID and password that you provide, the switches perform local authentication or authorization using the local database or remote authentication or authorization using one or more AAA servers. A preshared secret key provides security for communication between the switch and AAA servers. You can configure a common secret key for all AAA servers or for only a specific AAA server.

AAA security provides the following services:

- Authentication—Identifies users, including login and password dialog, challenge and response, messaging support, and, encryption depending on the security protocol that you select.
- Authorization—Provides access control.

Authorization to access a Cisco Nexus device is provided by attributes that are downloaded from AAA servers. Remote security servers, such as RADIUS and TACACS+, authorize users for specific rights by associating attribute-value (AV) pairs, which define those rights with the appropriate user.

Benefits of Using AAA

- Accounting—Provides the method for collecting information, logging the information locally, and sending the information to the AAA server for billing, auditing, and reporting.

**Note**

The Cisco NX-OS software supports authentication, authorization, and accounting independently. For example, you can configure authentication and authorization without configuring accounting.

Benefits of Using AAA

AAA provides the following benefits:

- Increased flexibility and control of access configuration
- Scalability
- Standardized authentication methods, such as RADIUS and TACACS+
- Multiple backup devices

Remote AAA Services

Remote AAA services provided through RADIUS and TACACS+ protocols have the following advantages over local AAA services:

- User password lists for each switch in the fabric are easier to manage.
- AAA servers are already deployed widely across enterprises and can be easily used for AAA services.
- The accounting log for all switches in the fabric can be centrally managed.
- User attributes for each switch in the fabric are easier to manage than using the local databases on the switches.

AAA Server Groups

You can specify remote AAA servers for authentication, authorization, and accounting using server groups. A server group is a set of remote AAA servers that implement the same AAA protocol. A server group provides for failover servers if a remote AAA server fails to respond. If the first remote server in the group fails to respond, the next remote server in the group is tried until one of the servers sends a response. If all the AAA servers in the server group fail to respond, that server group option is considered a failure. If required, you can specify multiple server groups. If a switch encounters errors from the servers in the first group, it tries the servers in the next server group.

AAA Service Configuration Options

On Cisco Nexus devices, you can have separate AAA configurations for the following services:

- User Telnet or Secure Shell (SSH) login authentication
- Console login authentication

- User management session accounting

The following table lists the CLI commands for each AAA service configuration option.

Table 1: AAA Service Configuration Commands

AAA Service Configuration Option	Related Command
Telnet or SSH login	aaa authentication login default
Console login	aaa authentication login console
User session accounting	aaa accounting default

You can specify the following authentication methods for the AAA services:

- RADIUS server groups—Uses the global pool of RADIUS servers for authentication.
- Specified server groups—Uses specified RADIUS or TACACS+ server groups for authentication.
- Local—Uses the local username or password database for authentication.
- None—Uses only the username.



Note

If the method is for all RADIUS servers, instead of a specific server group, the Cisco Nexus devices choose the RADIUS server from the global pool of configured RADIUS servers in the order of configuration. Servers from this global pool are the servers that can be selectively configured in a RADIUS server group on the Cisco Nexus devices.

The following table describes the AAA authentication methods that you can configure for the AAA services.

Table 2: AAA Authentication Methods for AAA Services

AAA Service	AAA Methods
Console login authentication	Server groups, local, and none
User login authentication	Server groups, local, and none
User management session accounting	Server groups and local



Note

For console login authentication, user login authentication, and user management session accounting, the Cisco Nexus devices try each option in the order specified. The local option is the default method when other configured options fail.

Authentication and Authorization Process for User Logins

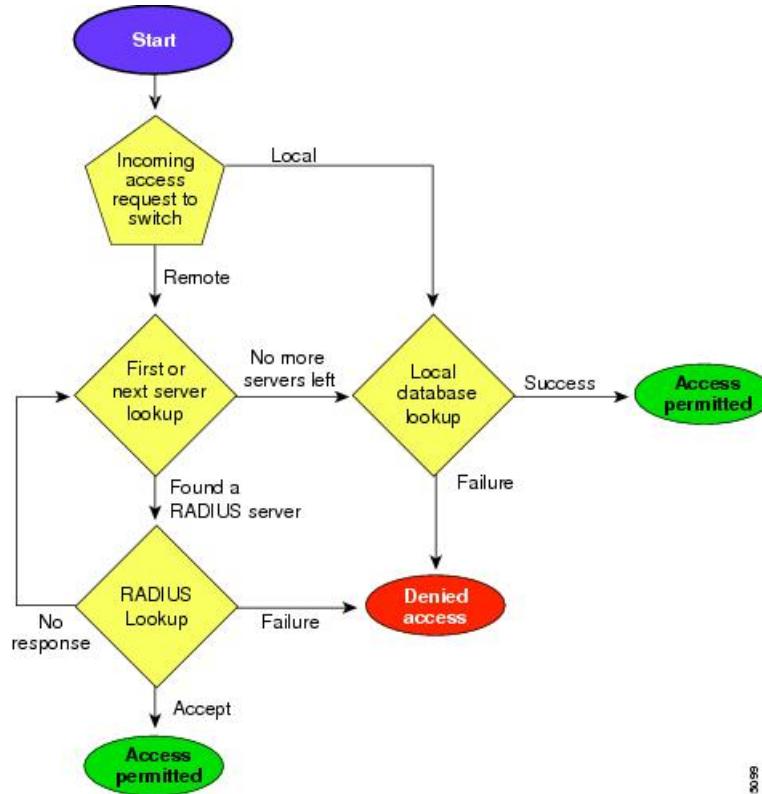
The authentication and authorization process for user login is as follows:

Authentication and Authorization Process for User Logins

- When you log in to the required Cisco Nexus device, you can use the Telnet, SSH, Fabric Manager or Device Manager, or console login options.
- When you have configured the AAA server groups using the server group authentication method, the Cisco Nexus device sends an authentication request to the first AAA server in the group as follows:
 - If the AAA server fails to respond, then the next AAA server is tried and so on until the remote server responds to the authentication request.
 - If all AAA servers in the server group fail to respond, the servers in the next server group are tried.
 - If all configured methods fail, the local database is used for authentication.
- If a Cisco Nexus device successfully authenticates you through a remote AAA server, the following conditions apply:
 - If the AAA server protocol is RADIUS, user roles specified in the cisco-av-pair attribute are downloaded with an authentication response.
 - If the AAA server protocol is TACACS+, another request is sent to the same server to get the user roles specified as custom attributes for the shell.
- If your username and password are successfully authenticated locally, the Cisco Nexus device logs you in and assigns you the roles configured in the local database.

The following figure shows a flowchart of the authentication and authorization process.

Figure 1: Authentication and Authorization Flow for User Login



In the figure, "No more servers left" means that there is no response from any server within this server group.

Prerequisites for Remote AAA

Remote AAA servers have the following prerequisites:

- At least one RADIUS or TACACS+ server must be IP reachable.
- The Cisco Nexus device is configured as a client of the AAA servers.
- The preshared secret key is configured on the Cisco Nexus device and on the remote AAA servers.
- The remote server responds to AAA requests from the Cisco Nexus device.

Guidelines and Limitations for AAA

The Cisco Nexus devices do not support all numeric usernames, whether created with TACACS+ or RADIUS, or created locally. If an all numeric username exists on an AAA server and is entered during a login, the Cisco Nexus device still logs in the user.



Caution You should not create user accounts with usernames that are all numeric.

Configuring AAA

Configuring Console Login Authentication Methods

The authentication methods include the following:

- Global pool of RADIUS servers
- Named subset of RADIUS or TACACS+ servers
- Local database on the Cisco Nexus device.
- Username only **none**

The default method is local.



Note The **group radius** and **group server-name** forms of the **aaa authentication** command are used for a set of previously defined RADIUS servers. Use the **radius server-host** command to configure the host servers. Use the **aaa group server radius** command to create a named group of servers.

Before you configure console login authentication methods, configure RADIUS or TACACS+ server groups as needed.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# aaa authentication login console {group group-list [none] local none}	<p>Configures login authentication methods for the console.</p> <p>The <i>group-list</i> argument consists of a space-delimited list of group names. The group names are the following:</p> <ul style="list-style-type: none"> • radius—Uses the global pool of RADIUS servers for authentication. • named-group—Uses a named subset of TACACS+ or RADIUS servers for authentication. <p>The local method uses the local database for authentication. The none method uses the username only.</p> <p>The default console login method is local, which is used when no methods are configured or when all of the configured methods fail to respond.</p>
Step 3	switch(config)# exit	Exits global configuration mode.
Step 4	(Optional) switch# show aaa authentication	Displays the configuration of the console login authentication methods.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

This example shows how to configure authentication methods for the console login:

```
switch# configure terminal
switch(config)# aaa authentication login console group radius
switch(config)# exit
switch# show aaa authentication
switch# copy running-config startup-config
```

Configuring Default Login Authentication Methods

The default method is local.

Before you configure default login authentication methods, configure RADIUS or TACACS+ server groups as needed.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# aaa authentication login default {group group-list [none] local none}	<p>Configures the default authentication methods. The <i>group-list</i> argument consists of a space-delimited list of group names. The group names are the following:</p> <ul style="list-style-type: none"> • radius—Uses the global pool of RADIUS servers for authentication. • named-group—Uses a named subset of TACACS+ or RADIUS servers for authentication. <p>The local method uses the local database for authentication. The none method uses the username only.</p> <p>The default login method is local, which is used when no methods are configured or when all of the configured methods do not respond.</p>
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show aaa authentication	Displays the configuration of the default login authentication methods.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Enabling Login Authentication Failure Messages

When you log in, the login is processed by the local user database if the remote AAA servers do not respond. If you have enabled the displaying of login failure messages, the following message is displayed:

```
Remote AAA servers unreachable; local authentication done.  
Remote AAA servers unreachable; local authentication failed.
```

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# aaa authentication login error-enable	Enables login authentication failure messages. The default is disabled.
Step 3	switch(config)# exit	Exits configuration mode.

Logging Successful and Failed Login Attempts

	Command or Action	Purpose
Step 4	(Optional) switch# show aaa authentication	Displays the login failure message configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Logging Successful and Failed Login Attempts

You can configure the switch to log all successful and failed login attempts to the configured syslog server.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal	Enters global configuration mode.
Step 2	Required: [no] login on-failure log Example: switch(config)# login on-failure log	Logs all failed authentication messages to the configured syslog server. With this configuration, the following syslog message appears after the failed login: AUTHPRIV-3-SYSTEM_MSG: pam_aaa:Authentication failed for user admin from 172.22.00.00 Note When logging level authpriv is 6, additional Linux kernel authentication messages appear along with the previous message. If these additional messages need to be ignored, the authpriv value should be set to 3.
Step 3	Required: [no] login on-success log Example: switch(config)# login on-success log	Logs all successful authentication messages to the configured syslog server. With this configuration, the following syslog message appears after the successful login: AUTHPRIV-6-SYSTEM_MSG: pam_aaa:Authentication success for user admin from 172.22.00.00 Note When logging level authpriv is 6, additional Linux kernel authentication messages appear along with the previous message.

	Command or Action	Purpose
Step 4	(Optional) show login on-failure log Example: switch(config)# show login on-failure log	Displays whether the switch is configured to log failed authentication messages to the syslog server.
Step 5	(Optional) show login on-successful log Example: switch(config)# show login on-successful log	Displays whether the switch is configured to log successful authentication messages to the syslog server.
Step 6	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring AAA Command Authorization

When a TACACS+ server authorization method is configured, you can authorize every command that a user executes with the TACACS+ server which includes all EXEC mode commands and all configuration mode commands.

The authorization methods include the following:

- Group—TACACS+ server group
- Local—Local role-based authorization
- None—No authorization is performed

The default method is Local.



Note There is no authorization on the console session.

Before you begin

You must enable TACACS+ before configuring AAA command authorization.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.

	Command or Action	Purpose
Step 2	<pre>aaa authorization {commands config-commands} {default} {[group group-name] [local]} {[group group-name] [none]}</pre> <p>Example:</p> <pre>switch(config)# aaa authorization config-commands default group tac1</pre> <p>Example:</p> <pre>switch# aaa authorization commands default group tac1</pre>	<p>Configures authorization parameters.</p> <p>Use the commands keyword to authorize EXEC mode commands.</p> <p>Use the config-commands keyword to authorize configuration mode commands.</p> <p>Use the group, local, or none keywords to identify the authorization method.</p>

Example

The following example shows how to authorize EXEC mode commands with TACACS+ server group *tac1*:

```
switch# aaa authorization commands default group tac1
```

The following example shows how to authorize configuration mode commands with TACACS+ server group *tac1*:

```
switch(config)# aaa authorization config-commands default group tac1
```

The following example shows how to authorize configuration mode commands with TACACS+ server group *tac1*:

- If the server is reachable, the command is allowed or not allowed based on the server response.
- If there is an error reaching the server, the command is authorized based on the user's *local* role.

```
switch(config)# aaa authorization config-commands default group tac1 local
```

The following example shows how to authorize configuration mode commands with TACACS+ server group *tac1*:

- If the server is reachable, the command is allowed or not allowed based on the server response.
- If there is an error reaching the server, allow the command regardless of the local role.

```
switch# aaa authorization commands default group tac1 none
```

The following example shows how to authorize EXEC mode commands regardless of the local role:

```
switch# aaa authorization commands default none
```

The following example shows how to authorize EXEC mode commands using the local role for authorization:

```
switch# aaa authorization commands default local
```

Enabling MSCHAP Authentication

Microsoft Challenge Handshake Authentication Protocol (MSCHAP) is the Microsoft version of CHAP. You can use MSCHAP for user logins to a Cisco Nexus device through a remote authentication server (RADIUS or TACACS+).

By default, the Cisco Nexus device uses Password Authentication Protocol (PAP) authentication between the switch and the remote server. If you enable MSCHAP, you must configure your RADIUS server to recognize the MSCHAP vendor-specific attributes (VSAs).

The following table describes the RADIUS VSAs required for MSCHAP.

Table 3: MSCHAP RADIUS VSAs

Vendor-ID Number	Vendor-Type Number	VSA	Description
311	11	MSCHAP-Challenge	Contains the challenge sent by an AAA server to an MSCHAP user. It can be used in both Access-Request and Access-Challenge packets.
211	11	MSCHAP-Response	Contains the response value provided by an MSCHAP user in response to the challenge. It is only used in Access-Request packets.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# aaa authentication login mschap enable	Enables MS-CHAP authentication. The default is disabled.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show aaa authentication login mschap	Displays the MS-CHAP configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Related Topics

[VSAs](#), on page 19

Configuring AAA Accounting Default Methods

The Cisco Nexus device supports TACACS+ and RADIUS methods for accounting. The switches report user activity to TACACS+ or RADIUS security servers in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the AAA server.

When you activate AAA accounting, the Cisco Nexus device reports these attributes as accounting records, which are then stored in an accounting log on the security server.

You can create default method lists defining specific accounting methods, which include the following:

- RADIUS server group—Uses the global pool of RADIUS servers for accounting.
- Specified server group—Uses a specified RADIUS or TACACS+ server group for accounting.
- Local—Uses the local username or password database for accounting.



Note If you have configured server groups and the server groups do not respond, by default, the local database is used for authentication.

Before you begin

Before you configure AAA accounting default methods, configure RADIUS or TACACS+ server groups as needed.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# aaa accounting default {group <i>group-list</i> local}	<p>Configures the default accounting method. One or more server group names can be specified in a space-separated list.</p> <p>The <i>group-list</i> argument consists of a space-delimited list of group names. The group names are the following:</p> <ul style="list-style-type: none"> • radius—Uses the global pool of RADIUS servers for accounting. • named-group—Uses a named subset of TACACS+ or RADIUS servers for accounting. <p>The local method uses the local database for accounting.</p> <p>The default method is local, which is used when no server groups are configured or when all the configured server group do not respond.</p>

	Command or Action	Purpose
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show aaa accounting	Displays the configuration AAA accounting default methods.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Using AAA Server VSAs

VSAs

You can use vendor-specific attributes (VSAs) to specify the Cisco Nexus device user roles and SNMPv3 parameters on AAA servers.

The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating VSAs between the network access server and the RADIUS server. The IETF uses attribute 26. VSAs allow vendors to support their own extended attributes that are not suitable for general use. The Cisco RADIUS implementation supports one vendor-specific option using the format recommended in the specification. The Cisco vendor ID is 9, and the supported option is vendor type 1, which is named cisco-av-pair. The value is a string with the following format:

```
protocol : attribute separator value *
```

The protocol is a Cisco attribute for a particular type of authorization, separator is an equal sign (=) for mandatory attributes, and an asterisk (*) indicates optional attributes.

When you use RADIUS servers for authentication on a Cisco Nexus device, the RADIUS protocol directs the RADIUS server to return user attributes, such as authorization information, with authentication results. This authorization information is specified through VSAs.

VSA Format

The following VSA protocol options are supported by the Cisco Nexus device:

- Shell—Used in access-accept packets to provide user profile information.
- Accounting—Used in accounting-request packets. If a value contains any white spaces, put it within double quotation marks.

The following attributes are supported by the Cisco Nexus device:

- roles—Lists all the roles assigned to the user. The value field is a string that stores the list of group names delimited by white space.
- accountinginfo—Stores additional accounting information in addition to the attributes covered by a standard RADIUS accounting protocol. This attribute is sent only in the VSA portion of the Account-Request frames from the RADIUS client on the switch, and it can only be used with the accounting protocol-related PDUs.

Specifying Switch User Roles and SNMPv3 Parameters on AAA Servers

You can use the VSA cisco-av-pair on AAA servers to specify user role mapping for the Cisco Nexus device using this format:

```
shell:roles="roleA roleB ..."
```

If you do not specify the role option in the cisco-av-pair attribute, the default user role is network-operator.



Note For information on Cisco Unified Wireless Network TACACS+ configurations and to change the user roles, see [Cisco Unified Wireless Network TACACS+ Configuration](#).

You can also specify your SNMPv3 authentication and privacy protocol attributes as follows:

```
shell:roles="roleA roleB..." snmpv3:auth=SHA priv=AES-128
```

The SNMPv3 authentication protocol options are SHA and MD5. The privacy protocol options are AES-128 and DES. If you do not specify these options in the cisco-av-pair attribute, MD5 and DES are the default authentication protocols.

For additional information, see the Configuring User Accounts and RBAC chapter in the System Management Configuration Guide for your Cisco Nexus device.

Secure Login Enhancements

Secure Login Enhancements

The following secure login enhancements are supported in Cisco NX-OS:

- Configuring Login Parameters
- Configuration Examples for Login Parameters
- Restricting Sessions Per User—Per User Per Login
- Enabling the Password Prompt for User Name
- Configuring Share Key Value for using RADIUS/TACACS+

Configuring Login Parameters

Use this task to configure your Cisco NX-OS device for login parameters that help detect suspected DoS attacks and slow down dictionary attacks.

All login parameters are disabled by default. You must enter the **login block-for** command, which enables default login functionality, before using any other login commands. After the **login block-for** command is enabled, the following default is enforced:

- All login attempts made through Telnet or SSH are denied during the quiet period; that is, no ACLs are exempt from the login period until the **login quiet-mode access-class** command is entered.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: Switch# configure terminal	Enters global configuration mode.
Step 2	[no] login block-for seconds attempts tries within seconds Example: Switch(config)# login block-for 100 attempts 2 within 100	Configures your Cisco NX-OS device for login parameters that help provide DoS detection. Note This command must be issued before any other login command can be used.
Step 3	[no] login quiet-mode access-class {acl-name acl-number} Example: Switch(config)# login quiet-mode access-class myacl	(Optional) Although this command is optional, it is recommended that it be configured to specify an ACL that is to be applied to the device when the device switches to quiet mode. When the device is in quiet mode, all login requests are denied and the only available connection is through the console.
Step 4	exit Example: Switch(config)# exit	Exits to privileged EXEC mode.
Step 5	show login failures Example: Switch# show login	Displays login parameters. • failures --Displays information related only to failed login attempts.

Configuration Examples for Login Parameters**Setting Login Parameters Example**

The following example shows how to configure your switch to enter a 100 second quiet period if 15 failed login attempts is exceeded within 100 seconds; all login requests are denied during the quiet period except hosts from the ACL "myacl."

```
Switch(config)# login block-for 100 attempts 15 within 100
Switch(config)# login quiet-mode access-class myacl
```

Showing Login Parameters Example

The following sample output from the **show login** command verifies that no login parameters have been specified:

Restricting Sessions Per User—Per User Per Login

```
Switch# show login

No Quiet-Mode access list has been configured, default ACL will be applied.

Switch is enabled to watch for login Attacks.
If more than 2 login failures occur in 45 seconds or less, logins will be disabled for 70
seconds.

Switch presently in Normal-Mode.
Current Watch Window remaining time 10 seconds.
Present login failure count 0.
```

The following sample output from the **show login failures** command shows all failed login attempts on the switch:

```
Switch# show login failures

Information about last 20 login failures with the device.
-----
Username           Line     Source          Appname
TimeStamp
-----
admin             pts/0    bgl-ads-728.cisco.com  login
                  Wed Jun 10 04:56:16 2015
admin             pts/0    bgl-ads-728.cisco.com  login
                  Wed Jun 10 04:56:19 2015
-----
```

The following sample output from the **show login failures** command verifies that no information is presently logged:

```
Switch# show login failures
*** No logged failed login attempts with the device.***
```

Restricting Sessions Per User—Per User Per Login

Use this task to restrict the maximum sessions per user.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: Switch# configure terminal	Enters global configuration mode.
Step 2	[no] user max-logins max-logins Example: Switch(config)# user max-logins 1	Restricts the maximum sessions per user. The range is from 1 to 7. If you set the maximum login limit as 1, then only one session (telnet/SSH) is allowed per user.
Step 3	exit Example:	Exits to privileged EXEC mode.

	Command or Action	Purpose
	Switch(config)# exit	

Enabling the Password Prompt for User Name

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: Switch# configure terminal	Enters global configuration mode.
Step 2	[no] password prompt username Example: Switch(config)# password prompt username	Enables the login knob. If this command is enabled and the user enters the username command without the password option, then the password is prompted. The password accepts hidden characters. Use the no form of this command to disable the login knob.
Step 3	exit Example: Switch(config)# exit	Exits to privileged EXEC mode.

Configuring Share Key Value for using RADIUS/TACACS+

The shared secret you configure for remote authentication and accounting must be hidden. For the **radius-server key** and **tacacs-server key** commands, a separate command to generate encrypted shared secret can be used.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: Switch# configure terminal	Enters global configuration mode.
Step 2	generate type7_encrypted_secret Example: Switch(config)# generate type7_encrypted_secret	Configures RADIUS and TACACS shared secret with key type 7. While generating an encrypted shared secret, user input is hidden. Note You can generate encrypted equivalent of plain text separately and can configure the encrypted shared secret later.

	Command or Action	Purpose
Step 3	exit Example: Switch(config)# exit	Exits to privileged EXEC mode.

Monitoring and Clearing the Local AAA Accounting Log

The Cisco Nexus device maintains a local log for the AAA accounting activity.

Procedure

	Command or Action	Purpose
Step 1	switch# show accounting log [size] [start-time year month day hh : mm : ss]	Displays the accounting log contents. By default, the command output contains up to 250,000 bytes of the accounting log. You can use the size argument to limit command output. The range is from 0 to 250000 bytes. You can also specify a start time for the log output.
Step 2	(Optional) switch# clear accounting log	Clears the accounting log contents.

Verifying the AAA Configuration

To display AAA configuration information, perform one of the following tasks:

Command	Purpose
show aaa accounting	Displays AAA accounting configuration.
show aaa authentication [login {error-enable mschap}]	Displays AAA authentication information.
show aaa authorization	Displays AAA authorization information.
show aaa groups	Displays the AAA server group configuration.
show login [failures]	Displays the login parameters. The failures option displays information related only to failed login attempts. Note The clear login failures command clears the login failures in the current watch period.
show login on-failure log	Displays whether the switch is configured to log failed authentication messages to the syslog server.

Command	Purpose
show login on-successful log	Displays whether the switch is configured to log successful authentication messages to the syslog server.
show running-config aaa [all]	Displays the AAA configuration in the running configuration.
show running-config aaa [all]	Displays the AAA configuration in the running configuration.
show running-config all i max-login	Displays the maximum number of login sessions allowed per user.
show startup-config aaa	Displays the AAA configuration in the startup configuration.
show userpassphrase {length max-length min-length}	Displays the minimum and maximum length of the user password.

Configuration Examples for AAA

The following example shows how to configure AAA:

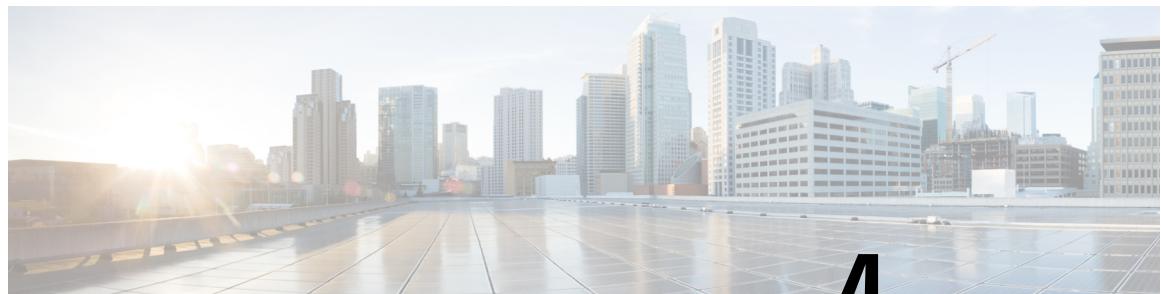
```
switch(config) # aaa authentication login default group radius
switch(config) # aaa authentication login console group radius
switch(config) # aaa accounting default group radius
```

Default AAA Settings

The following table lists the default settings for AAA parameters.

Table 4: Default AAA Parameters

Parameters	Default
Console authentication method	local
Default authentication method	local
Login authentication failure messages	Disabled
MSCHAP authentication	Disabled
Default accounting method	local
Accounting log display length	250 KB



CHAPTER 4

Configuring RADIUS

This chapter contains the following sections:

- [Information About RADIUS, on page 27](#)
- [Prerequisites for RADIUS, on page 30](#)
- [Guidelines and Limitations for RADIUS, on page 30](#)
- [Configuring RADIUS Servers, on page 30](#)
- [Verifying the RADIUS Configuration, on page 41](#)
- [Displaying RADIUS Server Statistics, on page 41](#)
- [Clearing RADIUS Server Statistics, on page 42](#)
- [Configuration Examples for RADIUS, on page 42](#)
- [Default Settings for RADIUS, on page 42](#)
- [Feature History for RADIUS, on page 43](#)

Information About RADIUS

The Remote Access Dial-In User Service (RADIUS) distributed client/server system allows you to secure networks against unauthorized access. In the Cisco implementation, RADIUS clients run on Cisco Nexus devices and send authentication and accounting requests to a central RADIUS server that contains all user authentication and network service access information.

RADIUS Network Environments

RADIUS can be implemented in a variety of network environments that require high levels of security while maintaining network access for remote users.

You can use RADIUS in the following network environments that require access security:

- Networks with multiple-vendor network devices, each supporting RADIUS.

For example, network devices from several vendors can use a single RADIUS server-based security database.

- Networks already using RADIUS.

You can add a Cisco Nexus device with RADIUS to the network. This action might be the first step when you make a transition to an AAA server.

- Networks that require resource accounting.

Information About RADIUS Operations

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 the RADIUS access control and accounting software to meet special security and billing needs.

- Networks that support authentication profiles.

Using the RADIUS server in your network, you can configure AAA authentication and set up per-user profiles. Per-user profiles enable the Cisco Nexus device to manage ports using their existing RADIUS solutions and to efficiently manage shared resources to offer different service-level agreements.

Information About RADIUS Operations

When a user attempts to log in and authenticate to a Cisco Nexus device using RADIUS, the following process occurs:

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

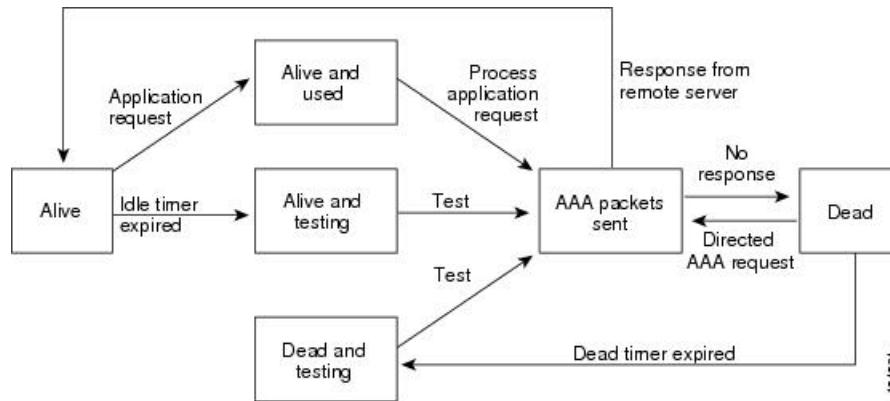
- Services that the user can access, including Telnet, rlogin, or local-area transport (LAT) connections, and Point-to-Point Protocol (PPP), Serial Line Internet Protocol (SLIP), or EXEC services.
- Connection parameters, including the host or client IPv4 or IPv6 address, access list, and user timeouts.

RADIUS Server Monitoring

An unresponsive RADIUS server can cause delay in processing of AAA requests. You can configure the switch to periodically monitor a RADIUS server to check whether it is responding (or alive) to save time in processing AAA requests. The switch marks unresponsive RADIUS servers as dead and does not send AAA requests to any dead RADIUS servers. The switch periodically monitors the dead RADIUS servers and brings them to the alive state once they respond. This process verifies that a RADIUS server is in a working state before real AAA requests are sent to the server. Whenever a RADIUS server changes to the dead or alive state, a Simple Network Management Protocol (SNMP) trap is generated and the switch displays an error message that a failure is taking place.

The following figure shows the different RADIUS server states:

Figure 2: RADIUS Server States



Note The monitoring interval for alive servers and dead servers are different and can be configured by the user. The RADIUS server monitoring is performed by sending a test authentication request to the RADIUS server.

Vendor-Specific Attributes

The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating vendor-specific attributes (VSAs) between the network access server and the RADIUS server. The IETF uses attribute 26. VSAs allow vendors to support their own extended attributes that are not suitable for general use. The Cisco RADIUS implementation supports one vendor-specific option using the format recommended in the specification. The Cisco vendor ID is 9, and the supported option is vendor type 1, which is named cisco-av-pair. The value is a string with the following format:

```
protocol : attribute separator value *
```

The protocol is a Cisco attribute for a particular type of authorization, the separator is an equal sign (=) for mandatory attributes, and an asterisk (*) indicates optional attributes.

When you use RADIUS servers for authentication on a Cisco Nexus device, the RADIUS protocol directs the RADIUS server to return user attributes, such as authorization information, with authentication results. This authorization information is specified through VSAs.

The following VSA protocol options are supported by the Cisco Nexus device:

- Shell—Used in access-accept packets to provide user profile information.
- Accounting—Used in accounting-request packets. If a value contains any white spaces, you should enclose the value within double quotation marks.

The Cisco Nexus device supports the following attributes:

- roles—Lists all the roles to which the user belongs. The value field is a string that lists the role names delimited by white spaces.

Prerequisites for RADIUS

- **accountinginfo**—Stores accounting information in addition to the attributes covered by a standard RADIUS accounting protocol. This attribute is sent only in the VSA portion of the Account-Request frames from the RADIUS client on the switch. It can be used only with the accounting protocol data units (PDUs).

Prerequisites for RADIUS

RADIUS has the following prerequisites:

- You must obtain IPv4 or IPv6 addresses or hostnames for the RADIUS servers.
- You must obtain preshared keys from the RADIUS servers.
- Ensure that the Cisco Nexus device is configured as a RADIUS client of the AAA servers.

Guidelines and Limitations for RADIUS

RADIUS has the following configuration guidelines and limitations:

- You can configure a maximum of 64 RADIUS servers on the Cisco Nexus device.

Configuring RADIUS Servers

This section describes how to configure RADIUS servers.

Procedure

- Step 1** Establish the RADIUS server connections to the Cisco Nexus device.
 - Step 2** Configure the preshared secret keys for the RADIUS servers.
 - Step 3** If needed, configure RADIUS server groups with subsets of the RADIUS servers for AAA authentication methods.
 - Step 4** If needed, configure any of the following optional parameters:
 - Dead-time interval.
 - Allow specification of a RADIUS server at login.
 - Transmission retry count and timeout interval.
 - Accounting and authentication attributes.
 - Step 5** If needed, configure periodic RADIUS server monitoring.
-

Configuring RADIUS Server Hosts

You must configure the IPv4 or IPv6 address or the hostname for each RADIUS server that you want to use for authentication. All RADIUS server hosts are added to the default RADIUS server group. You can configure up to 64 RADIUS servers.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# radius-server host {ipv4-address ipv6-address host-name}	Specifies the IPv4 or IPv6 address or hostname for a RADIUS server.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show radius-server	Displays the RADIUS server configuration.
Step 5	(Optional) switch# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

The following example shows how to configure host 10.10.1.1 as a RADIUS server:

```
switch# configure terminal
switch(config)# radius-server host 10.10.1.1
switch(config)# exit
switch# copy running-config startup-config
```

Configuring RADIUS Global Preshared Keys

You can configure preshared keys at the global level for all servers used by the Cisco Nexus device. A preshared key is a shared secret text string between the switch and the RADIUS server hosts.

Before you begin

Obtain the preshared key values for the remote RADIUS servers

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# radius-server key [0 7] key-value	Specifies a preshared key for all RADIUS servers. You can specify a clear text (0) or encrypted (7) preshared key. The default format is clear text.

	Command or Action	Purpose
		The maximum length is 63 characters. By default, no preshared key is configured.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show radius-server	Displays the RADIUS server configuration. Note The preshared keys are saved in encrypted form in the running configuration. Use the show running-config command to display the encrypted preshared keys.
Step 5	(Optional) switch# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

This example shows how to configure preshared keys at the global level for all servers used by the device:

```
switch# configure terminal
switch(config) # radius-server key 0 QsEfThUkO
switch(config) # exit
switch# copy running-config startup-config
```

Configuring RADIUS Server Preshared Keys

A preshared key is a shared secret text string between the Cisco Nexus device and the RADIUS server host.

Before you begin

Obtain the preshared key values for the remote RADIUS servers.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# radius-server host <i>{ipv4-address ipv6-address host-name} key</i> <i>[0 7] key-value</i>	Specifies a preshared key for a specific RADIUS server. You can specify a clear text (0) or encrypted (7) preshared key. The default format is clear text. The maximum length is 63 characters. This preshared key is used instead of the global preshared key.

	Command or Action	Purpose
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show radius-server	Displays the RADIUS server configuration. Note The preshared keys are saved in encrypted form in the running configuration. Use the show running-config command to display the encrypted preshared keys.
Step 5	(Optional) switch# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

This example shows how to configure RADIUS preshared keys:

```
switch# configure terminal
switch(config)# radius-server host 10.10.1.1 key 0 P1IjUhYg
switch(config)# exit
switch# show radius-server
switch# copy running-config startup-config
```

Configuring RADIUS Server Groups

You can specify one or more remote AAA servers for authentication using server groups. All members of a group must belong to the RADIUS protocol. The servers are tried in the same order in which you configure them.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch (config)# aaa group server radius group-name	Creates a RADIUS server group and enters the RADIUS server group configuration submode for that group. The <i>group-name</i> argument is a case-sensitive alphanumeric string with a maximum length of 127 characters. To delete a RADIUS server group, use the no form of this command. Note You are not allowed to delete the default system generated default group (RADIUS).

	Command or Action	Purpose
Step 3	switch (config-radius)# server { <i>ipv4-address</i> <i>ipv6-address</i> <i>server-name</i> }	Configures the RADIUS server as a member of the RADIUS server group. If the specified RADIUS server is not found, configure it using the radius-server host command and retry this command.
Step 4	(Optional) switch (config-radius)# deadtime <i>minutes</i>	Configures the monitoring dead time. The default is 0 minutes. The range is from 1 through 1440. Note If the dead-time interval for a RADIUS server group is greater than zero (0), that value takes precedence over the global dead-time value.
Step 5	(Optional) switch(config-radius)# source-interface <i>interface</i>	Assigns a source interface for a specific RADIUS server group. The supported interface types are management and VLAN. Note Use the source-interface command to override the global source interface assigned by the ip radius source-interface command.
Step 6	switch(config-radius)# exit	Exits configuration mode.
Step 7	(Optional) switch(config)# show radius-server group [<i>group-name</i>]	Displays the RADIUS server group configuration.
Step 8	(Optional) switch(config)# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

The following example shows how to configure a RADIUS server group:

```
switch# configure terminal
switch (config)# aaa group server radius RadServer
switch (config-radius)# server 10.10.1.1
switch (config-radius)# deadtime 30
switch (config-radius)# use-vrf management
switch (config-radius)# exit
switch (config)# show radius-server group
switch (config)# copy running-config startup-config
```

What to do next

Apply the RADIUS server groups to an AAA service.

Configuring the Global Source Interface for RADIUS Server Groups

You can configure a global source interface for RADIUS server groups to use when accessing RADIUS servers. You can also configure a different source interface for a specific RADIUS server group.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# ip radius source-interface interface	Configures the global source interface for all RADIUS server groups configured on the device. The source interface can be the management or the VLAN interface.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show radius-server	Displays the RADIUS server configuration information.
Step 5	(Optional) switch# copy running-config startup config	Copies the running configuration to the startup configuration.

Example

This example shows how to configure the mgmt 0 interface as the global source interface for RADIUS server groups:

```
switch# configure terminal
switch(config)# ip radius source-interface mgmt 0
switch(config)# exit
switch# copy running-config startup-config
```

Allowing Users to Specify a RADIUS Server at Login

You can allow users to specify a RADIUS server at login.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# radius-server directed-request	Allows users to specify a RADIUS server to send the authentication request when logging in. The default is disabled.
Step 3	switch(config)# exit	Exits configuration mode.

Configuring the Global RADIUS Transmission Retry Count and Timeout Interval

	Command or Action	Purpose
Step 4	(Optional) switch# show radius-server directed-request	Displays the directed request configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

This example shows how to allow users to select a RADIUS server when logging in to a network:

```
switch# configure terminal
switch(config)# radius-server directed-request
switch# exit
switch# copy running-config startup-config
```

Configuring the Global RADIUS Transmission Retry Count and Timeout Interval

You can configure a global retransmission retry count and timeout interval for all RADIUS servers. By default, a switch retries transmission to a RADIUS server only once before reverting to local authentication. You can increase this number up to a maximum of five retries per server. The timeout interval determines how long the Cisco Nexus device waits for responses from RADIUS servers before declaring a timeout failure.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# radius-server retransmit count	Specifies the retransmission count for all RADIUS servers. The default retransmission count is 1 and the range is from 0 to 5.
Step 3	switch(config)# radius-server timeout seconds	Specifies the transmission timeout interval for RADIUS servers. The default timeout interval is 5 seconds and the range is from 1 to 60 seconds.
Step 4	switch(config)# exit	Exits global configuration mode.
Step 5	(Optional) switch# show radius-server	Displays the RADIUS server configuration.
Step 6	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

This example shows how to set the retry count to 3 and the transmission timeout interval to 5 seconds for RADIUS servers:

```

switch# configure terminal
switch(config)# radius-server retransmit 3
switch(config)# radius-server timeout 5
switch(config)# exit
switch# copy running-config startup-config

```

Configuring the RADIUS Transmission Retry Count and Timeout Interval for a Server

By default, a Cisco Nexus switch retries transmission to a RADIUS server only once before reverting to local authentication. You can increase this number up to a maximum of five retries per server. You can also set a timeout interval that the switch waits for responses from RADIUS servers before declaring a timeout failure.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# radius-server host { <i>ipv4-address</i> <i>ipv6-address</i> <i>host-name</i> } retransmit <i>count</i>	Specifies the retransmission count for a specific server. The default is the global value. Note The retransmission count value specified for a RADIUS server overrides the count specified for all RADIUS servers.
Step 3	switch(config)# radius-server host { <i>ipv4-address</i> <i>ipv6-address</i> <i>host-name</i> } timeout <i>seconds</i>	Specifies the transmission timeout interval for a specific server. The default is the global value. Note The timeout interval value specified for a RADIUS server overrides the interval value specified for all RADIUS servers.
Step 4	switch(config)# exit	Exits global configuration mode.
Step 5	(Optional) switch# show radius-server	Displays the RADIUS server configuration.
Step 6	(Optional) switch# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

This example shows how to set the RADIUS transmission retry count to 3 and the timeout interval to 10 seconds on RADIUS host server server1:

```

switch# configure terminal
switch(config)# radius-server host server1 retransmit 3

```

```
switch(config)# radius-server host server1 timeout 10
switch(config)# exit
switch# copy running-config startup-config
```

Configuring Accounting and Authentication Attributes for RADIUS Servers

You can specify that a RADIUS server is to be used only for accounting purposes or only for authentication purposes. By default, RADIUS servers are used for both accounting and authentication. You can also specify the destination UDP port numbers where RADIUS accounting and authentication messages should be sent.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	(Optional) switch(config)# radius-server host {ipv4-address ipv6-address host-name} acct-port udp-port	Specifies a UDP port to use for RADIUS accounting messages. The default UDP port is 1812. The range is from 0 to 65535.
Step 3	(Optional) switch(config)# radius-server host {ipv4-address ipv6-address host-name} accounting	Specifies that the specified RADIUS server is to be used only for accounting purposes. The default is both accounting and authentication.
Step 4	(Optional) switch(config)# radius-server host {ipv4-address ipv6-address host-name} auth-port udp-port	Specifies a UDP port to use for RADIUS authentication messages. The default UDP port is 1812. The range is from 0 to 65535.
Step 5	(Optional) switch(config)# radius-server host {ipv4-address ipv6-address host-name} authentication	Specifies that the specified RADIUS server only be used for authentication purposes. The default is both accounting and authentication.
Step 6	switch(config)# exit	Exits configuration mode.
Step 7	(Optional) switch(config)# show radius-server	Displays the RADIUS server configuration.
Step 8	switch(config)# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

This example shows how to configure accounting and authentication attributes for a RADIUS server:

```
switch# configure terminal
switch(config)# radius-server host 10.10.1.1 acct-port 2004
switch(config)# radius-server host 10.10.1.1 accounting
switch(config)# radius-server host 10.10.2.2 auth-port 2005
switch(config)# radius-server host 10.10.2.2 authentication
switch # exit
```

```
switch # copy running-config startup-config
switch #
```

Configuring Periodic RADIUS Server Monitoring

You can monitor the availability of RADIUS servers. These parameters include the username and password to use for the server and an idle timer. The idle timer specifies the interval during which a RADIUS server receives no requests before the switch sends out a test packet. You can configure this option to test servers periodically.



Note For security reasons, we recommend that you do not configure a test username that is the same as an existing user in the RADIUS database.

The test idle timer specifies the interval during which a RADIUS server receives no requests before the switch sends out a test packet.

The default idle timer value is 0 minutes. When the idle time interval is 0 minutes, the switch does not perform periodic RADIUS server monitoring.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# radius-server host { <i>ipv4-address</i> <i>ipv6-address</i> <i>host-name</i> } test { idle-time <i>minutes</i> password <i>password</i> [<i>idle-time</i> <i>minutes</i>] username <i>name</i> [<i>password</i> <i>password</i> [idle-time <i>minutes</i>]]}	Specifies parameters for server monitoring. The default username is test and the default password is test. The default value for the idle timer is 0 minutes. The valid range is from 0 to 1440 minutes. Note For periodic RADIUS server monitoring, you must set the idle timer to a value greater than 0.
Step 3	switch(config)# radius-server deadtime <i>minutes</i>	Specifies the number of minutes before the switch checks a RADIUS server that was previously unresponsive. The default value is 0 minutes. The valid range is 1 to 1440 minutes.
Step 4	switch(config)# exit	Exits configuration mode.
Step 5	(Optional) switch# show radius-server	Displays the RADIUS server configuration.
Step 6	(Optional) switch# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Example

This example shows how to configure RADIUS server host 10.10.1.1 with a username (user1) and password (Ur2Gd2BH) and with an idle timer of 3 minutes and a deadtime of 5 minutes:

```
switch# configure terminal
switch(config)# radius-server host 10.10.1.1 test username user1 password Ur2Gd2BH idle-time
  3
switch(config)# radius-server deadtime 5
switch(config)# exit
switch# copy running-config startup-config
```

Configuring the Dead-Time Interval

You can configure the dead-time interval for all RADIUS servers. The dead-time interval specifies the time that the Cisco Nexus device waits after declaring a RADIUS server is dead, before sending out a test packet to determine if the server is now alive. The default value is 0 minutes.



- Note** When the dead-time interval is 0 minutes, RADIUS servers are not marked as dead even if they are not responding. You can configure the dead-time interval for a RADIUS server group.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# radius-server deadtime	Configures the dead-time interval. The default value is 0 minutes. The range is from 1 to 1440 minutes.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show radius-server	Displays the RADIUS server configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

This example shows how to configure a deadtime of 5 minutes for a radius server:

```
switch# configure terminal
switch(config)# radius-server deadtime 5
switch(config)# exit
switch# copy running-config startup-config
```

Manually Monitoring RADIUS Servers or Groups

Procedure

	Command or Action	Purpose
Step 1	switch# test aaa server radius { <i>ipv4-address</i> <i>ipv6-address</i> <i>server-name</i> } [vrf <i>vrf-name</i>] <i>username password</i> test aaa server radius { <i>ipv4-address</i> <i>ipv6-address</i> <i>server-name</i> } [vrf <i>vrf-name</i>] <i>username password</i>	Sends a test message to a RADIUS server to confirm availability.
Step 2	switch# test aaa group <i>group-name</i> <i>username password</i>	Sends a test message to a RADIUS server group to confirm availability.

Example

This example shows how to send a test message to the RADIUS server and server group to confirm availability:

```
switch# test aaa server radius 10.10.1.1 user 1 Ur2Gd2BH
switch# test aaa group RadGroup user2 As3He3CI
```

Verifying the RADIUS Configuration

To display AAA information, perform one of the following tasks:

Command	Purpose
show running-config radius [all]	Displays the RADIUS configuration in the running configuration.
show startup-config radius	Displays the RADIUS configuration in the startup configuration.
show radius-server [<i>server-name</i> <i>ipv4-address</i> <i>ipv6-address</i>] [directed-request groups sorted statistics]	Displays all configured RADIUS server parameters.

Displaying RADIUS Server Statistics

Procedure

	Command or Action	Purpose
Step 1	switch# show radius-server statistics { <i>hostname</i> <i>ipv4-address</i> <i>ipv6-address</i> }	Displays the RADIUS statistics.

Clearing RADIUS Server Statistics

You can display the statistics that the Cisco NX-OS device maintains for RADIUS server activity.

Before you begin

Configure RADIUS servers on the Cisco NX-OS device.

Procedure

	Command or Action	Purpose
Step 1	(Optional) switch# show radius-server statistics {hostname ipv4-address ipv6-address}	Displays the RADIUS server statistics on the Cisco NX-OS device.
Step 2	switch# clear radius-server statistics {hostname ipv4-address ipv6-address}	Clears the RADIUS server statistics.

Configuration Examples for RADIUS

The following example shows how to configure RADIUS:

```
switch# configure terminal
switch(config)# radius-server key 7 "ToIkLhPpG"
switch(config)# radius-server host 10.10.1.1 key 7 "ShMoMhTl" authentication accounting
switch(config)# aaa group server radius RadServer
switch(config-radius)# server 10.10.1.1
switch(config-radius)# exit
switch(config-radius)# use-vrf management
```

Default Settings for RADIUS

The following table lists the default settings for RADIUS parameters.

Table 5: Default RADIUS Parameters

Parameters	Default
Server roles	Authentication and accounting
Dead timer interval	0 minutes
Retransmission count	1
Retransmission timer interval	5 seconds

Parameters	Default
Idle timer interval	0 minutes
Periodic server monitoring username	test
Periodic server monitoring password	test

Feature History for RADIUS

Table 6: Feature History for RADIUS

Feature Name	Releases	Feature Information
RADIUS	5.0(3)U1(1)	This feature was introduced.
IPv6	5.0(3)U3(1)	IPv6 support was introduced.



CHAPTER 5

Configuring TACACS+

This chapter contains the following sections:

- [Information About Configuring TACACS+, on page 45](#)
- [Prerequisites for TACACS+, on page 47](#)
- [Guidelines and Limitations for TACACS+, on page 48](#)
- [Configuring TACACS+, on page 48](#)
- [Displaying TACACS+ Statistics, on page 57](#)
- [Verifying the TACACS+ Configuration, on page 58](#)
- [Configuration Examples for TACACS+, on page 58](#)
- [Default Settings for TACACS+, on page 58](#)

Information About Configuring TACACS+

The Terminal Access Controller Access Control System Plus (TACACS+) security protocol provides centralized validation of users attempting to gain access to a Cisco Nexus device. TACACS+ services are maintained in a database on a TACACS+ daemon typically running on a UNIX or Windows NT workstation. You must have access to and must configure a TACACS+ server before the configured TACACS+ features on your Cisco Nexus device are available.

TACACS+ provides for separate authentication, authorization, and accounting facilities. TACACS+ allows for a single access control server (the TACACS+ daemon) to provide each service (authentication, authorization, and accounting) independently. Each service is associated with its own database to take advantage of other services available on that server or on the network, depending on the capabilities of the daemon.

The TACACS+ client/server protocol uses TCP (TCP port 49) for transport requirements. The Cisco Nexus device provides centralized authentication using the TACACS+ protocol.

TACACS+ Advantages

TACACS+ has the following advantages over RADIUS authentication:

- Provides independent AAA facilities. For example, the Cisco Nexus device can authorize access without authenticating.
- Uses the TCP transport protocol to send data between the AAA client and server, making reliable transfers with a connection-oriented protocol.

- Encrypts the entire protocol payload between the switch and the AAA server to ensure higher data confidentiality. The RADIUS protocol only encrypts passwords.

User Login with TACACS+

When a user attempts a Password Authentication Protocol (PAP) login to a Cisco Nexus device using TACACS+, the following actions occur:

1. When the Cisco Nexus device establishes a connection, it contacts the TACACS+ daemon to obtain the username and password.



Note TACACS+ allows an arbitrary conversation between the daemon and the user until the daemon receives enough information to authenticate the user. This action is usually done by prompting for a username and password combination, but may include prompts for other items, such as the user's mother's maiden name.

2. The Cisco Nexus device receives one of the following responses from the TACACS+ daemon:
 - ACCEPT—User authentication succeeds and service begins. If the Cisco Nexus device requires user authorization, authorization begins.
 - REJECT—User authentication failed. The TACACS+ daemon either denies further access to the user or prompts the user to retry the login sequence.
 - ERROR—An error occurred at some time during authentication dither at the daemon or in the network connection between the daemon and the Cisco Nexus device. If the Cisco Nexus device receives an ERROR response, the switch tries to use an alternative method for authenticating the user.

The user also undergoes an additional authorization phase, if authorization has been enabled on the Cisco Nexus device. Users must first successfully complete TACACS+ authentication before proceeding to TACACS+ authorization.

3. If TACACS+ authorization is required, the Cisco Nexus device again contacts the TACACS+ daemon and it returns an ACCEPT or REJECT authorization response. An ACCEPT response contains attributes that are used to direct the EXEC or NETWORK session for that user and determines the services that the user can access.

Services include the following:

- Telnet, rlogin, Point-to-Point Protocol (PPP), Serial Line Internet Protocol (SLIP), or EXEC services
- Connection parameters, including the host or client IP address (IPv4), access list, and user timeouts

Default TACACS+ Server Encryption Type and Preshared Key

You must configure the TACACS+ that is preshared key to authenticate the switch to the TACACS+ server. A preshared key is a secret text string shared between the Cisco Nexus device and the TACACS+ server host. The length of the key is restricted to 63 characters and can include any printable ASCII characters (white spaces are not allowed). You can configure a global preshared secret key for all TACACS+ server configurations on the Cisco Nexus device to use.

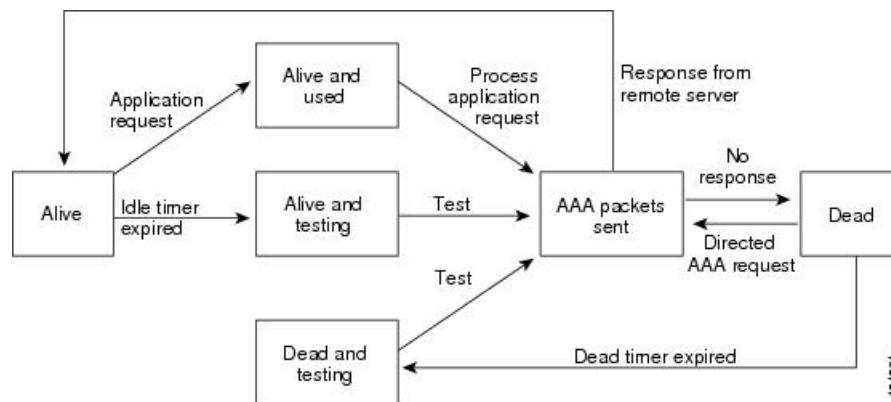
You can override the global preshared key assignment by using the **key** option when configuring an individual TACACS+ server.

TACACS+ Server Monitoring

An unresponsive TACACS+ server can delay the processing of AAA requests. A Cisco Nexus device can periodically monitor an TACACS+ server to check whether it is responding (or alive) to save time in processing AAA requests. The Cisco Nexus device marks unresponsive TACACS+ servers as dead and does not send AAA requests to any dead TACACS+ servers. The Cisco Nexus device periodically monitors dead TACACS+ servers and brings them to the alive state once they are responding. This process verifies that a TACACS+ server is in a working state before real AAA requests are sent to the server. Whenever an TACACS+ server changes to the dead or alive state, a Simple Network Management Protocol (SNMP) trap is generated and the Cisco Nexus device displays an error message that a failure is taking place before it can impact performance.

The following figure shows the different TACACS+ server states:

Figure 3: TACACS+ Server States



Note The monitoring interval for alive servers and dead servers are different and can be configured by the user. The TACACS+ server monitoring is performed by sending a test authentication request to the TACACS+ server.

Prerequisites for TACACS+

TACACS+ has the following prerequisites:

- You must obtain the IPv4 addresses or hostnames for the TACACS+ servers.
- You must obtain the preshared keys from the TACACS+ servers, if any.
- Ensure that the Cisco Nexus device is configured as a TACACS+ client of the AAA servers.

Guidelines and Limitations for TACACS+

TACACS+ has the following configuration guidelines and limitations:

- You can configure a maximum of 64 TACACS+ servers on the Cisco Nexus device.
- You may get the following error message sporadically after you have configured a TACACS+ server host followed by the AAA configuration to actually use the host:

%TACACS-3-TACACS_ERROR_MESSAGE: All servers failed to respond

This is a known issue and there is no workaround. If the remote authentication works properly without any TACACS server connectivity issue, you can ignore the message and continue with your further configuration.

Configuring TACACS+

TACACS+ Server Configuration Process

This section describes how to configure TACACS+ servers.

Procedure

- Step 1** Enable TACACS+.
 - Step 2** Establish the TACACS+ server connections to the Cisco Nexus device.
 - Step 3** Configure the preshared secret keys for the TACACS+ servers.
 - Step 4** If needed, configure TACACS+ server groups with subsets of the TACACS+ servers for AAA authentication methods.
 - Step 5** If needed, configure any of the following optional parameters:
 - Dead-time interval
 - Allow TACACS+ server specification at login
 - Timeout interval
 - TCP port
 - Step 6** If needed, configure periodic TACACS+ server monitoring.
-

Enabling TACACS+

Although by default, the TACACS+ feature is disabled on the Cisco Nexus device. You can enable the TACACS+ feature to access the configuration and verification commands for authentication.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# feature tacacs+	Enables TACACS+.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring TACACS+ Server Hosts

To access a remote TACACS+ server, you must configure the IPv4 address or the hostname for the TACACS+ server on the Cisco Nexus device. All TACACS+ server hosts are added to the default TACACS+ server group. You can configure up to 64 TACACS+ servers.

If a preshared key is not configured for a configured TACACS+ server, a warning message is issued if a global key is not configured. If a TACACS+ server key is not configured, the global key (if configured) is used for that server.

Before you configure TACACS+ server hosts, you should do the following:

- Enable TACACS+.
- Obtain the IPv4 addresses or the hostnames for the remote TACACS+ servers.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# exit	Exits configuration mode.
Step 3	(Optional) switch# show tacacs-server	Displays the TACACS+ server configuration.
Step 4	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

You can delete a TACACS+ server host from a server group.

Configuring TACACS+ Global Preshared Keys

You can configure preshared keys at the global level for all servers used by the Cisco Nexus device. A preshared key is a shared secret text string between the Cisco Nexus device and the TACACS+ server hosts.

Before you configure preshared keys, you should do the following:

- Enable TACACS+.

- Obtain the preshared key values for the remote TACACS+ servers.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	tacacs-server key [0 6 7] key-value Example: switch(config)# tacacs-server key 0 QsEfThUkO Example: switch(config)# tacacs-server key 7 "fewhg"	Specifies a TACACS+ key for all TACACS+ server. You can specify that the <i>key-value</i> is in clear text format (0), is type-6 encrypted (6), or is type-7 encrypted (7). The Cisco NX-OS software encrypts a clear text key before saving it to the running configuration. The default format is clear text. The maximum length is 63 characters. By default, no secret key is configured. Note If you already configured a shared secret using the generate type7_encrypted_secret command, enter it in quotation marks, as shown in the second example.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show tacacs-server	Displays the TACACS+ server configuration. Note The preshared keys are saved in encrypted form in the running configuration. Use the show running-config command to display the encrypted preshared keys.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to configure global preshared keys:

```
switch# configure terminal
switch(config)# tacacs-server key 0 QsEfThUkO
switch(config)# exit
switch# show tacacs-server
switch# copy running-config startup-config
```

Configuring TACACS+ Server Preshared Keys

You can configure preshared keys for a TACACS+ server. A preshared key is a shared secret text string between the Cisco Nexus device and the TACACS+ server host.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# exit	Exits configuration mode.
Step 3	(Optional) switch# show tacacs-server	Displays the TACACS+ server configuration. Note The preshared keys are saved in encrypted form in the running configuration. Use the show running-config command to display the encrypted preshared keys.
Step 4	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to configure the TACACS+ preshared keys:

```
switch# configure terminal
switch(config)# tacacs-server host 10.10.1.1 key 0 P1IjUhYg
switch(config)# exit
switch# show tacacs-server
switch# copy running-config startup-config
```

Configuring TACACS+ Server Groups

You can specify one or more remote AAA servers to authenticate users using server groups. All members of a group must belong to the TACACS+ protocol. The servers are tried in the same order in which you configure them.

You can configure these server groups at any time but they only take effect when you apply them to an AAA service.

Before you begin

You must use the **feature tacacs+** command to enable TACACS+ before you configure TACACS+.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# aaa group server tacacs+ group-name	Creates a TACACS+ server group and enters the TACACS+ server group configuration mode for that group.

	Command or Action	Purpose
Step 3	(Optional) switch(config-tacacs+)# deadtime <i>minutes</i>	Configures the monitoring dead time. The default is 0 minutes. The range is from 0 through 1440. Note If the dead-time interval for a TACACS+ server group is greater than zero (0), that value takes precedence over the global dead-time value.
Step 4	(Optional) switch(config-tacacs+)# source-interface <i>interface</i>	Assigns a source interface for a specific TACACS+ server group. The supported interface types are management and VLAN. Note Use the source-interface command to override the global source interface assigned by the ip tacacs source-interface command.
Step 5	switch(config-tacacs+)# exit	Exits configuration mode.
Step 6	(Optional) switch(config)# show tacacs-server groups	Displays the TACACS+ server group configuration.
Step 7	(Optional) switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to configure a TACACS+ server group:

```
switch# configure terminal
switch(config)# aaa group server tacacs+ TacServer
switch(config-tacacs+)# server 10.10.2.2
switch(config-tacacs+)# deadtime 30
switch(config-tacacs+)# exit
switch(config)# show tacacs-server groups
switch(config)# copy running-config startup-config
```

Configuring the Global Source Interface for TACACS+ Server Groups

You can configure a global source interface for TACACS+ server groups to use when accessing TACACS+ servers. You can also configure a different source interface for a specific TACACS+ server group.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
Step 2	ip tacacs source-interface <i>interface</i> Example: switch(config)# ip tacacs source-interface mgmt 0	Configures the global source interface for all TACACS+ server groups configured on the device. The source interface can be the management or the VLAN interface.
Step 3	exit Example: switch(config)# exit switch#	Exits configuration mode.
Step 4	(Optional) show tacacs-server Example: switch# show tacacs-server	Displays the TACACS+ server configuration information.
Step 5	(Optional) copy running-config startup config Example: switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Specifying a TACACS+ Server at Login

You can configure the switch to allow the user to specify which TACACS+ server to send the authenticate request by enabling the directed-request option. By default, a Cisco Nexus device forwards an authentication request based on the default AAA authentication method. If you enable this option, the user can log in as *username@hostname*, where *hostname* is the name of a configured RADIUS server.

**Note**

User specified logins are only supported for Telnet sessions.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# tacacs-server directed-request	Allows users to specify a TACACS+ server to send the authentication request when logging in. The default is disabled.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show tacacs-server directed-request	Displays the TACACS+ directed request configuration.

Configuring the Global TACACS+ Timeout Interval

	Command or Action	Purpose
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring the Global TACACS+ Timeout Interval

You can set a global timeout interval that the Cisco Nexus device waits for responses from all TACACS+ servers before declaring a timeout failure. The timeout interval determines how long the switch waits for responses from TACACS+ servers before declaring a timeout failure.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# tacacs-server timeout seconds	Specifies the timeout interval for TACACS+ servers. The default timeout interval is 5 second and the range is from 1 to 60 seconds.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show tacacs-server	Displays the TACACS+ server configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring the Timeout Interval for a Server

You can set a timeout interval that the Cisco Nexus device waits for responses from a TACACS+ server before declaring a timeout failure. The timeout interval determines how long the switch waits for responses from a TACACS+ server before declaring a timeout failure.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# exit	Exits configuration mode.
Step 3	(Optional) switch# show tacacs-server	Displays the TACACS+ server configuration.
Step 4	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring TCP Ports

You can configure another TCP port for the TACACS+ servers if there are conflicts with another application. By default, the Cisco Nexus device uses port 49 for all TACACS+ requests.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# exit	Exits configuration mode.
Step 3	(Optional) switch# show tacacs-server	Displays the TACACS+ server configuration.
Step 4	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to configure TCP ports:

```
switch# configure terminal
switch(config)# tacacs-server host 10.10.1.1 port 2
switch(config)# exit
switch# show tacacs-server
switch# copy running-config startup-config
```

Configuring Periodic TACACS+ Server Monitoring

You can monitor the availability of TACACS+ servers. These parameters include the username and password to use for the server and an idle timer. The idle timer specifies the interval in which a TACACS+ server receives no requests before the Cisco Nexus device sends out a test packet. You can configure this option to test servers periodically, or you can run a one-time only test.



Note To protect network security, we recommend that you use a username that is not the same as an existing username in the TACACS+ database.

The test idle timer specifies the interval in which a TACACS+ server receives no requests before the Cisco Nexus device sends out a test packet.



Note The default idle timer value is 0 minutes. When the idle time interval is 0 minutes, periodic TACACS+ server monitoring is not performed.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# tacacs-server dead-time minutes	Specifies the number minutes before the Cisco Nexus device checks a TACACS+ server that was previously unresponsive. The default value

Configuring the Dead-Time Interval

	Command or Action	Purpose
		is 0 minutes and the valid range is 0 to 1440 minutes.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show tacacs-server	Displays the TACACS+ server configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to configure periodic TACACS+ server monitoring:

```
switch# configure terminal
switch(config)# tacacs-server host 10.10.1.1 test username user1 password Ur2Gd2BH idle-time
  3
switch(config)# tacacs-server dead-time 5
switch(config)# exit
switch# show tacacs-server
switch# copy running-config startup-config
```

Configuring the Dead-Time Interval

You can configure the dead-time interval for all TACACS+ servers. The dead-time interval specifies the time that the Cisco Nexus device waits, after declaring a TACACS+ server is dead, before sending out a test packet to determine if the server is now alive.



Note When the dead-time interval is 0 minutes, TACACS+ servers are not marked as dead even if they are not responding. You can configure the dead-time interval per group.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# tacacs-server deadtime minutes	Configures the global dead-time interval. The default value is 0 minutes. The range is from 1 to 1440 minutes.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# show tacacs-server	Displays the TACACS+ server configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Manually Monitoring TACACS+ Servers or Groups

Procedure

	Command or Action	Purpose
Step 1	switch# test aaa server tacacs+ {ipv4-address ipv6-address host-name} [vrf vrf-name] <i>username password</i>	Sends a test message to a TACACS+ server to confirm availability.
Step 2	switch# test aaa group group-name username password	Sends a test message to a TACACS+ server group to confirm availability.

Example

The following example shows how to manually issue a test message:

```
switch# test aaa server tacacs+ 10.10.1.1 user1 Ur2Gd2BH
switch# test aaa group TacGroup user2 As3He3CI
```

Disabling TACACS+

You can disable TACACS+.



Caution

When you disable TACACS+, all related configurations are automatically discarded.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# no feature tacacs+	Disables TACACS+.
Step 3	switch(config)# exit	Exits configuration mode.
Step 4	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Displaying TACACS+ Statistics

To display the statistics, the switch maintains for TACACS+ activity, perform this task:

Example

For detailed information about the fields in the output from this command, see the *Command Reference* for your Nexus switch.

Verifying the TACACS+ Configuration

To display TACACS+ information, perform one of the following tasks:

Command	Purpose
show tacacs+ {status pending pending-diff}	Displays the TACACS+ Cisco Fabric Services distribution status and other details.
show running-config tacacs [all]	Displays the TACACS+ configuration in the running configuration.
show startup-config tacacs	Displays the TACACS+ configuration in the startup configuration.
show tacacs-serve [host-name ipv4-address ipv6-address] [directed-request groups sorted statistics]	Displays all configured TACACS+ server parameters.

Configuration Examples for TACACS+

This example shows how to configure TACACS+:

```
switch# configure terminal
switch(config)# feature tacacs+
switch(config)# tacacs-server key 7 "ToIkLhPpG"
switch(config)# tacacs-server host 10.10.2.2 key 7 "ShMoMhTl"
switch(config)# aaa group server tacacs+ TacServer
switch(config-tacacs+)# server 10.10.2.2
switch(config-tacacs+)# use-vrf management
```

This example shows how to enable tacacs+ and how to configure the tacacs+ server preshared keys to specify remote AAA servers to authenticate server group TacServer1:

```
switch# configure terminal
switch(config)# feature tacacs+
switch(config)# tacacs-server key 7 "ikvhw10"
switch(config)# tacacs-server host 1.1.1.1
switch(config)# tacacs-server host 1.1.1.2

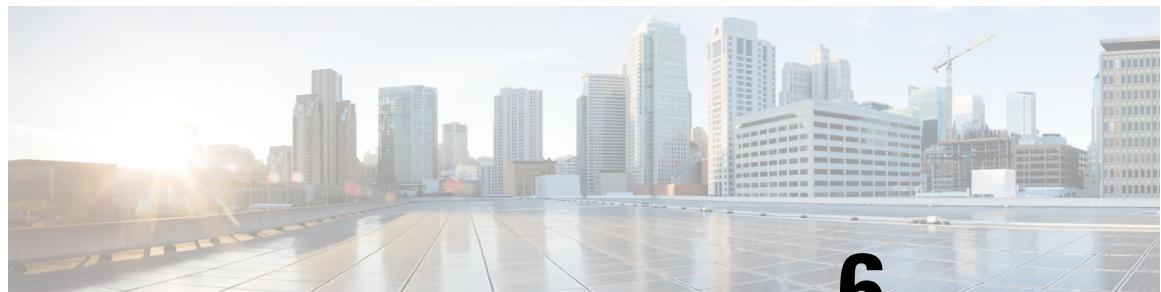
switch(config)# aaa group server tacacs+ TacServer1
switch(config-tacacs+)# server 1.1.1.1
switch(config-tacacs+)# server 1.1.1.2
```

Default Settings for TACACS+

The following table lists the default settings for TACACS+ parameters.

Table 7: Default TACACS+ Parameters

Parameters	Default
TACACS+	Disabled
Dead-time interval	0 minutes
Timeout interval	5 seconds
Idle timer interval	0 minutes
Periodic server monitoring username	test
Periodic server monitoring password	test



CHAPTER 6

Configuring SSH and Telnet

This chapter contains the following sections:

- [Information About SSH and Telnet, on page 61](#)
- [Guidelines and Limitations for SSH, on page 63](#)
- [Configuring SSH, on page 63](#)
- [Configuration Examples for SSH, on page 68](#)
- [Configuring X.509v3 Certificate-Based SSH Authentication, on page 69](#)
- [Configuration Example for X.509v3 Certificate-Based SSH Authentication, on page 71](#)
- [Configuring Telnet, on page 72](#)
- [Verifying the SSH and Telnet Configuration, on page 74](#)
- [Default Settings for SSH, on page 75](#)

Information About SSH and Telnet

SSH Server

The Secure Shell Protocol (SSH) server feature enables a SSH client to make a secure, encrypted connection to a Cisco Nexus device. SSH uses strong encryption for authentication. The SSH server in the Cisco Nexus device switch interoperates with publicly and commercially available SSH clients.

The user authentication mechanisms supported for SSH are RADIUS, TACACS+, and the use of locally stored user names and passwords.

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 switch to make a secure, encrypted connection to another Cisco Nexus device or to any other device running an SSH server. This connection provides an outbound connection that is encrypted. With authentication and encryption, the SSH client allows for a secure communication over an insecure network.

The SSH client in the Cisco Nexus device works with publicly and commercially available SSH servers.

SSH Server Keys

SSH requires server keys for secure communications to the Cisco Nexus device. You can use SSH keys for the following SSH options:

- SSH version 2 using Rivest, Shamir, and Adelman (RSA) public-key cryptography
- SSH version 2 using the Digital System Algorithm (DSA)

Be sure to have an SSH server key-pair with the appropriate version before enabling the SSH service. You can generate the SSH server key-pair according to the SSH client version used. The SSH service accepts three types of key-pairs for use by SSH version 2:

- The `dsa` option generates the DSA key-pair for the SSH version 2 protocol.
- The `rsa` option generates the RSA key-pair for the SSH version 2 protocol.

By default, the Cisco Nexus device generates an RSA key using 1024 bits.

SSH supports the following public key formats:

- OpenSSH
- IETF Secure Shell (SECSH)


Caution

If you delete all of the SSH keys, you cannot start the SSH services.

SSH Authentication Using Digital Certificates

SSH authentication on Cisco NX-OS devices provide X.509 digital certificate support for host authentication. An X.509 digital certificate is a data item that ensures the origin and integrity of a message. It contains encryption keys for secured communications and is signed by a trusted certification authority (CA) to verify the identity of the presenter. The X.509 digital certificate support provides either DSA or RSA algorithms for authentication.

The certificate infrastructure uses the first certificate that supports the Secure Socket Layer (SSL) and is returned by the security infrastructure, either through a query or a notification. Verification of certificates is successful if the certificates are from any of the trusted CAs.

You can configure your device for SSH authentication using an X.509 certificate. If the authentication fails, you are prompted for a password.

Telnet Server

The Telnet protocol enables TCP/IP connections to a host. Telnet allows a user at one site to establish a TCP connection to a login server at another site, and then passes the keystrokes from one system to the other. Telnet can accept either an IP address or a domain name as the remote system address.

The Telnet server is enabled by default on the Cisco Nexus device.

Guidelines and Limitations for SSH

SSH has the following configuration guidelines and limitations:

- The Cisco Nexus device supports only SSH version 2 (SSHv2).
- SSH public and private keys imported into user accounts that are remotely authenticated through a AAA protocol (such as RADIUS or TACACS+) for the purpose of SSH Passwordless File Copy will not persist when the Nexus device is reloaded unless a local user account with the same name as the remote user account is configured on the device before the SSH keys are imported.

Configuring SSH

Generating SSH Server Keys

You can generate an SSH server key based on your security requirements. The default SSH server key is an RSA key that is generated using 1024 bits.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	feature ssh Example: switch(config)# feature ssh	Enables SSH.
Step 3	switch(config)# exit	Exits global configuration mode.
Step 4	(Optional) show ssh key [dsa rsa] [] Example: switch# show ssh key	Displays the SSH server keys.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to generate an SSH server key:

```
switch# configure terminal
switch(config)# ssh key rsa 2048
switch(config)# exit
switch# show ssh key
switch# copy running-config startup-config
```

Specifying the SSH Public Keys for User Accounts

You can configure an SSH public key to log in using an SSH client without being prompted for a password. You can specify the SSH public key in one of three different formats:

- Open SSH format
- IETF SECSH format
- Public Key Certificate in PEM format

Specifying the SSH Public Keys in Open SSH Format

You can specify the SSH public keys in SSH format for user accounts.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# username username sshkey ssh-key	Configures the SSH public key in SSH format.
Step 3	switch(config)# exit	Exits global configuration mode.
Step 4	(Optional) switch# show user-account	Displays the user account configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to specify an SSH public key in open SSH format:

```
switch# configure terminal
switch(config)# username User1 sshkey ssh-rsa
AAAAAB3NzaC1yc2EAAABIAwAAAIEAri3mQy4W1AV9Y2t2hrEWgbUEYz
CfTPo5B8LRkedn563Ey2N9ZcdpqE6aqJLZwfZcTFEzaAAZp9AS86dgBAjsKGs7UxnhGySr8ZELv+DQBsDQH6rZt0KR+2Da8hJD4Z
XleccWk0gS1DQUNZ300xstQsYZUtqnx1bvm5Ninn0McNinn0Mc=
switch(config)# exit
switch# show user-account
switch# copy running-config startup-config
```



Note

The **username** command in the example above is a single line that has been broken for legibility.

Specifying the SSH Public Keys in IETF SECSH Format

You can specify the SSH public keys in IETF SECSH format for user accounts.

Procedure

	Command or Action	Purpose
Step 1	switch# copy server-file bootflash:filename	Downloads the file that contains the SSH key in IETF SECSH format from a server. The server can be FTP, SCP, SFTP, or TFTP.
Step 2	switch# configure terminal	Enters global configuration mode.
Step 3	switch(config)# username username sshkey file filename	Configures the SSH public key in SSH format.
Step 4	switch(config)# exit	Exits global configuration mode.
Step 5	(Optional) switch# show user-account	Displays the user account configuration.
Step 6	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to specify the SSH public key in the IETF SECSH format:

```
switch#copy tftp://10.10.1.1/secsh_file.pub bootflash:secsh_file.pub
switch# configure terminal
switch(config)# username User1 sshkey file bootflash:secsh_file.pub
switch(config)# exit
switch# show user-account
switch# copy running-config startup-config
```

Specifying the SSH Public Keys in PEM-Formatted Public Key Certificate Form

You can specify the SSH public keys in PEM-formatted Public Key Certificate form for user accounts.

Procedure

	Command or Action	Purpose
Step 1	switch# copy server-file bootflash:filename	Downloads the file that contains the SSH key in PEM-formatted Public Key Certificate form from a server. The server can be FTP, SCP, SFTP, or TFTP
Step 2	switch# configure terminal	Enters global configuration mode.
Step 3	(Optional) switch# show user-account	Displays the user account configuration.
Step 4	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to specify the SSH public keys in PEM-formatted public key certificate form:

```
switch# copy tftp://10.10.1.1/cert.pem bootflash:cert.pem
switch# configure terminal
switch# show user-account
switch# copy running-config startup-config
```

Configuring the SSH Source Interface

You can configure SSH to use a specific interface.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# ip ssh source-interface type slot/port	Configures the source interface for all SSH packets. The following list contains the valid values for <i>interface</i> . <ul style="list-style-type: none"> • ethernet • loopback • mgmt • port-channel • vlan
Step 3	switch(config)# show ip ssh source-interface	Displays the configured SSH source interface.

Example

This example shows how to configure the SSH source interface:

```
switch(config)# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
switch(config)# ip ssh source-interface ethernet 1/7
switch(config)# show ip ssh source-interface
VRF Name                                Interface
default                                     Ethernet1/7
```

Starting SSH Sessions to Remote Devices

You can start SSH sessions to connect to remote devices from your Cisco Nexus device.

Procedure

	Command or Action	Purpose
Step 1	switch# ssh {hostname username@hostname} [vrf vrf-name]	Creates an SSH session to a remote device. The <i>hostname</i> argument can be an IPv4 address or a hostname.

Clearing SSH Hosts

When you download a file from a server using SCP or SFTP, you establish a trusted SSH relationship with that server.

Procedure

	Command or Action	Purpose
Step 1	switch# clear ssh hosts	Clears the SSH host sessions.

Disabling the SSH Server

By default, the SSH server is enabled on the Cisco Nexus device.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# [no] feature ssh	Enables/disables the SSH server. The default is enabled.
Step 3	switch(config)# exit	Exits global configuration mode.
Step 4	(Optional) switch# show ssh server	Displays the SSH server configuration.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Deleting SSH Server Keys

You can delete SSH server keys after you disable the SSH server.



Note To reenable SSH, you must first generate an SSH server key.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# no feature ssh	Disables the SSH server.
Step 3	switch(config)# no ssh key [dsa rsa]	Deletes the SSH server key. The default is to delete all the SSH keys.
Step 4	switch(config)# exit	Exits global configuration mode.
Step 5	(Optional) switch# show ssh key	Displays the SSH server configuration.
Step 6	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Clearing SSH Sessions

You can clear SSH sessions from the Cisco Nexus device.

Procedure

	Command or Action	Purpose
Step 1	switch# show users	Displays user session information.
Step 2	switch# clear line vty-line	Clears a user SSH session.

Configuration Examples for SSH

The following example shows how to configure SSH:

Procedure

-
- Step 1** Generate an SSH server key.

```
switch(config)# ssh key rsa
generating rsa key(1024 bits).....
.
generated rsa key
```

- Step 2** Enable the SSH server.

```
switch# configure terminal
switch(config)# feature ssh
```

Note This step should not be required because the SSH server is enabled by default.

Step 3 Display the SSH server key.

```
switch(config) # show ssh key
rsa Keys generated:Fri May  8 22:09:47 2009

ssh-rsa
AAAAB3NzaC1yc2EAAAABIwAAAIEAri3mQy4W1AV9Y2t2hrEWgbUEYzCfTP05B8LRkedn56BEy2N9ZcdpqE6aqJLzwfZ/
cTFEzaAAZp9AS86dgBAjsKGs7UxnhGySr8ZELv+DQBsDQH6rZt0KR+2Da8hJD4ZXIeccWk0gS1DQUNZ300xstQsYZUtqnx1bvm5/
Ninn0Mc=>

bitcount:1024
fingerprint:
4b:4d:f6:b9:42:e9:d9:71:3c:bd:09:94:4a:93:ac:ca
*****
could not retrieve dsa key information
*****
```

Step 4 Specify the SSH public key in Open SSH format.

```
switch(config) # username User1 sshkey ssh-rsa
AAAAB3NzaC1yc2EAAAABIwAAAIEAri3mQy4W1AV9Y2t2hrEWgbUEYz
CfTP05B8LRkedn56BEy2N9ZcdpqE6aqJLzwfZcTFEzaAAZp9AS86dgBAjsKGs7UxnhGySr8ZELv+DQBsDQH6rZt0KR+2Da8hJD4Z
XIeccWk0gS1DQUNZ300xstQsYZUtqnx1bvm5Ninn0McNinn0Mc=
```

Step 5 Save the configuration.

```
switch(config) # copy running-config startup-config
```

Configuring X.509v3 Certificate-Based SSH Authentication

You can configure SSH authentication using X.509v3 certificates.

Before you begin

Enable the SSH server on the remote device.

Procedure

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

	Command or Action	Purpose
	switch# configure terminal switch(config)#	
Step 2	username user-id [password [0 5] password] Example: <pre>switch(config)# username jsmith password 4Tyl8Rnt</pre>	<p>Configures a user account. The <i>user-id</i> argument is a case-sensitive, alphanumeric character string with a maximum length of 28 characters. Valid characters are uppercase letters A through Z, lowercase letters a through z, numbers 0 through 9, hyphen (-), period (.), underscore (_), plus sign (+), and equal sign (=). The at symbol (@) is supported in remote usernames but not in local usernames.</p> <p>Usernames must begin with an alphanumeric character.</p> <p>The default password is undefined. The 0 option indicates that the password is clear text, and the 5 option indicates that the password is encrypted. The default is 0 (clear text).</p> <p>Note If you do not specify a password, the user might not be able to log in to the Cisco NX-OS device.</p> <p>Note If you create a user account with the encrypted password option, the corresponding SNMP user will not be created.</p>
Step 3	username user-id ssh-cert-dn dn-name {dsa rsa} Example: <pre>switch(config)# username jsmith ssh-cert-dn "/O = ABCcompany, OU = ABC1, emailAddress = jsmith@ABCcompany.com, L = Metropolis, ST = New York, C = US, CN = jsmith" rsa</pre>	Specifies an SSH X.509 certificate distinguished name and DSA or RSA algorithm to use for authentication for an existing user account. The distinguished name can be up to 512 characters and must follow the format shown in the examples. Make sure the email address and state are configured as emailAddress and ST, respectively.
Step 4	[no] crypto ca trustpoint trustpoint Example: <pre>switch(config)# crypto ca trustpoint winca</pre>	Configures a trustpoint.
Step 5	[no] crypto ca authentication trustpoint Example: <pre>switch(config)# crypto ca authentication winca</pre>	Configures a certificate chain for the trustpoint.
Step 6	crypto ca crl request trustpoint bootflash:static-crl.crl	Configures the certificate revocation list (CRL) for the trustpoint. The CRL file is a snapshot

	Command or Action	Purpose
	Example: <pre>switch(config)# crypto ca crl request winca bootflash:crllist.crl</pre>	of the list of revoked certificates by the trustpoint. This static CRL list is manually copied to the device from the Certification Authority (CA). Note Static CRL is the only supported revocation check method.
Step 7	(Optional) show crypto ca certificates Example: <pre>switch(config)# show crypto ca certificates</pre>	Displays the configured certificate chain and associated trustpoint.
Step 8	(Optional) show crypto ca crl trustpoint Example: <pre>switch(config)# show crypto ca crl winca</pre>	Displays the contents of the CRL list of the specified trustpoint.
Step 9	(Optional) show user-account Example: <pre>switch(config)# show user-account</pre>	Displays configured user account details.
Step 10	(Optional) show users Example: <pre>switch(config)# show users</pre>	Displays the users logged into the device.
Step 11	(Optional) copy running-config startup-config Example: <pre>switch(config)# copy running-config startup-config</pre>	Copies the running configuration to the startup configuration.

Configuration Example for X.509v3 Certificate-Based SSH Authentication

The following example shows how to configure SSH authentication using X.509v3 certificates:

```
configure terminal
username jsmith password 4Ty18Rnt
username jsmith ssh-cert-dn "/O = ABCcompany, OU = ABC1,
emailAddress = jsmith@ABCcompany.com, L = Metropolis, ST = New York, C = US, CN = jsmith"
rsa
crypto ca trustpoint tp1
crypto ca authentication tp1
crypto ca crl request tp1 bootflash:crl1.crl

show crypto ca certificates
Trustpoint: tp1
CA certificate 0:
```

```

subject= /CN=SecDevCA
issuer= /CN=SecDevCA
serial=01AB02CD03EF04GH05IJ06KL07MN
notBefore=Jun 29 12:36:26 2016 GMT
notAfter=Jun 29 12:46:23 2021 GMT
SHA1 Fingerprint=47:29:E3:00:C1:C1:47:F2:56:8B:AC:B2:1C:64:48:FC:F4:8D:53:AF
purposes: sslserver sslclient

show crypto ca crl tp1
Trustpoint: tp1 CRL: Certificate Revocation List (CRL):
    Version 2 (0x1)
    Signature Algorithm: sha1WithRSAEncryption
    Issuer: /CN=SecDevCA
    Last Update: Aug 8 20:03:15 2016 GMT
    Next Update: Aug 16 08:23:15 2016 GMT
    CRL extensions:
        X509v3 Authority Key Identifier:
            keyid:30:43:AA:80:10:FE:72:00:DE:2F:A2:17:E4:61:61:44:CE:78:FF:2A

show user-account
user:user1
    this user account has no expiry date
    roles:network-operator
    ssh cert DN : /C = US, ST = New York, L = Metropolis, O = cisco , OU = csg, CN =
user1; Algo: x509v3-sign-rsa

show users
NAME      LINE      TIME      IDLE      PID      COMMENT
user1     pts/1     Jul 27 18:43  00:03    18796    (10.10.10.1) session=ssh

```

Configuring Telnet

Enabling the Telnet Server

By default, the Telnet server is enabled. You can disable the Telnet server on your Cisco Nexus device.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# [no] feature telnet	Enables/disables the Telnet server. The default is enabled.

Reenabling the Telnet Server

If the Telnet server on your Cisco Nexus device has been disabled, you can reenable it.

Procedure

	Command or Action	Purpose
Step 1	switch(config)# [no] feature telnet	Reenables the Telnet server.

Configuring the Telnet Source Interface

You can configure Telnet to use a specific interface.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# ip telnet source-interface type slot/port	Configures the source interface for all Telnet packets. The following list contains the valid values for <i>interface</i> . <ul style="list-style-type: none"> • ethernet • loopback • mgmt • port-channel • vlan

Example

This example shows how to configure the Telnet source interface:

```
switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
switch(config)# ip telnet source-interface ethernet 1/6
switch(config)# show ip telnet source-interface
VRF Name                               Interface
default                                Ethernet1/6
switch(config) #
```

Starting Telnet Sessions to Remote Devices

Before you start a Telnet session to connect to remote devices, you should do the following:

- Obtain the hostname for the remote device and, if needed, obtain the username on the remote device.
- Enable the Telnet server on the Cisco Nexus device.
- Enable the Telnet server on the remote device.

Procedure

	Command or Action	Purpose
Step 1	switch# telnet hostname	Creates a Telnet session to a remote device. The <i>hostname</i> argument can be an IPv4 address, an IPv6 address, or a device name.

Example

The following example shows how to start a Telnet session to connect to a remote device:

```
switch# telnet 10.10.1.1
Trying 10.10.1.1...
Connected to 10.10.1.1.
Escape character is '^].
switch login:
```

Clearing Telnet Sessions

You can clear Telnet sessions from the Cisco Nexus device.

Procedure

	Command or Action	Purpose
Step 1	switch# show users	Displays user session information.
Step 2	switch# clear line <i>vty-line</i>	Clears a user Telnet session.

Verifying the SSH and Telnet Configuration

To display the SSH configuration information, perform one of the following tasks:

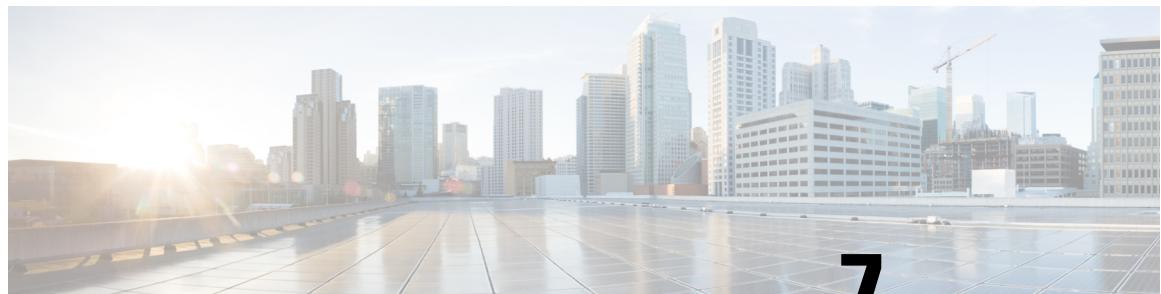
Command or Action	Purpose
switch# show ssh key [dsa rsa][md5]	Displays SSH server keys.
switch# show running-config security [all]	Displays the SSH and user account configuration in the running configuration. The all keyword displays the default values for the SSH and user accounts.
switch# show ssh server	Displays the SSH server configuration.
switch# show user-account	Displays user account information.
switch# show users	Displays the users logged into the device.
switch# show crypto ca certificates	Displays the configured certificate chain and associated trustpoint for X.509v3 certificate-based SSH authentication.
switch# show crypto ca crt <i>trustpoint</i>	Displays the contents of the CRL list of the specified trustpoint for X.509v3 certificate-based SSH authentication.

Default Settings for SSH

The following table lists the default settings for SSH parameters.

Table 8: Default SSH Parameters

Parameters	Default
SSH server	Enabled
SSH server key	RSA key generated with 1024 bits
RSA key bits for generation	1024
Telnet server	Disabled



CHAPTER 7

Configuring PKI

This chapter contains the following sections:

- [Information About PKI, on page 77](#)
- [Licensing Requirements for PKI, on page 81](#)
- [Guidelines and Limitations for PKI, on page 81](#)
- [Default Settings for PKI, on page 82](#)
- [Configuring CAs and Digital Certificates, on page 82](#)
- [Verifying the PKI Configuration, on page 96](#)
- [Configuration Examples for PKI, on page 96](#)

Information About PKI

This section provides information about PKI.

CAs and Digital Certificates

Certificate authorities (CAs) manage certificate requests and issue certificates to participating entities such as hosts, network devices, or users. The CAs provide centralized key management for the participating entities.

Digital signatures, based on public key cryptography, digitally authenticate devices and individual users. In public key cryptography, such as the RSA encryption system, each device or user has a key pair that contains both a private key and a public key. The private key is kept secret and is known only to the owning device or user only. However, the public key is known to everybody. Anything encrypted with one of the keys can be decrypted with the other. A signature is formed when data is encrypted with a sender's private key. The receiver verifies the signature by decrypting the message with the sender's public key. This process relies on the receiver having a copy of the sender's public key and knowing with a high degree of certainty that it really does belong to the sender and not to someone pretending to be the sender.

Digital certificates link the digital signature to the sender. 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 CA that signs the certificate is a third party that the receiver explicitly trusts 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. Typically, 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.

Trust Model, Trust Points, and Identity CAs

The PKI trust model is hierarchical with multiple configurable trusted CAs. You can configure each participating device with a list of trusted CAs so that a peer certificate obtained during the security protocol exchanges can be authenticated if it was issued by one of the locally trusted CAs. The Cisco NX-OS software locally stores the self-signed root certificate of the trusted CA (or certificate chain for a subordinate CA). The process of securely obtaining a trusted CA's root certificate (or the entire chain in the case of a subordinate CA) and storing it locally is called *CA authentication*.

The information about a trusted CA that you have configured is called the *trust point* and the CA itself is called a *trust point CA*. This information consists of a CA certificate (or certificate chain in case of a subordinate CA) and certificate revocation checking information.

The Cisco NX-OS device can also enroll with a trust point to obtain an identity certificate to associate with a key pair. This trust point is called an *identity CA*.

RSA Key Pairs and Identity Certificates

You can obtain an identity certificate by generating one or more RSA key pairs and associating each RSA key pair with a trust point CA where the Cisco NX-OS device intends to enroll. The Cisco NX-OS device needs only one identity per CA, which consists of one key pair and one identity certificate per CA.

The Cisco NX-OS software allows you to generate RSA key pairs with a configurable key size (or modulus). The default key size is 512. You can also configure an RSA key-pair label. The default key label is the device fully qualified domain name (FQDN).

The following list summarizes the relationship between trust points, RSA key pairs, and identity certificates:

- A trust point corresponds to a specific CA that the Cisco NX-OS device trusts for peer certificate verification for any application (such as SSH).
- A Cisco NX-OS device can have many trust points and all applications on the device can trust a peer certificate issued by any of the trust point CAs.
- A trust point is not restricted to a specific application.
- A Cisco NX-OS device enrolls with the CA that corresponds to the trust point to obtain an identity certificate. You can enroll your device with multiple trust points which means that you can obtain a separate identity certificate from each trust point. The identity certificates are used by applications depending upon the purposes specified in the certificate by the issuing CA. The purpose of a certificate is stored in the certificate as a certificate extension.
- When enrolling with a trust point, you must specify an RSA key pair to be certified. This key pair must be generated and associated to the trust point before generating the enrollment request. The association between the trust point, key pair, and identity certificate is valid until it is explicitly removed by deleting the certificate, key pair, or trust point.
- The subject name in the identity certificate is the fully qualified domain name for the Cisco NX-OS device.
- You can generate one or more RSA key pairs on a device and each can be associated to one or more trust points. But no more than one key pair can be associated to a trust point, which means only one identity certificate is allowed from a CA.
- If the Cisco NX-OS device obtains multiple identity certificates (each from a distinct CA), the certificate that an application selects to use in a security protocol exchange with a peer is application specific.

- You do not need to designate one or more trust points for an application. Any application can use any certificate issued by any trust point as long as the certificate purpose satisfies the application requirements.
- You do not need more than one identity certificate from a trust point or more than one key pair to be associated to a trust point. A CA certifies a given identity (or name) only once and does not issue multiple certificates with the same name. If you need more than one identity certificate for a CA and if the CA allows multiple certificates with the same names, you must define another trust point for the same CA, associate another key pair to it, and have it certified.

Multiple Trusted CA Support

The Cisco NX-OS device can trust multiple CAs by configuring multiple trust points and associating each with a distinct CA. With multiple trusted CAs, you do not have to enroll a device with the specific CA that issued the certificate to a peer. Instead, you can configure the device with multiple trusted CAs that the peer trusts. The Cisco NX-OS device can then use a configured trusted CA to verify certificates received from a peer that were not issued by the same CA defined in the identity of the peer device.

PKI Enrollment Support

Enrollment is the process of obtaining an identity certificate for the device that is used for applications like SSH. It occurs between the device that requests the certificate and the certificate authority.

The Cisco NX-OS device performs the following steps when performing the PKI enrollment process:

- Generates an RSA private and public key pair on the device.
- Generates a certificate request in standard format and forwards it to the CA.

**Note**

The CA administrator may be required to manually approve the enrollment request at the CA server, when the request is received by the CA.

- Receives the issued certificate back from the CA, signed with the CA's private key.
- Writes the certificate into a nonvolatile storage area on the device (bootflash).

Manual Enrollment Using Cut-and-Paste

The Cisco NX-OS software supports certificate retrieval and enrollment using manual cut-and-paste. Cut-and-paste enrollment means that you must cut and paste the certificate requests and resulting certificates between the device and the CA.

You must perform the following steps when using cut and paste in the manual enrollment process:

- Create an enrollment certificate request, which the Cisco NX-OS device displays in base64-encoded text form.
- Cut and paste the encoded certificate request text in an e-mail or in a web form and send it to the CA.
- Receive the issued certificate (in base64-encoded text form) from the CA in an e-mail or in a web browser download.

Multiple RSA Key Pair and Identity CA Support

- Cut and paste the issued certificate to the device using the certificate import facility.

Multiple RSA Key Pair and Identity CA Support

Multiple identity CAs enable the device to enroll with more than one trust point, which results in multiple identity certificates, each from a distinct CA. With this feature, the Cisco NX-OS device can participate in SSH and other applications with many peers using certificates issued by CAs that are acceptable to those peers.

The multiple RSA key-pair feature allows the device to maintain a distinct key pair for each CA with which it is enrolled. It can match policy requirements for each CA without conflicting with the requirements specified by the other CAs, such as the key length. The device can generate multiple RSA key pairs and associate each key pair with a distinct trust point. Thereafter, when enrolling with a trust point, the associated key pair is used to construct the certificate request.

Peer Certificate Verification

The PKI support on a Cisco NX-OS device can verify peer certificates. The Cisco NX-OS software verifies certificates received from peers during security exchanges for applications, such as SSH. The applications verify the validity of the peer certificates. The Cisco NX-OS software performs the following steps when verifying peer certificates:

- Verifies that the peer certificate is issued by one of the locally trusted CAs.
- Verifies that the peer certificate is valid (not expired) with respect to current time.
- Verifies that the peer certificate is not yet revoked by the issuing CA.

For revocation checking, the Cisco NX-OS software supports the certificate revocation list (CRL). A trust point CA can use this method to verify that the peer certificate has not been revoked.

Certificate Revocation Checking

The Cisco NX-OS software can check the revocation status of CA certificates. The applications can use the revocation checking mechanisms in the order that you specify. The choices are CRL, none, or a combination of these methods.

CRL Support

The CAs maintain certificate revocation lists (CRLs) to provide information about certificates revoked prior to their expiration dates. The CAs publish the CRLs in a repository and provide the download public URL in all issued certificates. A client verifying a peer's certificate can obtain the latest CRL from the issuing CA and use it to determine if the certificate has been revoked. A client can cache the CRLs of some or all of its trusted CAs locally and use them later if necessary until the CRLs expire.

The Cisco NX-OS software allows the manual configuration of predownloaded CRLs for the trust points, and then caches them in the device bootflash (cert-store). During the verification of a peer certificate, the Cisco NX-OS software checks the CRL from the issuing CA only if the CRL has already been cached locally and the revocation checking is configured to use the CRL. Otherwise, the Cisco NX-OS software does not perform CRL checking and considers the certificate to be not revoked unless you have configured other revocation checking methods.

Import and Export Support for Certificates and Associated Key Pairs

As part of the CA authentication and enrollment process, the subordinate CA certificate (or certificate chain) and identity certificates can be imported in standard PEM (base64) format.

The complete identity information in a trust point can be exported to a file in the password-protected PKCS#12 standard format. It can be later imported to the same device (for example, after a system crash) or to a replacement device. The information in a PKCS#12 file consists of the RSA key pair, the identity certificate, and the CA certificate (or chain).

Licensing Requirements for PKI

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	The PKI feature requires no license. Any feature not included in a license package is bundled with the Cisco NX-OS system images and is provided at no extra charge to you. For an explanation of the Cisco NX-OS licensing scheme, see the <i>Cisco NX-OS Licensing Guide</i> .

Guidelines and Limitations for PKI

PKI has the following configuration guidelines and limitations:

- The maximum number of key pairs you can configure on a Cisco NX-OS device is 16.
- The maximum number of trust points you can declare on a Cisco NX-OS device is 16.
- The maximum number of identify certificates you can configure on a Cisco NX-OS device is 16.
- The maximum number of certificates in a CA certificate chain is 10.
- The maximum number of trust points you can authenticate to a specific CA is 10.
- Configuration rollbacks do not support the PKI configuration.
- The Cisco NX-OS software does not support OSCP.

**Note**

If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Default Settings for PKI

This table lists the default settings for PKI parameters.

Table 9: Default PKI Parameters

Parameters	Default
Trust point	None
RSA key pair	None
RSA key-pair label	Device FQDN
RSA key-pair modulus	512
RSA key-pair exportable	Enabled
Revocation check method	CRL

Configuring CAs and Digital Certificates

This section describes the tasks that you must perform to allow CAs and digital certificates on your Cisco NX-OS device to interoperate.

Configuring the Hostname and IP Domain Name

You must configure the hostname and IP domain name of the device if you have not yet configured them because the Cisco NX-OS software uses the fully qualified domain name (FQDN) of the device as the subject in the identity certificate. Also, the Cisco NX-OS software uses the device FQDN as a default key label when you do not specify a label during key-pair generation. For example, a certificate named DeviceA.example.com is based on a device hostname of DeviceA and a device IP domain name of example.com.



Caution Changing the hostname or IP domain name after generating the certificate can invalidate the certificate.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config) #</pre>	Enters global configuration mode.

	Command or Action	Purpose
Step 2	hostname <i>hostname</i> Example: switch(config)# hostname DeviceA	Configures the hostname of the device.
Step 3	ip domain-name <i>name</i> [use-vrf <i>vrf-name</i>] Example: DeviceA(config)# ip domain-name example.com	Configures the IP domain name of the device. If you do not specify a VRF name, the command uses the default VRF.
Step 4	exit Example: switch(config)# exit switch#	Exits configuration mode.
Step 5	(Optional) show hosts Example: switch# show hosts	Displays the IP domain name.
Step 6	(Optional) copy running-config startup-config Example: switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Generating an RSA Key Pair

You can generate an RSA key pairs to sign and/or encrypt and decrypt the security payload during security protocol exchanges for applications. You must generate the RSA key pair before you can obtain a certificate for your device.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#[/td> <td>Enters global configuration mode.</td>	Enters global configuration mode.
Step 2	crypto key generate rsa [label <i>label-string</i>] [exportable] [modulus <i>size</i>] Example: switch(config)# crypto key generate rsa exportable	Generates an RSA key pair. The maximum number of key pairs on a device is 16. The label string is alphanumeric, case sensitive, and has a maximum length of 64 characters. The default label string is the hostname and the FQDN separated by a period character (.). Valid modulus values are 512, 768, 1024, 1536, and 2048. The default modulus size is 512.

	Command or Action	Purpose
		<p>Note The security policy on the Cisco NX-OS device and on the CA (where enrollment is planned) should be considered when deciding the appropriate key modulus.</p> <p>By default, the key pair is not exportable. Only exportable key pairs can be exported in the PKCS#12 format.</p> <p>Caution You cannot change the exportability of a key pair.</p>
Step 3	exit Example: switch(config)# exit switch#	Exits configuration mode.
Step 4	(Optional) show crypto key mypubkey rsa Example: switch# show crypto key mypubkey rsa	Displays the generated key.
Step 5	(Optional) copy running-config startup-config Example: switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Creating a Trust Point CA Association

You must associate the Cisco NX-OS device with a trust point CA.

Before you begin

Generate the RSA key pair.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.
Step 2	crypto ca trustpoint name Example:	Declares a trust point CA that the device should trust and enters trust point configuration mode.

	Command or Action	Purpose
	<pre>switch(config)# crypto ca trustpoint admin-ca switch(config-trustpoint)#{/pre></pre>	Note The maximum number of trust points that you can configure on a device is 16.
Step 3	enrollment terminal Example: <pre>switch(config-trustpoint)# enrollment terminal{/pre></pre>	Enables manual cut-and-paste certificate enrollment. The default is enabled. Note The Cisco NX-OS software supports only the manual cut-and-paste method for certificate enrollment.
Step 4	rsakeypair label Example: <pre>switch(config-trustpoint)# rsakeypair SwitchA{/pre></pre>	Specifies the label of the RSA key pair to associate to this trust point for enrollment. Note You can specify only one RSA key pair per CA.
Step 5	exit Example: <pre>switch(config-trustpoint)# exit switch(config)#{/pre></pre>	Exits trust point configuration mode.
Step 6	(Optional) show crypto ca trustpoints Example: <pre>switch(config)# show crypto ca trustpoints{/pre></pre>	Displays trust point information.
Step 7	(Optional) copy running-config startup-config Example: <pre>switch(config)# copy running-config startup-config{/pre></pre>	Copies the running configuration to the startup configuration.

Authenticating the CA

The configuration process of trusting a CA is complete only when the CA is authenticated to the Cisco NX-OS device. You must authenticate your Cisco NX-OS device to the CA by obtaining the self-signed certificate of the CA in PEM format, which contains the public key of the CA. Because the certificate of the CA is self-signed (the CA signs its own certificate) the public key of the CA should be manually authenticated by contacting the CA administrator to compare the fingerprint of the CA certificate.



Note The CA that you are authenticating is not a self-signed CA when it is a subordinate CA to another CA, which itself may be a subordinate to yet another CA, and so on, finally ending in a self-signed CA. This type of CA certificate is called the *CA certificate chain* of the CA being authenticated. In this case, you must input the full list of the CA certificates of all the CAs in the certification chain during the CA authentication. The maximum number of certificates in a CA certificate chain is 10.

Before you begin

Create an association with the CA.

Obtain the CA certificate or CA certificate chain.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config) #</pre>	Enters global configuration mode.
Step 2	crypto ca authenticate name Example: <pre>switch(config)# crypto ca authenticate admin-ca input (cut & paste) CA certificate (chain) in PEM format; end the input with a line containing only END OF INPUT : -----BEGIN CERTIFICATE----- MIIC4jCCaygAwIBAgIQWdSizyGCRESRUjK0zeIANBjkjhkiGwCEQUEAD kDExB4CCsGSIb3DQNTARYRWhnRzLBjaNjb5j20xCABjNWAYTAK0 MRIWAYDQjBvIYXJuXRA2xEjAQBjWAcICUhndhG9yZIEOAqAUIE chMj21zY28E2ABjWAS0t5ldHn03jH21xEjAQBjWAcICUhndhG9yZIEOAqAUIE QjPeFw0NIAIMM4MjQ2MdaFw0NzAMMMjUIMCgMICQMAhjkKz2hN AjEshFhFUGlQNgp2MvnbjELMA1EBMCU4EjAQBjWAcICUhndhG9yZIEOAqAUIE arhdGPyIDESMACAUeB+MQFUZFSb3JIM04wDAYDQjBwDwAjocZEMEG A1ECAxMarVc3RdnfZIESMACAUeB+MQFUZFSb3JIM04wDAYDQjBwDwAjocZEMEG AQBHQADSsA8AEPMW7b3DKJFNBsIHzLncm87yzzwuSNZOMpeRXI OzyPgjxt2ASFUwQ1iDMR0/41jfrwWky5CwFAaOBzCBDAEgWQ8E EAVCaWDMVR0TQH/FAjwAEB/zbjNMQERQujyjPmDmCMU2qRq GsjWHeavMDR0FBQwja0QyKoYcaH0DwI3zz00C9D2X0W5j2xs I0RwxJiSuMNEInnyjDw0C6jLYqmlsZIov1LccCN1UT4XNlcrRhuJv bGcQPhmftJUQ0Ei3JSMAGCCsGAQBjvAQQgFMA0CCsGSIb3DQE EQAAOFAm6QhRE399tw+KcQ0g0NLjaqbjhAFc10Eyuyt/WGP2ksFEa NBG7E0oN66zex0EOEfG1Vs6mXp1//w== -----END CERTIFICATE----- END OF INPUT Fingerprint(s): MD5 Fingerprint=65:84:9A:27:D5:71:03:33:9C:12:23:92:38:6F:78:12 Do you accept this certificate? [yes/no]: yes</pre>	Prompts you to cut and paste the certificate of the CA. Use the same name that you used when declaring the CA. The maximum number of trust points that you can authenticate to a specific CA is 10. <p>Note For subordinate CA authentication, the Cisco NX-OS software requires the full chain of CA certificates ending in a self-signed CA because the CA chain is needed for certificate verification as well as for PKCS#12 format export.</p>
Step 3	exit Example: <pre>switch(config)# exit switch#</pre>	Exits configuration mode.
Step 4	(Optional) show crypto ca trustpoints Example: <pre>switch# show crypto ca trustpoints</pre>	Displays the trust point CA information.

	Command or Action	Purpose
Step 5	(Optional) copy running-config startup-config Example: switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring Certificate Revocation Checking Methods

During security exchanges with a client (for example, an SSH user), the Cisco NX-OS device performs the certificate verification of the peer certificate sent by the client. The verification process may involve certificate revocation status checking.

You can configure the device to check the CRL downloaded from the CA. Downloading the CRL and checking locally does not generate traffic in your network. However, certificates can be revoked between downloads and your device would not be aware of the revocation.

Before you begin

Authenticate the CA.

Ensure that you have configured the CRL if you want to use CRL checking.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	crypto ca trustpoint name Example: switch(config)# crypto ca trustpoint admin-ca switch(config-trustpoint)#	Specifies a trust point CA and enters trust point configuration mode.
Step 3	revocation-check {crl [none] none} Example: switch(config-trustpoint)# revocation-check none	Configures the certificate revocation checking methods. The default method is crl . The Cisco NX-OS software uses the certificate revocation methods in the order that you specify.
Step 4	exit Example: switch(config-trustpoint)# exit switch(config)#	Exits trust point configuration mode.

	Command or Action	Purpose
Step 5	(Optional) show crypto ca trustpoints Example: switch(config)# show crypto ca trustpoints	Displays the trust point CA information.
Step 6	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Generating Certificate Requests

You must generate a request to obtain identity certificates from the associated trust point CA for each of your device's RSA key pairs. You must then cut and paste the displayed request into an e-mail or in a website form for the CA.

Before you begin

Create an association with the CA.

Obtain the CA certificate or CA certificate chain.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	crypto ca enroll name Example: switch(config)# crypto ca enroll admin-ca Create the certificate request .. 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:nbv123 The subject name in the certificate will be: DeviceA.cisco.com Include the switch serial number in the subject name? [yes/no]: no Include an IP address in the subject name [yes/no]: yes ip address:172.22.31.162 The certificate request will be displayed...	Generates a certificate request for an authenticated CA. Note You must remember the challenge password. It is not saved with the configuration. You must enter this password if your certificate needs to be revoked.

	Command or Action	Purpose
	-----BEGIN CERTIFICATE REQUEST----- MIIBBzCCAPQDQwHEMBGAIUEAxMRMhYMMMS5jaXNjb5jb20wgZ8vDQJ KzTlhwNQERQADj0MTGPaCBL81CA2NC7W1Dva8qNtg2k2r14IK OJOMarNy4qk8veMZSiLJ4gtzWdkiDKITysnjUCGrjbwj0Ehv/y5IT9 PNU8mcg8rvFZg7ySNPjMKcgzbpbj+targ0HGJ91Xlq4bVSC2Ae3 VgAOBuAgEPAGj2ABjgkdgCwECQcQMGm2M112DGCSgsb3Dg DfEMCaQJDROACH/Bs/GYTRhMyMMMS5jaXNjb5jb22ERWh61DQJ KzTlhwNQERQADj0EAK160ER6Q8rj0sDXMHSfJz66tD23cb99G1FWt PfrnWLE/pw8HytQ2T3egNel2d15133yF2bkExiT6018nTOjglXmjja 8s23Dpn8sBrdwA9NkrV18NZEFUwpjfngRN7acJUS82qPMetkytk0 -----END CERTIFICATE REQUEST-----	
Step 3	exit Example: <pre>switch(config-trustpoint)# exit switch(config) #</pre>	Exits trust point configuration mode.
Step 4	(Optional) show crypto ca certificates Example: <pre>switch(config) # show crypto ca certificates</pre>	Displays the CA certificates.
Step 5	(Optional) copy running-config startup-config Example: <pre>switch(config) # copy running-config startup-config</pre>	Copies the running configuration to the startup configuration.

Installing Identity Certificates

You can receive the identity certificate from the CA by e-mail or through a web browser in base64 encoded text form. You must install the identity certificate from the CA by cutting and pasting the encoded text.

Before you begin

Create an association with the CA.

Obtain the CA certificate or CA certificate chain.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config) #</pre>	Enters global configuration mode.
Step 2	crypto ca import name certificate Example:	Prompts you to cut and paste the identity certificate for the CA named admin-ca.

Ensuring Trust Point Configurations Persist Across Reboots

	Command or Action	Purpose
	<pre>switch(config)# crypto ca import admin-ca certificate input (cut & paste) certificate in PEM format: -----BEGIN CERTIFICATE----- MIIEADCCAggCgIQCj00QAAAQDANBjghidG9wEAQUD03kdgM4G CSgsIb3DQEARYRWhPzLBjaNjb5j20xCABNBVAYTAKlOMRtFAYD VQOjEWlyXUYXPa2E5jQBmBaCUCUhrhbg9yZEMoWCAUEChM921z Y28Ne2PR9NMAstGt6ldH0b3jhZ2UEjQBmWBAMICUFWXJUSeDQjAeF0 NIEMTiMzAyNDBzF0WnJEMiTWEjNDBmBwGjAYBjNBMiE512ZFz1E1 Y21z20a29MIGMA0Cs3gs1b3DQEFAQAA4NADBiQk8jGQACqjQ41C dQWjkjS1Cq1fGgBnNQjgpaJkZExjD2joiyeCgBylnWwED08r47 glxr42/s19IRlb/3uL/cj9jSSP456ca7WMA8nd2jMCHM4lAv/c294b x7Rifz/06PqZEq517Elash9LxLwIDQ9B41CEzCC49wJQDVRQH/BSw G1RmhyWMMS5jaNjjo5j22EWWh6lWQDVR0EMEFCLi+2spWFgjR bWmLVoj9jnMIBgjMSEBgQgGFCo8kDD6wJEMjskUBoFrrwoG/ pICMIGQAhyKcZThvDNQEFfFhDfRZG1Qjpc2WmNtHtHtIAUfE BmcS4xEjABBNMBAfCUthmhdGFYMEVAG1UEBMMQHfz2fs3JIMQ4w DAYDQKEWdAnjzbEMFALCmknv0c3vcrFZIESMAC1UEAxMQkH cnfjENBjAFNkjHjQ2jE9EjWMr16McGA1UCHRMGlwpsoCgKh0fH4 Iy9zc2tMdyQ2ydcEVicr9abCBcGjbnElmjEDQSjcnwM7AxoyGfrzbGJ8 Iy9cHbzZ0wOF4DX0Fw5j2xsSEFWXJUJSjMNEInNyjD0igTRWEQH AQEEjBMsCCsQAUFBzCh9cdRw018vc3LT4T1NlcRhnjtGwc3Nl LTF40FwXUJySjMNEInyjDA9BjgBjEEQowoyZmlsZl0v1xxc3NLT4 XEnlcRhnjtGwc3NLT4QFwXJUjSjMNEInyjDA9BjgkqjkgwBQH ANBd0G5be7G1h9sOWBn24U69Z3uDcoDZUlgp1j0PyejtsyfW E36cIZu4WsExREqxbTk8ycx7V5o= -----END CERTIFICATE-----</pre>	The maximum number of identify certificates that you can configure on a device is 16.
Step 3	exit Example: <pre>switch(config)# exit switch#</pre>	Exits configuration mode.
Step 4	(Optional) show crypto ca certificates Example: <pre>switch# show crypto ca certificates</pre>	Displays the CA certificates.
Step 5	(Optional) copy running-config startup-config Example: <pre>switch# copy running-config startup-config</pre>	Copies the running configuration to the startup configuration.

Ensuring Trust Point Configurations Persist Across Reboots

You can ensure that the trustpoint configuration persists across Cisco NX-OS device reboots.

The trust point configuration is a normal Cisco NX-OS device configuration that persists across system reboots only if you copy it explicitly to the startup configuration. The certificates, key pairs, and CRL associated with a trust point are automatically persistent if you have already copied the trust point configuration in the startup configuration. Conversely, if the trust point configuration is not copied to the startup configuration, the certificates, key pairs, and CRL associated with it are not persistent since they require the corresponding trust point configuration after a reboot. Always copy the running configuration to the startup configuration to ensure

that the configured certificates, key pairs, and CRLs are persistent. Also, save the running configuration after deleting a certificate or key pair to ensure that the deletions permanent.

The certificates and CRL associated with a trust point automatically become persistent when imported (that is, without explicitly copying to the startup configuration) if the specific trust point is already saved in startup configuration.

We recommend that you create a password-protected backup of the identity certificates and save it to an external server.



Note Copying the configuration to an external server does include the certificates and key pairs.

Exporting Identity Information in PKCS 12 Format

You can export the identity certificate along with the RSA key pair and CA certificate (or the entire chain in the case of a subordinate CA) of a trust point to a PKCS#12 file for backup purposes. You can import the certificate and RSA key pair to recover from a system crash on your device or when you replace the supervisor modules.



Note You can use only the bootflash:*filename* format when specifying the export URL.

Before you begin

Authenticate the CA.

Install an identity certificate.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	crypto ca export name pkcs12 bootflash:<i>filename</i> password Example: switch(config)# crypto ca export admin-ca pkcs12 bootflash:adminid.p12 nbv123	Exports the identity certificate and associated key pair and CA certificates for a trust point CA. The password is alphanumeric, case sensitive, and has a maximum length of 128 characters.
Step 3	exit Example: switch(config)# exit switch#	Exits configuration mode.

Importing Identity Information in PKCS 12 Format

	Command or Action	Purpose
Step 4	copy booflash:filename scheme://server/ [url /]filename Example: <pre>switch# copy bootflash:adminid.p12 tftp:adminid.p12</pre>	Copies the PKCS#12 format file to a remote server. For the <i>scheme</i> argument, you can enter tftp: , ftp: , scp: , or sftp: . The <i>server</i> argument is the address or name of the remote server, and the <i>url</i> argument is the path to the source file on the remote server. The <i>server</i> , <i>url</i> , and <i>filename</i> arguments are case sensitive.

Importing Identity Information in PKCS 12 Format

You can import the certificate and RSA key pair to recover from a system crash on your device or when you replace the supervisor modules.



Note You can use only the *bootflash:filename* format when specifying the import URL.

Before you begin

Ensure that the trust point is empty by checking that no RSA key pair is associated with it and no CA is associated with the trust point using CA authentication.

Procedure

	Command or Action	Purpose
Step 1	copy scheme:// server/[url /]filename bootflash:filename Example: <pre>switch# copy tftp:adminid.p12 bootflash:adminid.p12</pre>	Copies the PKCS#12 format file from the remote server. For the <i>scheme</i> argument, you can enter tftp: , ftp: , scp: , or sftp: . The <i>server</i> argument is the address or name of the remote server, and the <i>url</i> argument is the path to the source file on the remote server. The <i>server</i> , <i>url</i> , and <i>filename</i> arguments are case sensitive.
Step 2	configure terminal Example: <pre>switch# configure terminal switch(config) #</pre>	Enters global configuration mode.
Step 3	crypto ca import name pksc12 bootflash:filename Example: 	Imports the identity certificate and associated key pair and CA certificates for trust point CA.

	Command or Action	Purpose
	switch(config)# crypto ca import admin-ca pkcs12 bootflash:adminid.p12 nbv123	
Step 4	exit Example: switch(config)# exit switch#	Exits configuration mode.
Step 5	(Optional) show crypto ca certificates Example: switch# show crypto ca certificates	Displays the CA certificates.
Step 6	(Optional) copy running-config startup-config Example: switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring a CRL

You can manually configure CRLs that you have downloaded from the trust points. The Cisco NX-OS software caches the CRLs in the device bootflash (cert-store). During the verification of a peer certificate, the Cisco NX-OS software checks the CRL from the issuing CA only if you have downloaded the CRL to the device and you have configured certificate revocation checking to use the CRL.

Before you begin

Ensure that you have enabled certificate revocation checking.

Procedure

	Command or Action	Purpose
Step 1	copy scheme:[//server/[url /]]filename bootflash:filename Example: switch# copy tftp:adminca.crl bootflash:adminca.crl	Downloads the CRL from a remote server. For the <i>scheme</i> argument, you can enter tftp: , ftp: , scp: , or sftp: . The <i>server</i> argument is the address or name of the remote server, and the <i>url</i> argument is the path to the source file on the remote server. The <i>server</i> , <i>url</i> , and <i>filename</i> arguments are case sensitive.
Step 2	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.

Deleting Certificates from the CA Configuration

	Command or Action	Purpose
Step 3	crypto ca crt request name bootflash:filename Example: switch(config)# crypto ca crt request admin-ca bootflash:adminca.crl	Configures or replaces the current CRL with the one specified in the file.
Step 4	exit Example: switch(config)# exit switch#	Exits configuration mode.
Step 5	(Optional) show crypto ca crt name Example: switch# show crypto ca crt admin-ca	Displays the CA CRL information.
Step 6	(Optional) copy running-config startup-config Example: switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Deleting Certificates from the CA Configuration

You can delete the identity certificates and CA certificates that are configured in a trust point. You must first delete the identity certificate, followed by the CA certificates. After deleting the identity certificate, you can disassociate the RSA key pair from a trust point. You must delete certificates to remove expired or revoked certificates, certificates that have compromised (or suspected to be compromised) key pairs, or CAs that are no longer trusted.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.
Step 2	crypto ca trustpoint name Example: switch(config)# crypto ca trustpoint admin-ca switch(config-trustpoint) #	Specifies a trust point CA and enters trust point configuration mode.
Step 3	delete ca-certificate Example: switch(config-trustpoint) # delete ca-certificate	Deletes the CA certificate or certificate chain.

	Command or Action	Purpose
Step 4	delete certificate [force] Example: <pre>switch(config-trustpoint)# delete certificate</pre>	Deletes the identity certificate. You must use the force option if the identity certificate you want to delete is the last certificate in a certificate chain or only identity certificate in the device. This requirement ensures that you do not mistakenly delete the last certificate in a certificate chain or only the identity certificate and leave the applications (such as SSH) without a certificate to use.
Step 5	exit Example: <pre>switch(config-trustpoint)# exit switch(config)#</pre>	Exits trust point configuration mode.
Step 6	(Optional) show crypto ca certificates [name] Example: <pre>switch(config)# show crypto ca certificates admin-ca</pre>	Displays the CA certificate information.
Step 7	(Optional) copy running-config startup-config Example: <pre>switch(config)# copy running-config startup-config</pre>	Copies the running configuration to the startup configuration.

Deleting RSA Key Pairs from a Cisco NX-OS Device

You can delete the RSA key pairs from a Cisco NX-OS device if you believe the RSA key pairs were compromised in some way and should no longer be used.



Note

After you delete RSA key pairs from a device, ask the CA administrator to revoke your device's certificates at the CA. You must supply the challenge password that you created when you originally requested the certificates.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config)#</pre>	Enters global configuration mode.

	Command or Action	Purpose
Step 2	crypto key zeroize rsa <i>label</i> Example: switch(config)# crypto key zeroize rsa MyKey	Deletes the RSA key pair.
Step 3	exit Example: switch(config)# exit switch#	Exits configuration mode.
Step 4	(Optional) show crypto key mypubkey rsa Example: switch# show crypto key mypubkey rsa	Displays the RSA key pair configuration.
Step 5	(Optional) copy running-config startup-config Example: switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Verifying the PKI Configuration

To display PKI configuration information, perform one of the following tasks:

Command	Purpose
show crypto key mypubkey rsa	Displays information about the RSA public keys generated on the Cisco NX-OS device.
show crypto ca certificates	Displays information about CA and identity certificates.
show crypto ca crt	Displays information about CA CRLs.
show crypto ca trustpoints	Displays information about CA trust points.

Configuration Examples for PKI

This section shows examples of the tasks that you can use to configure certificates and CRLs on Cisco NX-OS devices using a Microsoft Windows Certificate server.



Note You can use any type of certificate server to generate digital certificates. You are not limited to using the Microsoft Windows Certificate server.

Configuring Certificates on a Cisco NX-OS Device

To configure certificates on a Cisco NX-OS device, follow these steps:

Procedure

Step 1 Configure the device FQDN.

```
switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
switch(config)# hostname Device-1
Device-1(config) #
```

Step 2 Configure the DNS domain name for the device.

```
Device-1(config) # ip domain-name cisco.com
```

Step 3 Create a trust point.

```
Device-1(config) # crypto ca trustpoint myCA
Device-1(config-trustpoint) # exit
Device-1(config) # show crypto ca trustpoints
trustpoint: myCA; key:
revocation methods: crl
```

Step 4 Create an RSA key pair for the device.

```
Device-1(config) # crypto key generate rsa label myKey exportable modulus 1024
Device-1(config) # show crypto key mypubkey rsa
key label: myKey
key size: 1024
exportable: yes
```

Step 5 Associate the RSA key pair to the trust point.

```
Device-1(config) # crypto ca trustpoint myCA
Device-1(config-trustpoint) # rsakeypair myKey
Device-1(config-trustpoint) # exit
Device-1(config) # show crypto ca trustpoints
trustpoint: myCA; key: myKey
revocation methods: crl
```

Step 6 Download the CA certificate from the Microsoft Certificate Service web interface.

Step 7 Authenticate the CA that you want to enroll to the trust point.

```
Device-1(config) # crypto ca authenticate myCA
input (cut & paste) CA certificate (chain) in PEM format;
end the input with a line containing only END OF INPUT :
```

```

-----BEGIN CERTIFICATE-----
MIIC4jCCAoygAwIBAgIQBWDSiay0GZRPSR1ljk0ZejANBgkqhkiG9w0BAQUFADCB
kDEgMB4GCSqGS1b3DQEJARYRYW1hbmRrZUBjaXNjby5jb20xCzAJBgNVBAYTAK1O
MRIwEAYDVQQIEw1LYXJuYXRha2ExEjAQBgNVBAcTCUjhbmdbG9yZTEOMAwGA1UE
ChMFQ21zY28xEzARBgNVBAAsTCm51dHN0b3JhZ2UxEjAQBgNVBAMTCUFwYXJuYSBD
QTAeFw0wNTA1MDMyMjQ2MzdaFw0wNzA1MDMyMjU1MTdaMIGQMSAwHgYJKoZIhvcN
AQkBFhFhbWFuZGt1QGNpc2NvLmNbTELMAkGA1UEBhMCSU4xEjAQBgNVBAgTCUth
cm5hdGFryTESMBA1UEBxMJQmFuZ2Fsb3J1MQ4wDAYDVQQKEwVdaxNjbzETMBEG
A1UECxMKbmV0c3RvcmlnZTESMBA1UEAxMjQXBhcm5hIENBMFwwDQYJKoZIhvcN
AQEBBQADSwAwSAJBAMW/7b3+DXJPANBsIHHzluNccNM87ypyzwuoSNZXOMpeRXI
OzyBAGiXT2ASFUOwQ1iDM8rO/41jf8RxvYKvysCAwEAAaOBvzCBvDALBgNVHQ8E
BAMCACYwDwYDVR0TAQH/BAUwAwEB/zAdBgNVHQ4EFgQUJyjyRoMbrCNMRU2OyRhQ
GgsWbHEwawYDVR0fBGQwYjAuoCygKoYoaHR0cDovL3NzZS0wOC9DZXJ0RW5yb2xs
L0FwYXJuYSUyMENBLmNybDAwoC6gLIYqZmlsZTovL1xcc3N1LTA4XEN1cnRFbnJv
bGxcQXBhcm5hJTIwQ0EuY3JsMBAGCSsGAQQBgjcVAQDAgEAMA0GCSqGS1b3DQE
BQUAA0EAHv6UQ+8nE399Tww+KaGr0gONIJaqNgLh0Afct0rEyuyt/WYGPzksF9Ea
NBG7E0oN66ze0EOEfG1Vs6mXp1//w==
-----END CERTIFICATE-----
END OF INPUT

```

Fingerprint(s): MD5 Fingerprint=65:84:9A:27:D5:71:03:33:9C:12:23:92:38:6F:78:12
Do you accept this certificate? [yes/no]:**y**

```

Device-1(config)# show crypto ca certificates
Trustpoint: myCA
CA certificate 0:
subject= /emailAddress=admin@yourcompany.com/C=IN/ST=Karnataka/
L=Bangalore/O=Yourcompany/OU=netstorage/CN=Aparna CA
issuer= /emailAddress=admin@yourcompany.com/C=IN/ST=Karnataka/
L=Bangalore/O=Yourcompany/OU=netstorage/CN=Aparna CA
serial=0560D289ACB419944F4912258CAD197A
notBefore=May 3 22:46:37 2005 GMT
notAfter=May 3 22:55:17 2007 GMT
MD5 Fingerprint=65:84:9A:27:D5:71:03:33:9C:12:23:92:38:6F:78:12
purposes: sslserver ssclient ike

```

Step 8

Generate a request certificate to use to enroll with a trust point.

```

Device-1(config)# crypto ca enroll myCA
Create the certificate request ..
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: nbv123
The subject name in the certificate will be: Device-1.cisco.com
Include the switch serial number in the subject name? [yes/no]: no
Include an IP address in the subject name [yes/no]: yes
ip address: 10.10.1.1
The certificate request will be displayed...
-----BEGIN CERTIFICATE REQUEST-----
MIIByzCCARQCAQAwHDEaMBgGA1UEAxMRVmVnYXMtMS5jaXNjby5jb20wgZ8wDQYJ
KoZIhvcNAQEBBQADGy0AMIGJAoGBAL8Y1UAJ2NC7jUJ1DVaSMqNIgJ2kt8rl41KY
0JC6ManNy4qxk8VeMXZSiLJ4JgTzKWdxblDkTTysnjuCXGvjb+wj0hEhv/y51T9y
P2NJJ8ornqShrvFZgC7ysN/PyMwKcgzhbVpj+rargZvHtGJ91XTq4WoVkSczXv8S
VqyH0vEvAgMBAAGGtZAVBkgqhkiG9w0BCQcxCBMGbmJ2MTIzMDYGCSqGS1b3DQEJ
DjEpMCCwJQYDVR0RAQH/BBswGYIRVmVnYXMtMS5jaXNjby5jb22HBKwWH6IwDQYJ
KoZIhvcNAQEEBQADGyEAKT60KER6Qo8nj0sDXZVHSfJZh6K6JtDz3Gkd99G1FWgt
PftrNcWUE/pw6HayfQl2T3ecgNwe1d15133YBF2bktExi16U188nTOjglXMjja8
8a23bNDpNsM8rklwA6hWkrVL8NUZEJxqbjfngPNTZacJCUS6ZqKCMetbKytUx0=
-----END CERTIFICATE REQUEST-----

```

- Step 9** Request an identity certificate from the Microsoft Certificate Service web interface.
- Step 10** Import the identity certificate.

```
Device-1(config)# crypto ca import myCA certificate
input (cut & paste) certificate in PEM format:
-----BEGIN CERTIFICATE-----
MIIEADCCA6ggAwIBAgIKCjOOoQAAAAAAAdDANBgkqhkiG9w0BAQUFADCBkDEgMB4G
CSqGSIB3DQEJARYRYW1hbmrZUBjaXNjby5jb20xCzAJBgNVBAYTAK1OMRIwEAYD
VQQIEw1LYXJuYXRha2ExEjAQBgNVBAcTCUJhbmdhbG9yZTEOMAwGA1UEChMFQ21z
Y28xEzARBgNVBAsTCm51dHN0b3JhZ2UxExEjAQBgNVBAMTCUFwYXJuYSBDQTAeFw0w
NTExMTIwMzAyNDBaFw0wNjExMTIwMzEyNDBaMBwxGjAYBgNVBAMTEVz1Z2FzLTEu
Y21zY28uY29tMIGfMA0GCSqGSIB3DQEBAQUAA4GNADCBiQKBgQC/GNVACdjQu41C
dQ1WkjKjSICdpLfk5eJSnNCQujGpzcuKsZPFXjF2UoiyeCYE8ylncWyw5E08rJ47
glxr42/sI9IRib/8udU/cj9jSSfKK56ko7xWYAu8rDfz8jMCnIM4W1aY/q2q4Gb
x7RifdV06uFqFZEgsl7/Elash9LxLwIDAQABo4ICEzCCAg8wJQYDVR0RAQH/BBsw
GYIRVmVnYXMtMS5jaXNjby5jb22HBKwWH6IwHQYDVR0OBYEFKCLi+2sspWEfgrR
bhWmlVyo9jngMIHMBgNVHSMgcQwgccGAFCco8kaDG6wjTEVNjskYUBcLFmxxoYGW
pIGTMIGQMSAwHgYJKoZIhvNAQkBFhFhbWFuZGt1QGNpc2NvLmNvbTELMAkGA1UE
BhMCSU4xEjAQBgNVBAgTCUthcm5hdGFfYTESMBAGA1UEBxMJOmFuZ2Fsb3JlMQ4w
DAYDVQQKEwVDaXNjbzETMBEGA1UECxMKbmV0c3RvcfmFnZTESMBAGA1UEAxMJQXBh
cm5hIENBghAFYNKJrLQZ1E9JEiWMrR16MGsGA1UdHwRkMGIwLqAsoCqGKKh0dHA6
Ly9zc2UtMDgvQ2VydEVucm9sbC9BcGFybmElMjBDQS5jcmwwMKAuoCyGKmZpbGU6
Ly9cXHNzZS0wOFxDZXJ0RW5yb2xsXEFwYXJuYSUyMENBLmNybDCBiYIKwYBBQUH
AQEEfjb8MDsGCCsGAQUFBzAChi9odHRwOi8vc3N1LTA4L0N1cnRFbnJvbGwvc3N1
LTA4X0FwYXJuYSUyMENBLmNyda9BggBgEFBQcwAoYxZmlsZTovL1xcc3N1LTA4
XEN1cnRFbnJvbGxcc3N1LTA4X0FwYXJuYSUyMENBLmNyDANBgkqhkiG9w0BAQUF
AANBADbGBGsbe7GNLh9xeOTWBnm24U69ZSuDDcOcUZUUTgrpnTqVpPyejtsyflw
E36cIZu4WsExREqxrbTk8ycx7V5o=
-----END CERTIFICATE-----
Device-1(config)# exit
Device-1#
```

- Step 11** Verify the certificate configuration.
- Step 12** Save the certificate configuration to the startup configuration.

Downloading a CA Certificate

To download a CA certificate from the Microsoft Certificate Services web interface, follow these steps:

Procedure

- Step 1** From the Microsoft Certificate Services web interface, click **Retrieve the CA certificate or certificate revocation task** and click **Next**.

■ Downloading a CA Certificate

The screenshot shows a web browser window for Microsoft Certificate Services. The title bar reads "Microsoft Certificate Services -- Aparna CA". Below the title is a green header bar with the word "Welcome". The main content area contains text explaining the purpose of the site and a list of tasks:

You use this web site to request a certificate for your web browser, e-mail client, or other secure program. Once you will be able to securely identify yourself to other people over the web, sign your e-mail messages, encrypt your e-mail depending upon the type of certificate you request.

Select a task:

- Retrieve the CA certificate or certificate revocation list
- Request a certificate
- Check on a pending certificate

- Step 2** From the display list, choose the CA certificate file to download from the displayed list. Then click **Base 64 encoded** and click **Download CA certificate**.

Microsoft Certificate Services -- Apama CA

Retrieve The CA Certificate Or Certificate Revocation List

[Install this CA certification path](#) to allow your computer to trust certificates issued from this certification authority.

It is not necessary to manually install the CA certification path if you request and install a certificate from this certification authority. The CA certification path will be installed for you automatically.

Choose file to download:

CA Certificate: [Current \[Apama CA\]](#)

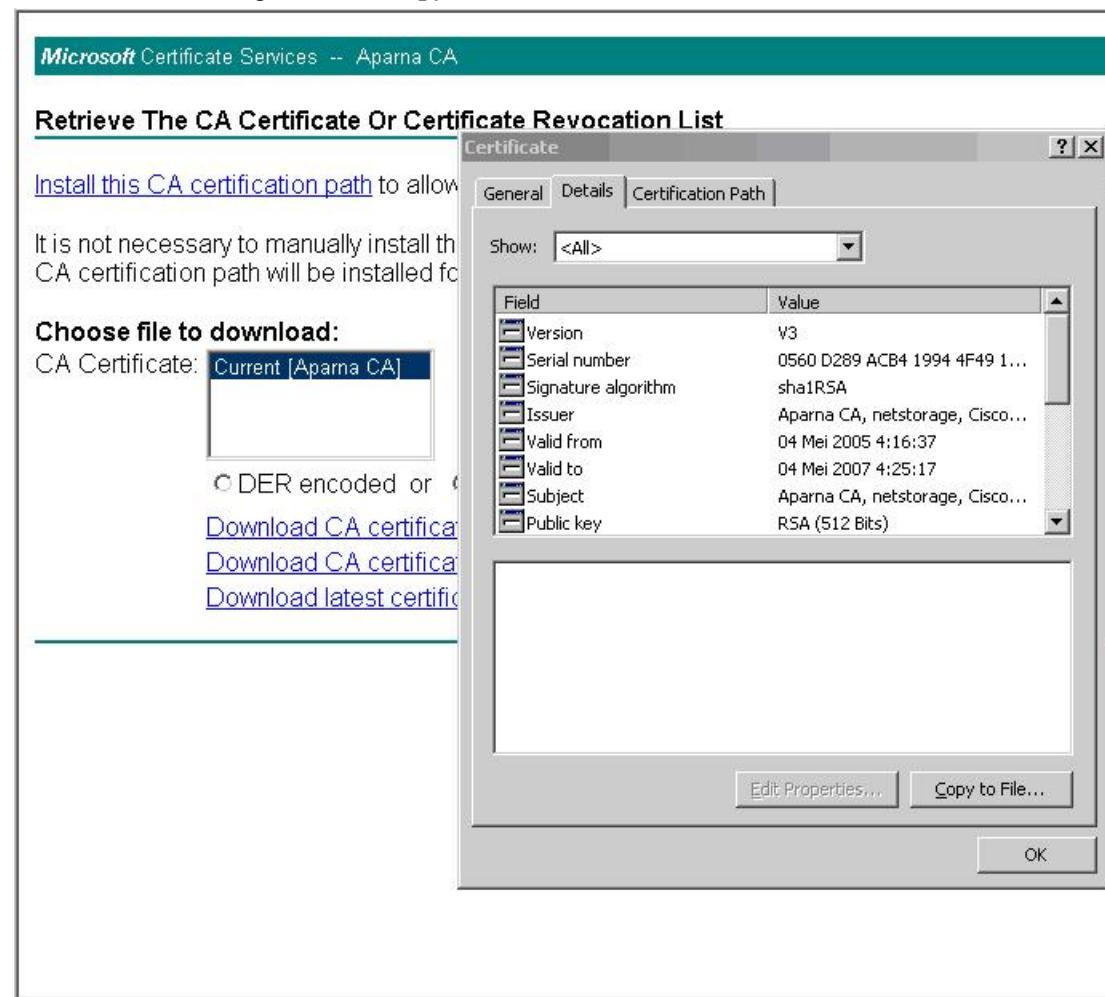
DER encoded or Base 64 encoded

[Download CA certificate](#)
[Download CA certification path](#)
[Download latest certificate revocation list](#)

- Step 3** Click **Open** in the File Download dialog box.

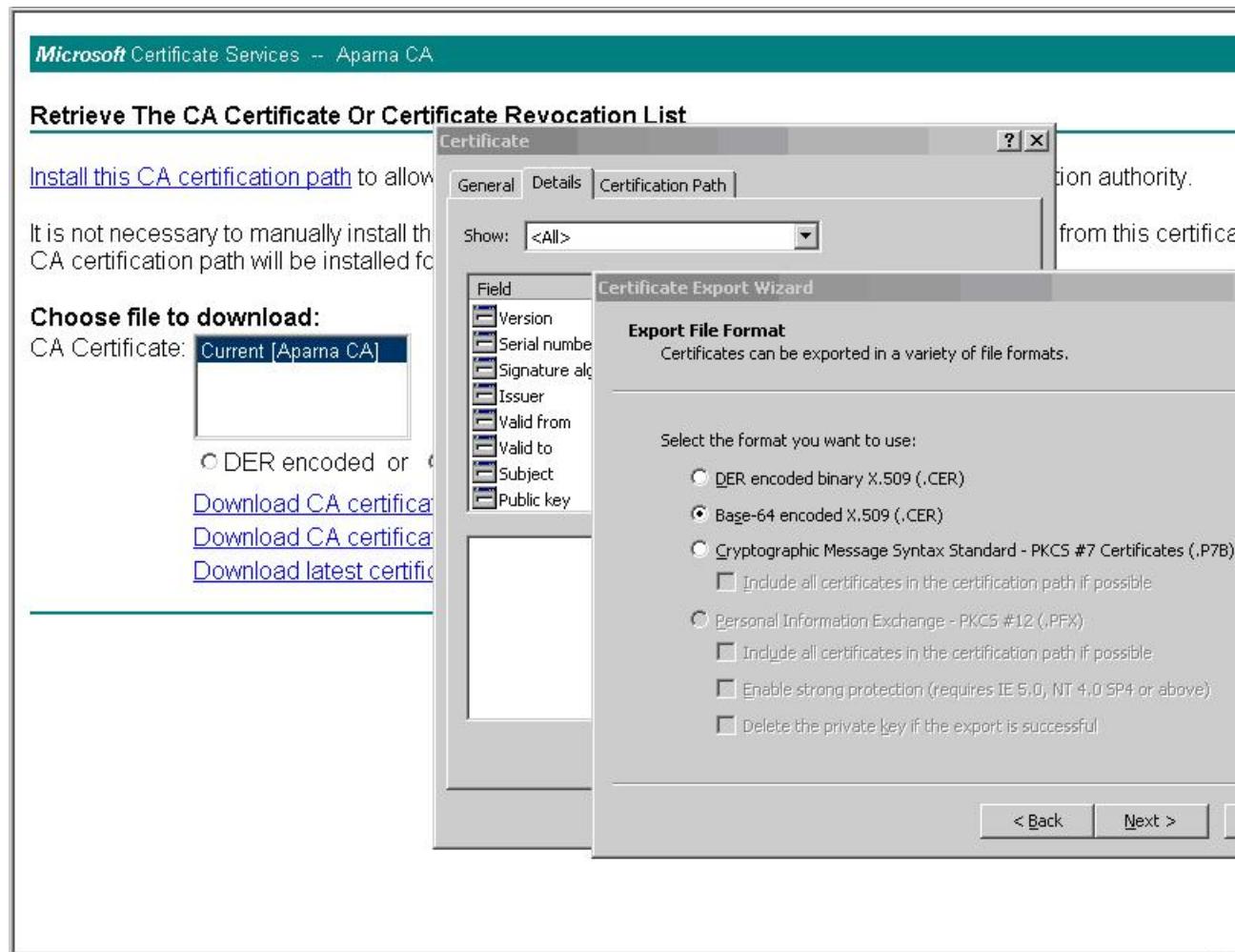
The screenshot shows the Microsoft Certificate Services interface for the 'Aparna CA' certification authority. The main window title is 'Microsoft Certificate Services -- Aparna CA'. Below it, a section titled 'Retrieve The CA Certificate Or Certificate Revocation List' contains the instruction 'Install this CA certification path' to allow your computer to trust certificates issued from this certification authority. It also states that it is not necessary to manually install the CA certificate, as the CA certification path will be installed for you. On the left, there is a 'Choose file to download:' section with a dropdown menu set to 'Current [Aparna CA]'. Below this are options for 'DER encoded' or 'Base64 encoded' files, with 'Base64 encoded' selected. There are three download links: 'Download CA certificate', 'Download CA certification path', and 'Download latest certificate revocation list'. A 'File Download' dialog box is overlaid on the interface. The dialog has a question mark icon and the text: 'Some files can harm your computer. If the file information below looks suspicious, or you do not fully trust the source, do not open or save this file.' It displays the following details: File name: certnew.cer, File type: Security Certificate, From: 10.76.45.108. A warning icon indicates: 'This type of file could harm your computer if it contains malicious code.' At the bottom, it asks 'Would you like to open the file or save it to your computer?' with buttons for Open, Save, Cancel, and More Info. A checked checkbox says 'Always ask before opening this type of file'.

Step 4 In the Certificate dialog box, click **Copy to File** and click **OK**.



Step 5 From the Certificate Export Wizard dialog box, choose the **Base-64 encoded X.509 (CER)** and click **Next**.

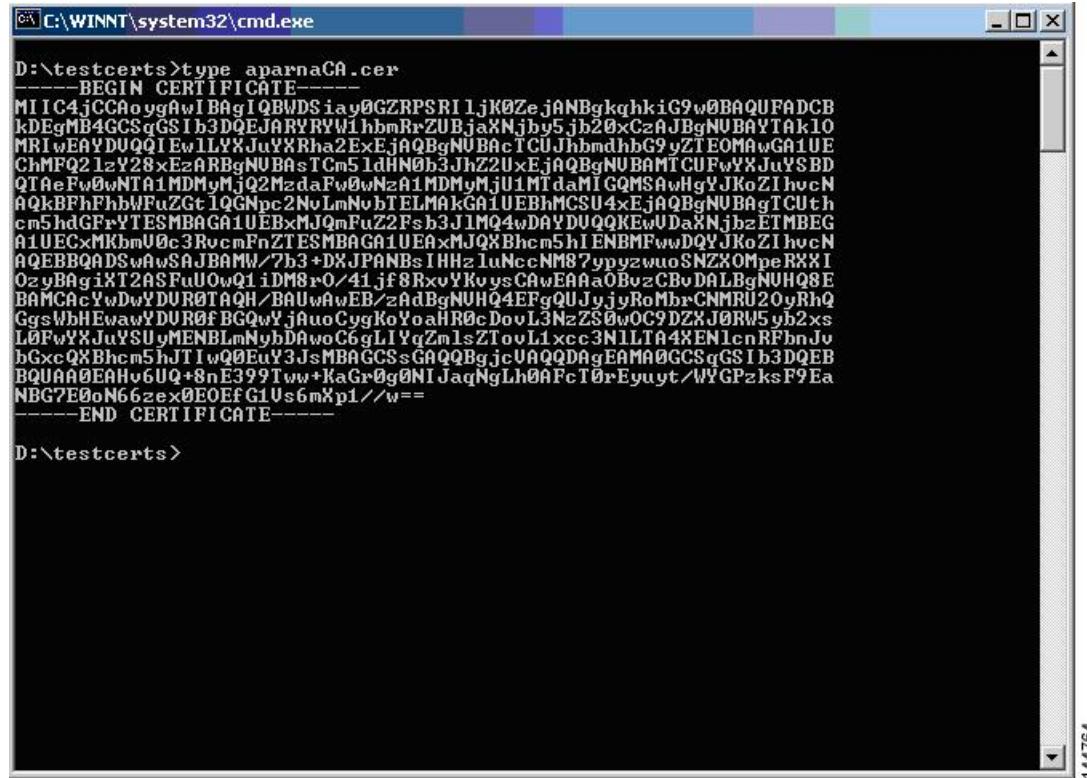
■ Downloading a CA Certificate



Step 6 In the File name: text box on the Certificate Export Wizard dialog box, enter the destination file name and click **Next**.

Step 7 In the Certificate Export Wizard dialog box, click **Finish**.

Step 8 Enter the Microsoft Windows **type** command to display the CA certificate stored in Base-64 (PEM) format.



```
D:\>testcerts>type aparnaCA.cer
-----BEGIN CERTIFICATE-----
MIIC4jCCAooygAvIBAgIQBWDSiay0GZRPSRI1jK0ZejANBgkqhkiG9w0BAQUFADC
kDEgMB4GCSqGS1b3DQEJARYRV1hbmrZUBjaXNjby5jb20xCzAJBgNUBaYTak10
MRIwEAYDUQQIEw1LYXJuYXRha2ExEjAQBgNUBacTCUJhbmdhbC9yZTEOMAuGA1UE
CHMPQ21zY28xEzARBgNUBAsTCm51dHN0b3JhZ2UxEjAQBgNUBAMTCUPwYXJuYSBD
QTReFu0wNTA1MDMyMjQ2MzdaFu0wNzA1MDMyMjU1MTdaMIGOMSAwHgYJKoZIhvcN
AQkBFhFhbWFuZGt1QGNpc2NuLmNvbTELMAkGA1UEBhMCSU4xEjAQBgNUB0gTCUth
cm5hdGFrYTESMBAgA1UEBxMjQmFuZ2Fs b3JIMQ4wDAYDUqqREwUDaXNjbzETMBEG
A1UECxMKbmU0c3RvcmFnZTESMBAgA1UEAxMjQX Bhcm5hIENBMFwwDQYJKoZIhvcN
AQEBBQADSwAwSAJBAMW/7b3+DXJPAnBsIHHzluNccNM87ypywu0SNZXOMpeRXxi
OzvBragiXT2ASFuUowQ1iDM8r0/41jf8RvxYKwysCaWEAAaOBuzCBvDALBgNUHQ8E
BAMCACYwDwYDUR0TAQH/BAUwAwEB/zAdBgNUH04EFgQUJyjyRoMbrCNMRU20yRhQ
GgsWhHEwawYDUR0fBGQwYjAu0CygKoYoahR0cDoVL3NzZS0wOC9DZXJ0RW5yb2xs
L0PwYXJuYSUyMEUBLmNybDAwoC6gLIYqZmlsZTovlxcc3NlLTA4XEnlcnRFbnJv
bGxcQXBhcm5hJT1wQ0EuY3JsmBAGCScsGAQQBgjcUAAQDAgEAMA0GCSqGSIb3DQE
BQUAA0EAHu6UQ+8nE399Tw+KaGr0g0NIJaqNgLh0AFcT0rEyuyt/WYGP2ksF9Ea
NBG7P0oN66zex0EOEfG1Us6mXp1//w==
-----END CERTIFICATE-----

D:\>testcerts>
```

Requesting an Identity Certificate

To request an identify certificate from a Microsoft Certificate server using a PKCS#12 certificate signing request (CRS), follow these steps:

Procedure

- Step 1** From the Microsoft Certificate Services web interface, click **Request a certificate** and click **Next**.

The screenshot shows a web browser window for 'Microsoft Certificate Services -- Aparna CA'. The title bar says 'Microsoft Certificate Services -- Aparna CA'. The main content area has a teal header bar with the text 'Welcome'. Below it, a paragraph of text reads: 'You use this web site to request a certificate for your web browser, e-mail client, or other secure program. Once you will be able to securely identify yourself to other people over the web, sign your e-mail messages, encrypt your e-mail depending upon the type of certificate you request.' Underneath this, there is a section titled 'Select a task:' with three radio buttons:

- Retrieve the CA certificate or certificate revocation list
- Request a certificate
- Check on a pending certificate

Step 2 Click **Advanced request** and click **Next**.

Microsoft Certificate Services -- Aparna CA

Choose Request Type

Please select the type of request you would like to make:

- User certificate request:

Web Browser Certificate
E-Mail Protection Certificate

- Advanced request

- Step 3** Click Submit a certificate request using a base64 encoded PKCS#10 file or a renewal request using a base64 encoded PKCS#7 file and click Next.

Microsoft Certificate Services -- Apama CA

Advanced Certificate Requests

You can request a certificate for yourself, another user, or a computer using one of the following methods. Note that the certification authority (CA) will determine the certificates that you can obtain.

- Submit a certificate request to this CA using a form.
- Submit a certificate request using a base64 encoded PKCS #10 file or a renewal request using a base64 encoded PKCS#7 file.
- Request a certificate for a smart card on behalf of another user using the Smart Card Enrollment Station.
You must have an enrollment agent certificate to submit a request for another user.

- Step 4** In the Saved Request text box, paste the base64 PKCS#10 certificate request and click **Next**. The certificate request is copied from the Cisco NX-OS device console.

Microsoft Certificate Services -- Aparna CA

Submit A Saved Request

Paste a base64 encoded PKCS #10 certificate request or PKCS #7 renewal request generated by an external server) into the request field to submit the request to the certification authority (CA).

Saved Request:

Base64 Encoded Certificate Request (PKCS #10 or #7):

```
VcqyHOvEvAgMBAAGgTzAVBgkqhkiG9wOBCQcxCBMG
DjEpMCcwJQYDVRORAQH/BBswGYIRVmVnYXMtMS5j
KoZIhvcNAQEEBQADgYEAKT6OKER6Qo8njOsDXZVH
PftrNcWUE/pw6HayfQ12T3ecgNwe12d15133YBF2
8a23bNDpNsM8rk1wA6hWkrVL8NUZEJxqbjfngPN
-----END CERTIFICATE REQUEST-----
```

[Browse](#) for a file to insert.

Additional Attributes:

Attributes:

- Step 5** Wait one or two days until the certificate is issued by the CA administrator.

Microsoft Certificate Services -- Aparna CA

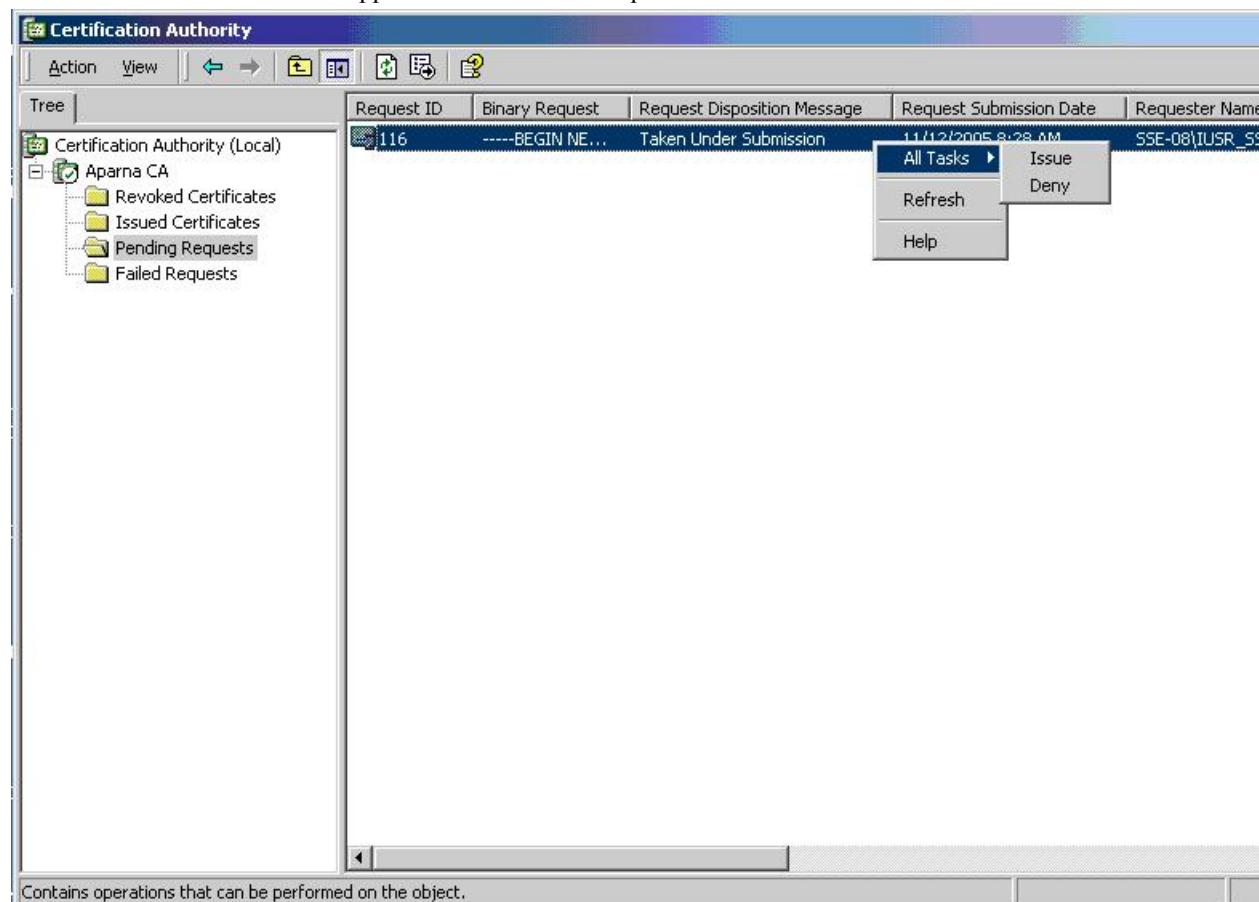
Certificate Pending

Your certificate request has been received. However, you must wait for an administrator to issue the certificate you requested.

Please return to this web site in a day or two to retrieve your certificate.

Note: You must return with **this** web browser within 10 days to retrieve your certificate.

- Step 6** Note that the CA administrator approves the certificate request.



- Step 7** From the Microsoft Certificate Services web interface, click **Check on a pending certificate** and click **Next**.

Requesting an Identity Certificate

The screenshot shows a web-based interface for Microsoft Certificate Services. At the top, a green header bar displays the text "Microsoft Certificate Services -- Aparna CA". Below this, a section titled "Welcome" is visible. A descriptive paragraph explains the purpose of the site: "You use this web site to request a certificate for your web browser, e-mail client, or other secure program. Once you will be able to securely identify yourself to other people over the web, sign your e-mail messages, encrypt your e-mail depending upon the type of certificate you request." Underneath this paragraph, there is a section titled "Select a task:" followed by a list of three options, each preceded by a radio button:

- Retrieve the CA certificate or certificate revocation list
- Request a certificate
- Check on a pending certificate

- Step 8** Choose the certificate request that you want to check and click **Next**.

The screenshot shows a Microsoft Certificate Services interface titled "Microsoft Certificate Services -- Aparna CA". Below the title, a section titled "Check On A Pending Certificate Request" displays a message: "Please select the certificate request you want to check:". A single item is listed in a box: "Saved-Request Certificate (12 Nopember 2005 20:30:22)".

Step 9 Click **Base 64 encoded** and click **Download CA certificate**.

Microsoft Certificate Services -- Aparna CA

Certificate Issued

The certificate you requested was issued to you.

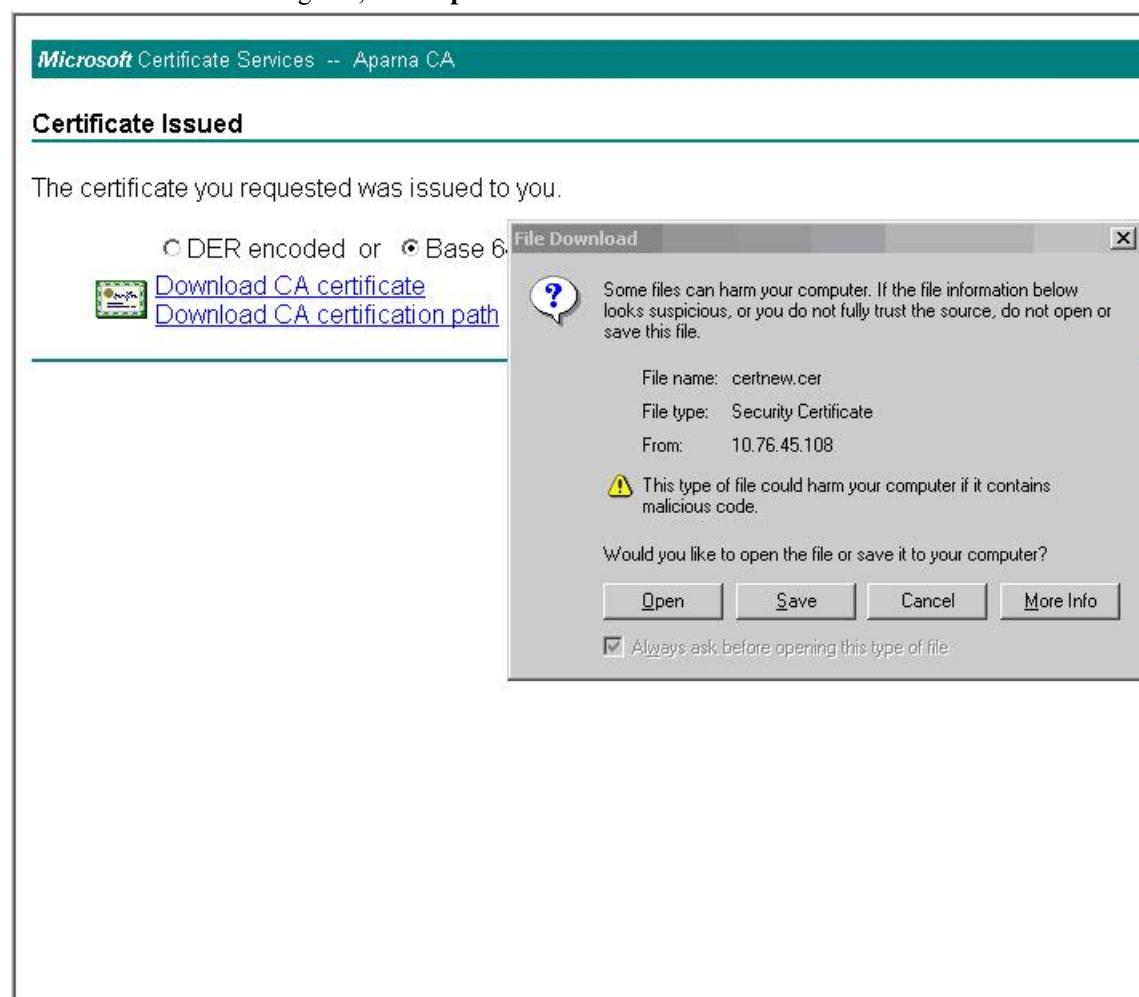
DER encoded or Base 64 encoded



[Download CA certificate](#)

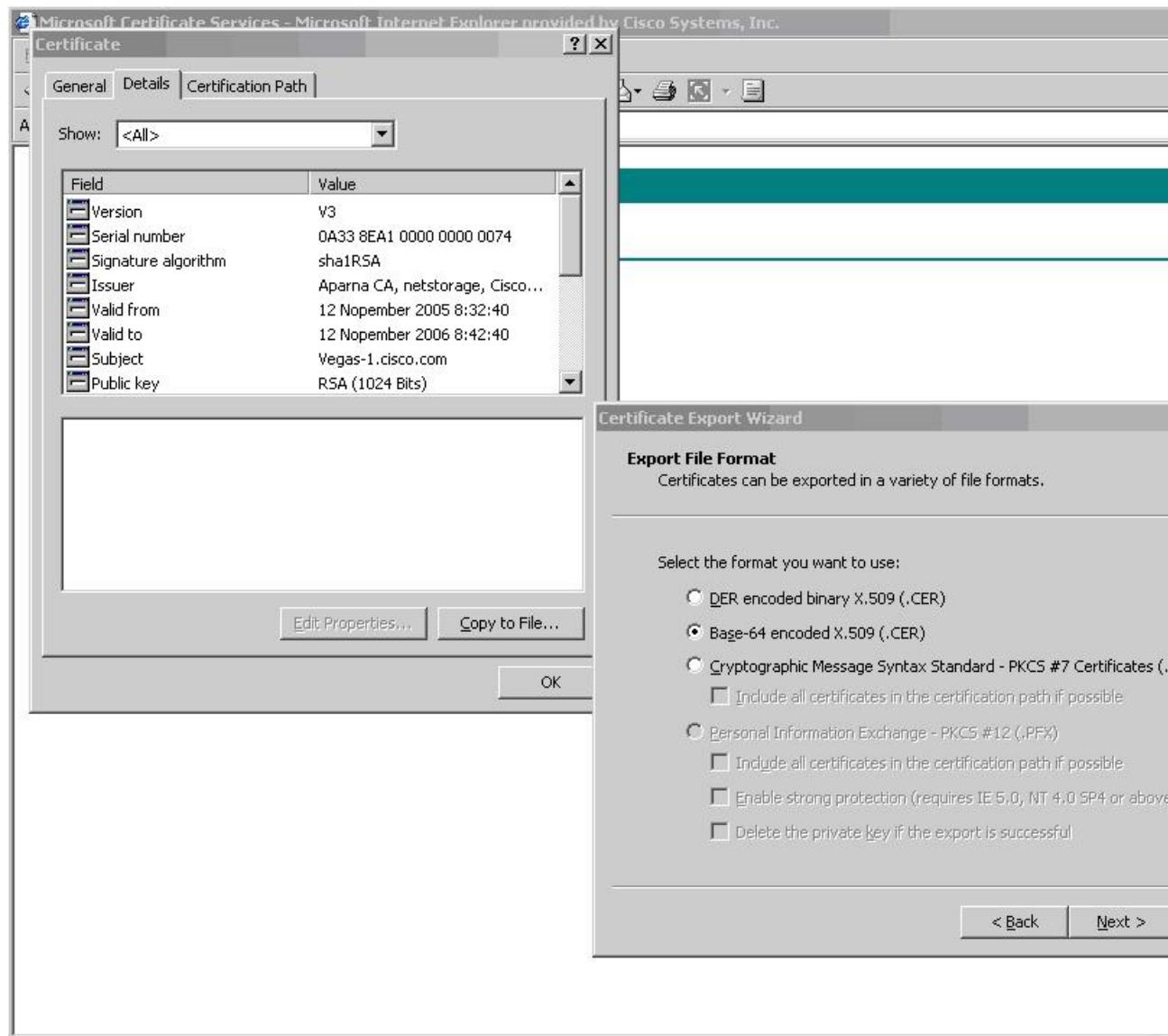
[Download CA certification path](#)

Step 10 In the File Download dialog box, click **Open**.

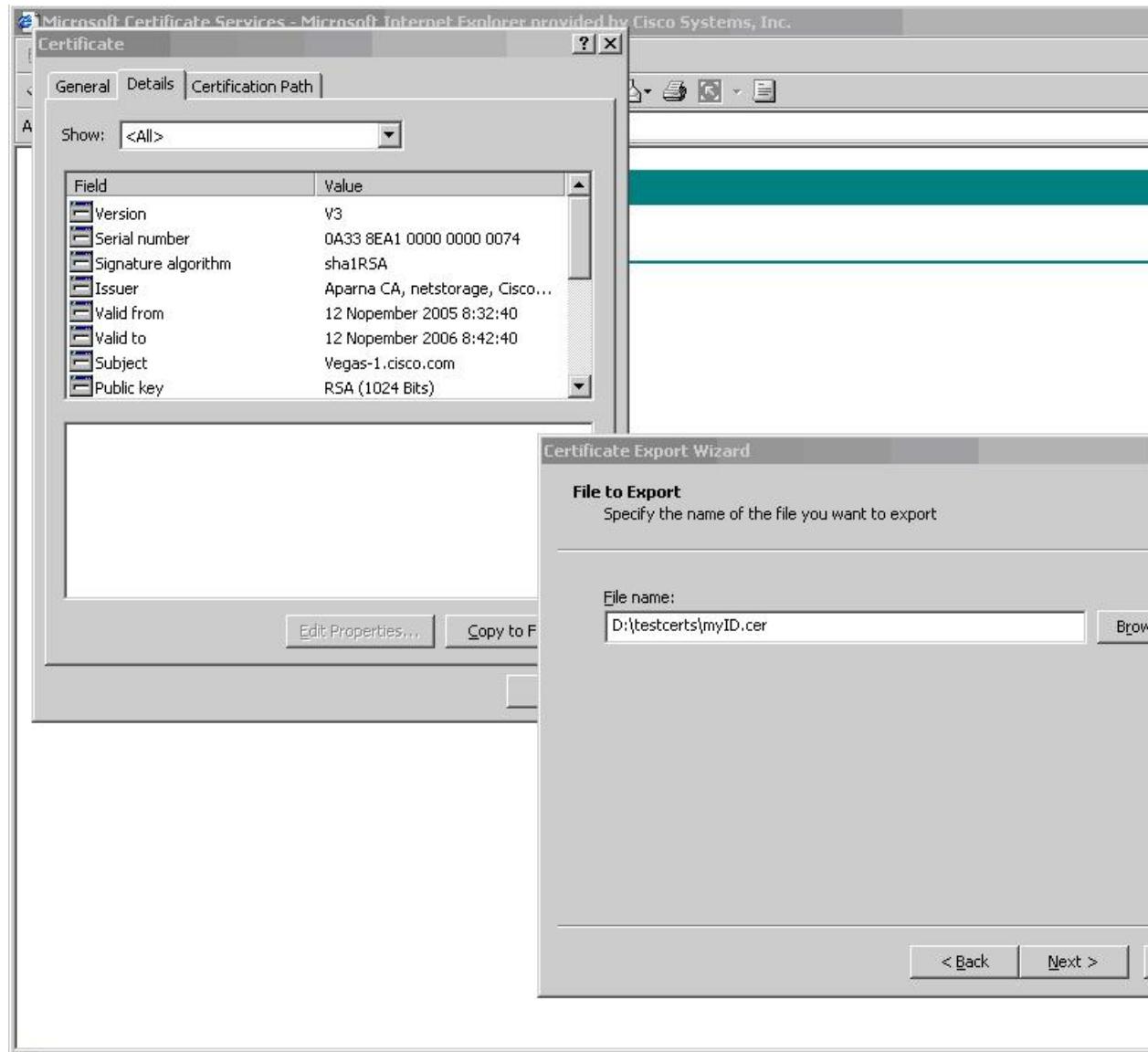


Requesting an Identity Certificate

- Step 11** In the Certificate box, click **Details** tab and click **Copy to File...**. In the Certificate Export Dialog box, click **Base-64 encoded X.509 (.CER)**, and click **Next**.

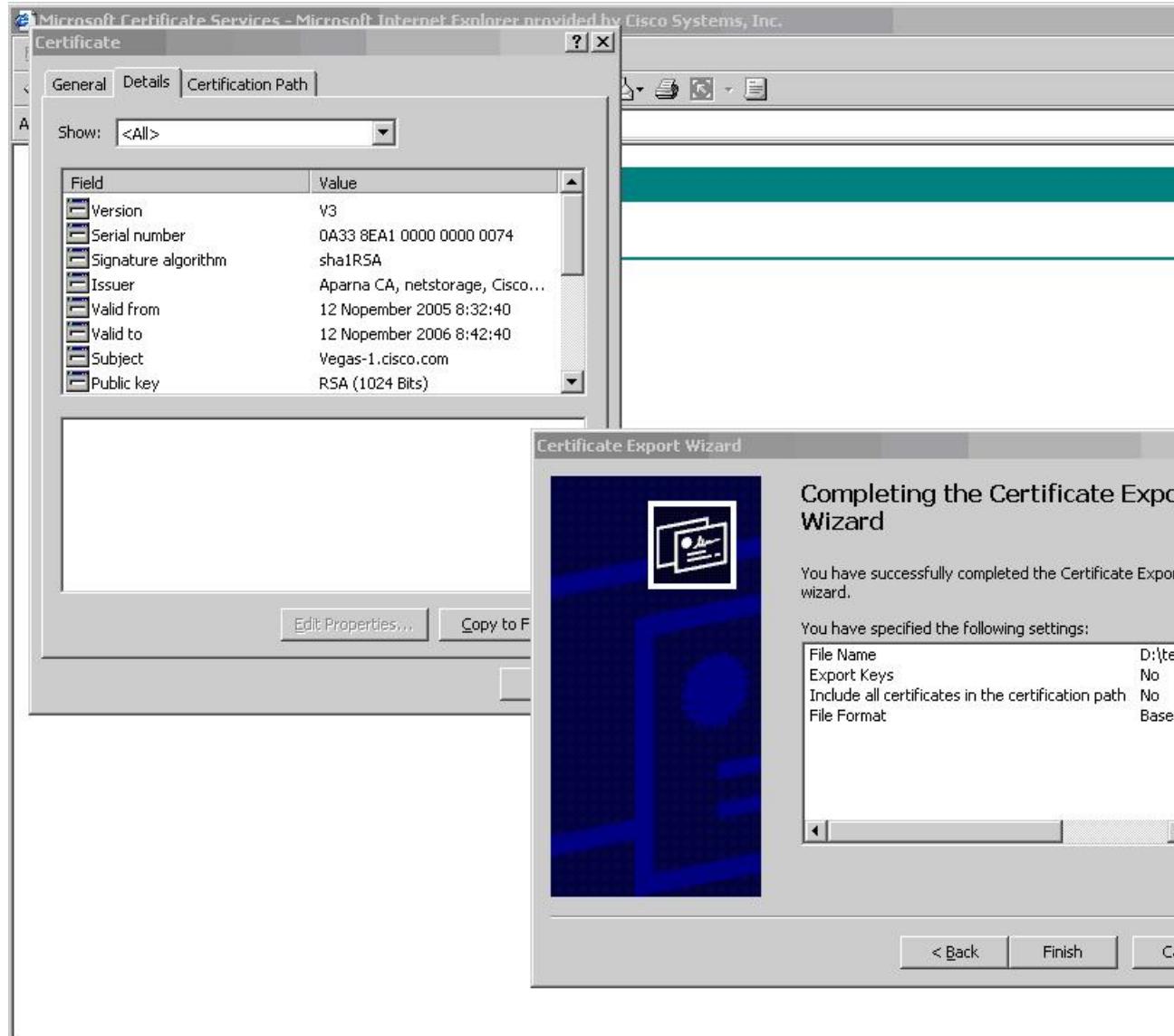


- Step 12** In the File name: text box on the Certificate Export Wizard dialog box, enter the destination file name and click **Next**.



Step 13 Click Finish.

Requesting an Identity Certificate



Step 14

Enter the Microsoft Windows **type** command to display the identity certificate in base64-encoded format.

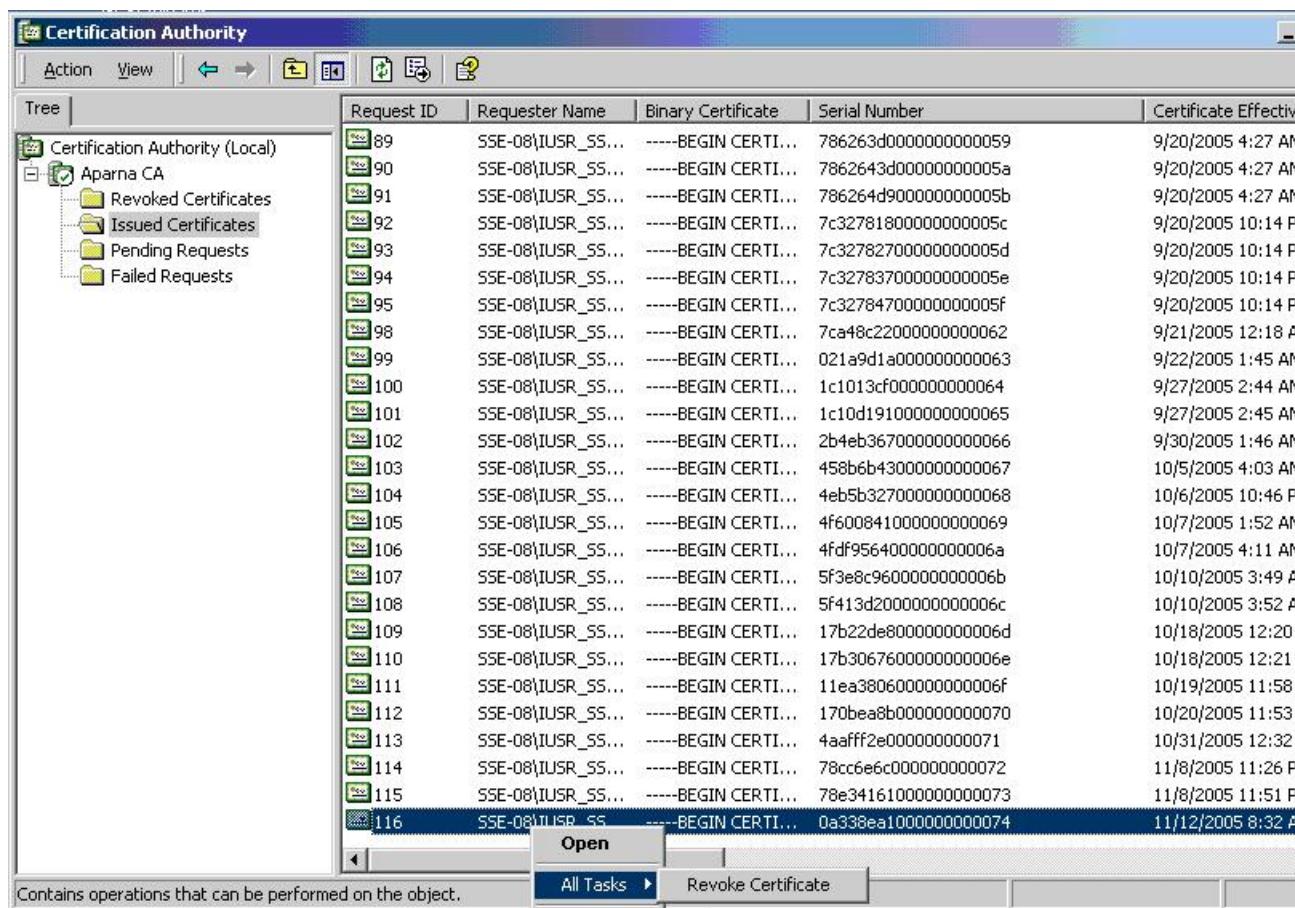
```
D:\>testcerts>type myID.cer
-----BEGIN CERTIFICATE-----
MIIEADCA6gsAwIBAgIJKCj0oQAAAAAAAdDANBgkqhkiG9w0BAQUFADCBkDEgMB4G
CSqGSIsb3DQEJARYRYW1hbmrRzUBjaXNjbv5jb20x0CzAJBgNUBAYTAk10MRIwEAYD
UQQIEw1b2ExJyXRAh2ExJyQBgNUBACtCUJhbmdhb9yZTEOMawGA1UEChMFQ21z
Y28xExARBgNUBAsTcM51dHNB0b3JhZ2UxExJyQBgNUBAMTCUFWYXJuYSBDQTAEpw0w
NTExMTIwMzAyNDBaFw0wNjExMTIwMzEyNDBaMBwxGjAYBqNUBAMTEVZlZ2FzLTEu
Y2lzY28uY29tMIGfMA0GQCSqGSIsb3DQEBAQUA4GNADCBiQKBgQC/GNUACdjoqu41C
dQ1WkjKjsICdpLfK5eJSnJyGpzeuKsZPFKjF2UoIyeGE8y1ncWwy5E88rJ47
glxr42s191Rhb/8udU/cj9jSSFFK56koa7xWFAu8rDFz8jMCnIM4W1aY/q2q4Gb
x7RifdU06uFgFZEg17/Elash9LxLwIDAQABo41CEzCCAg8wJQYDUR0RAQH/BBsw
ghWIRuMvNyxMtMS5jaXNjbv5jb20BKhwWH61wQYDUR00BByEFKCLi+2sspWEfgrR
bhWIRuMvyo9.jngIMHMBgNUHMEgcQwgcGAFCe0skaDG6wjtEUNjskyUBoLFmxxoYGW
pIGTMIGQMSAwHgYJKoZIhwCNQkBfhFhbWFuZGt1QGNpc2NuLmNbTELMAkGA1UE
BHMCUs4xEjAQBgNUBAgICUhcm5hdGFryTESMBAGA1UEBxMJQmFuZ2Fsb3JIMQ4w
DAYDUQKEwUdaXNjbzETMBEGAtUECxMKbmU0c3RvcFnZTESMBAGA1UEAxMjQXbh
cm5h1ENBgjAFYNYKJrLQZ1E9JEiWMrR16MgsGA1UdHwRkMGIVLqAsosCqGKGH0dHA6
Ly9zc2UtMDgv2UydeUvCm9sGCFyBnE1MjBDQ55jcnvwuMKAuoCyGKmZpbGU6
Ly9cxHNhsZS0u0FxDXZJ0RWS5yb2xsXEFWYXJuYsUyMENBLmNybdCBigYIKwYBBQUH
AQEEFjB8MDsGCCsGAQUFBzAChi9odHRw0i8vc3N1LTa4L0NlcnRFbnJvbGwv3N1
LTA4X0FwYXJuYsUyMENBLmNydg9BggBgEFBQcwAoYxZmlsZTovL1xcc3N1LTa4
XENlcnRFbnJvbGxcx3N1LTa4X0FwYXJuYsUyMENBLmNygdDANBgkqhkiG9w0BAQUF
AANBADbGBGsbe?GNlh9xeOTWBnm24U69ZSuDDcOcUZUUTgrpnTqUpPyejtsyflw
E36cIZu4WsExReqxbsTk8ycx7U5o=
-----END CERTIFICATE-----
D:\>testcerts>
```

Revoking a Certificate

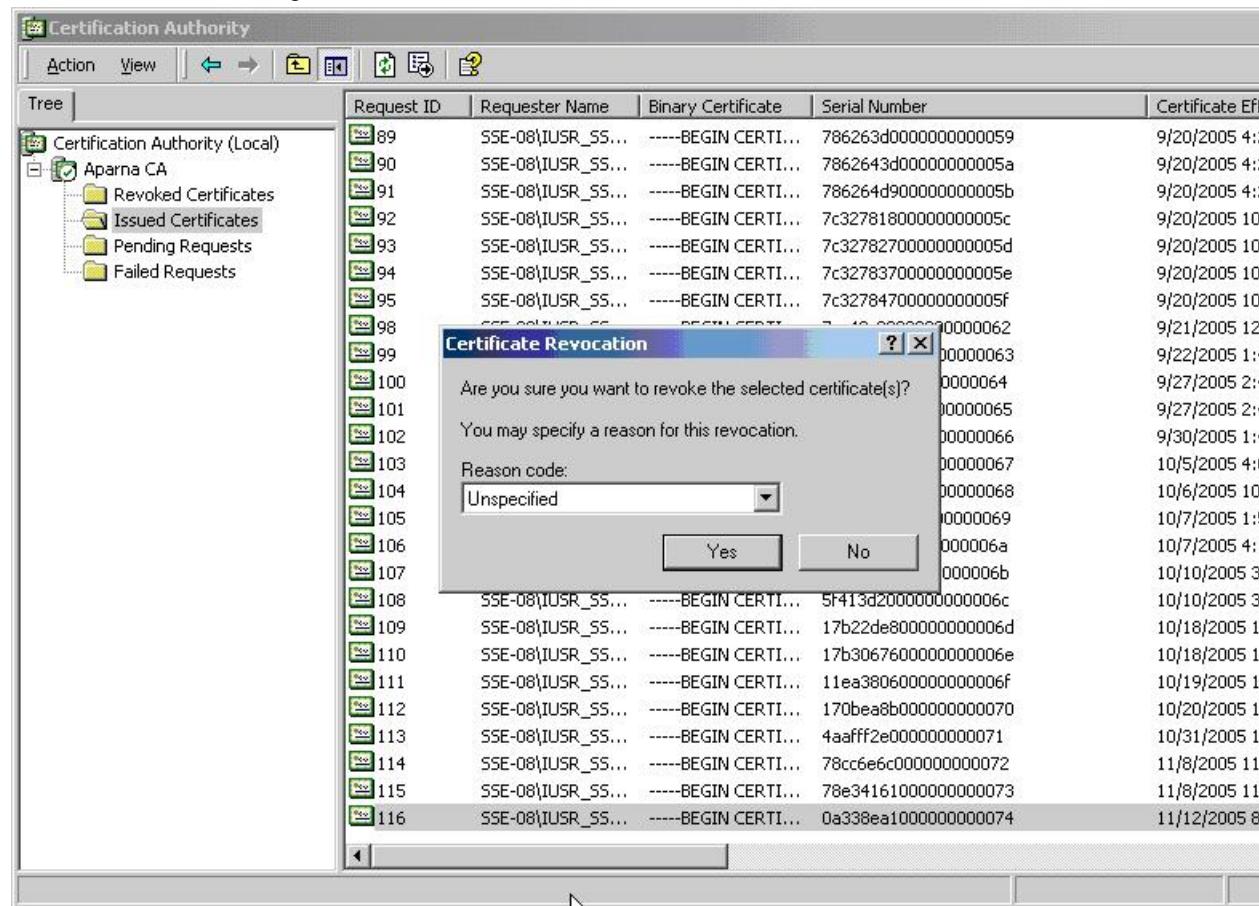
To revoke a certificate using the Microsoft CA administrator program, follow these steps:

Procedure

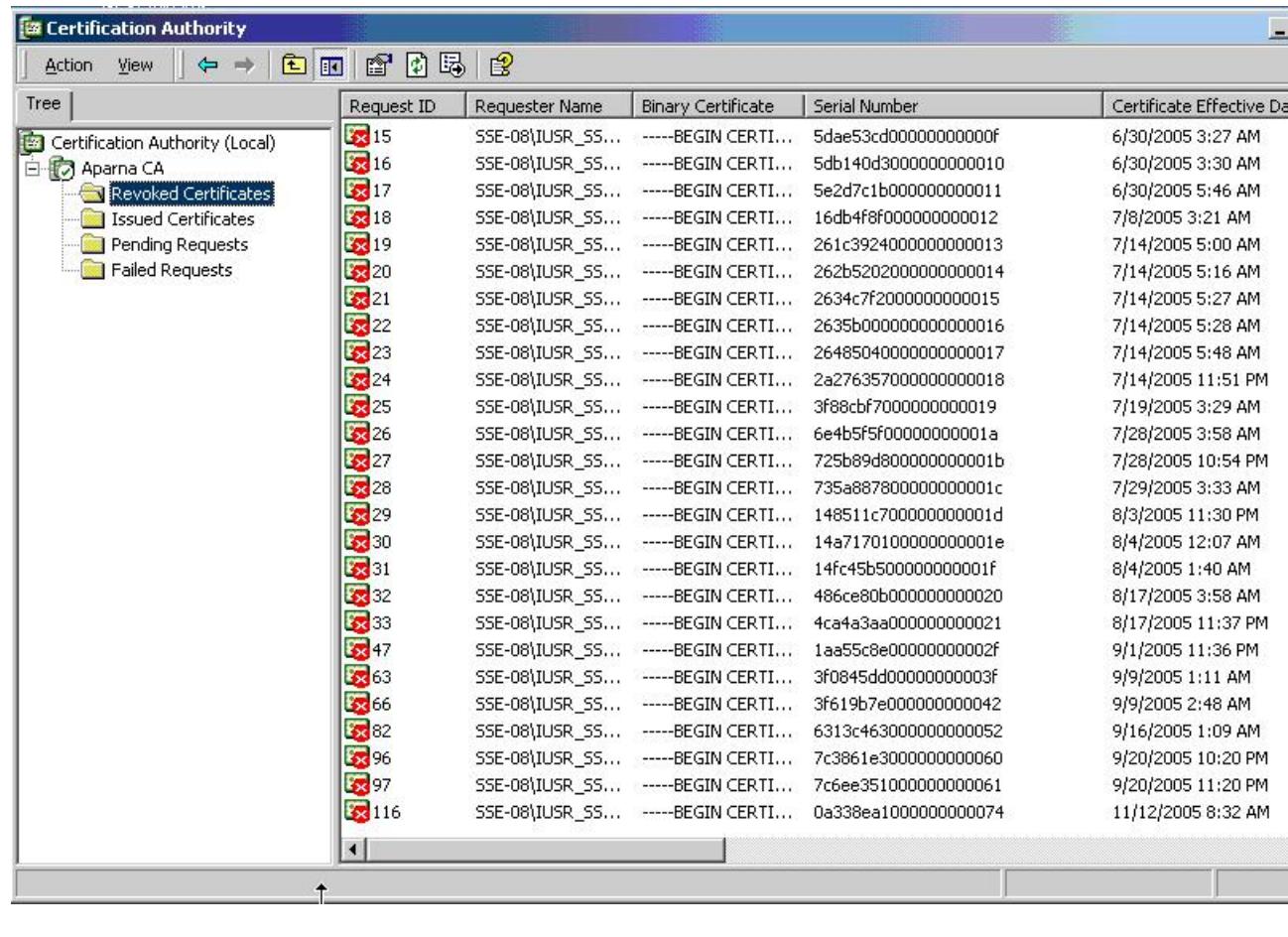
- Step 1** From the Certification Authority tree, click **Issued Certificates** folder. From the list, right-click the certificate that you want to revoke.

Revoking a Certificate**Step 2** Choose All Tasks > Revoke Certificate.

Step 3 From the Reason code drop-down list, choose a reason for the revocation and click **Yes**.



Step 4 Click the Revoked Certificates folder to list and verify the certificate revocation.



The screenshot shows the Microsoft Certification Authority (CA) administrator interface. On the left, there is a tree view pane showing the structure of the certification authority, including 'Certification Authority (Local)', 'Aparna CA', 'Revoked Certificates' (which is selected and highlighted in blue), 'Issued Certificates', 'Pending Requests', and 'Failed Requests'. On the right, there is a detailed table listing revoked certificates. The columns are 'Request ID', 'Requester Name', 'Binary Certificate', 'Serial Number', and 'Certificate Effective Date'. The table contains 116 rows of data, each representing a revoked certificate entry. The 'Request ID' column lists entries from 15 to 116. The 'Requester Name' column shows entries like 'SSE-08\IUSR_SS...' repeated multiple times. The 'Binary Certificate' column shows truncated certificate data starting with '-----BEGIN CERTI...'. The 'Serial Number' column contains long hexadecimal strings. The 'Certificate Effective Date' column shows various dates from 2005, such as '6/30/2005 3:27 AM' and '11/12/2005 8:32 AM'.

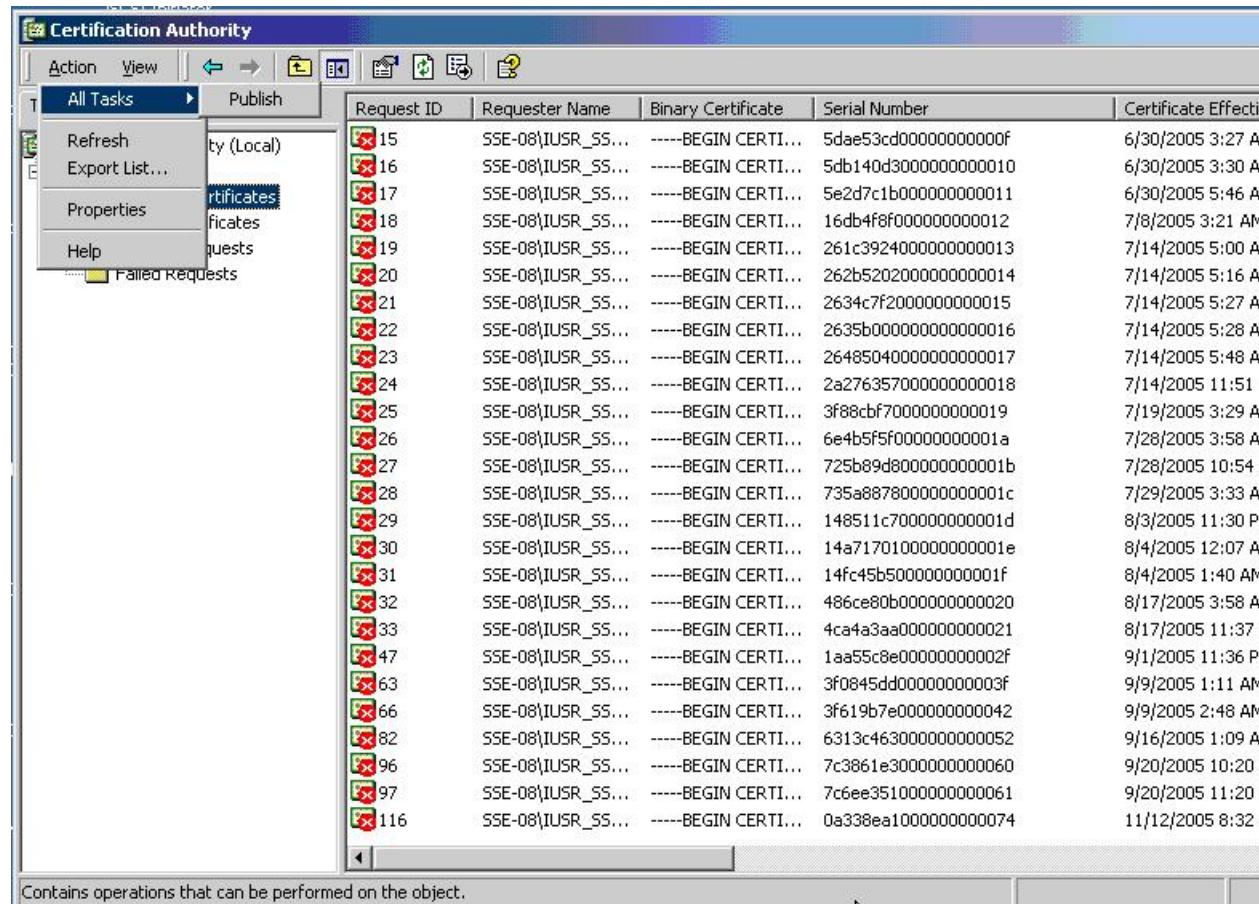
Request ID	Requester Name	Binary Certificate	Serial Number	Certificate Effective Date
15	SSE-08\IUSR_SS...	-----BEGIN CERTI...	5dae53cd00000000000f	6/30/2005 3:27 AM
16	SSE-08\IUSR_SS...	-----BEGIN CERTI...	5db140d3000000000010	6/30/2005 3:30 AM
17	SSE-08\IUSR_SS...	-----BEGIN CERTI...	5e2d7c1b000000000011	6/30/2005 5:46 AM
18	SSE-08\IUSR_SS...	-----BEGIN CERTI...	16db4f8f000000000012	7/8/2005 3:21 AM
19	SSE-08\IUSR_SS...	-----BEGIN CERTI...	261c3924000000000013	7/14/2005 5:00 AM
20	SSE-08\IUSR_SS...	-----BEGIN CERTI...	262b5202000000000014	7/14/2005 5:16 AM
21	SSE-08\IUSR_SS...	-----BEGIN CERTI...	2634c7f20000000000015	7/14/2005 5:27 AM
22	SSE-08\IUSR_SS...	-----BEGIN CERTI...	2635b0000000000000016	7/14/2005 5:28 AM
23	SSE-08\IUSR_SS...	-----BEGIN CERTI...	26485040000000000017	7/14/2005 5:48 AM
24	SSE-08\IUSR_SS...	-----BEGIN CERTI...	2a276357000000000018	7/14/2005 11:51 PM
25	SSE-08\IUSR_SS...	-----BEGIN CERTI...	3f88cbf70000000000019	7/19/2005 3:29 AM
26	SSE-08\IUSR_SS...	-----BEGIN CERTI...	6e4b5f5f00000000001a	7/28/2005 3:58 AM
27	SSE-08\IUSR_SS...	-----BEGIN CERTI...	725b89d8000000000001b	7/28/2005 10:54 PM
28	SSE-08\IUSR_SS...	-----BEGIN CERTI...	735a8878000000000001c	7/29/2005 3:33 AM
29	SSE-08\IUSR_SS...	-----BEGIN CERTI...	148511c700000000001d	8/3/2005 11:30 PM
30	SSE-08\IUSR_SS...	-----BEGIN CERTI...	14a7170100000000001e	8/4/2005 12:07 AM
31	SSE-08\IUSR_SS...	-----BEGIN CERTI...	14fc45b500000000001f	8/4/2005 1:40 AM
32	SSE-08\IUSR_SS...	-----BEGIN CERTI...	486ce80b000000000020	8/17/2005 3:58 AM
33	SSE-08\IUSR_SS...	-----BEGIN CERTI...	4ca4a3aa000000000021	8/17/2005 11:37 PM
47	SSE-08\IUSR_SS...	-----BEGIN CERTI...	1aa55c8e00000000002f	9/1/2005 11:36 PM
63	SSE-08\IUSR_SS...	-----BEGIN CERTI...	3f0845dd00000000003f	9/9/2005 1:11 AM
66	SSE-08\IUSR_SS...	-----BEGIN CERTI...	3f619b7e000000000042	9/9/2005 2:48 AM
82	SSE-08\IUSR_SS...	-----BEGIN CERTI...	6313c463000000000052	9/16/2005 1:09 AM
96	SSE-08\IUSR_SS...	-----BEGIN CERTI...	7c3861e3000000000060	9/20/2005 10:20 PM
97	SSE-08\IUSR_SS...	-----BEGIN CERTI...	7c6ee351000000000061	9/20/2005 11:20 PM
116	SSE-08\IUSR_SS...	-----BEGIN CERTI...	0a338ea1000000000074	11/12/2005 8:32 AM

Generating and Publishing the CRL

To generate and publish the CRL using the Microsoft CA administrator program, follow these steps:

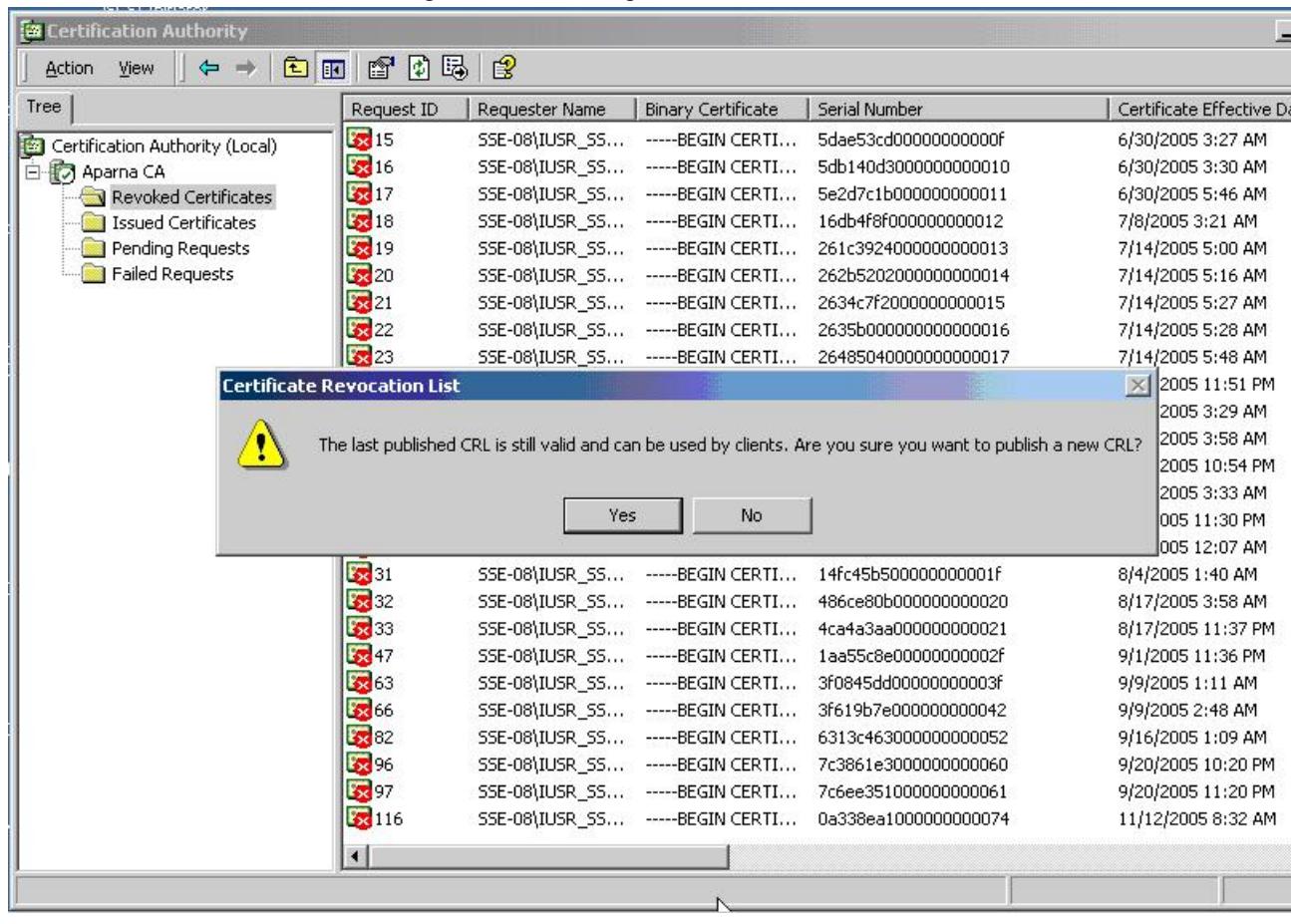
Procedure

Step 1 From the Certification Authority screen, choose **Action > All Tasks > Publish**.



■ Downloading the CRL

Step 2 In the Certificate Revocation List dialog box, click **Yes** to publish the latest CRL.



Downloading the CRL

To download the CRL from the Microsoft CA website, follow these steps:

Procedure

Step 1

From the Microsoft Certificate Services web interface, click **Retrieve the CA certificate or certificate revocation list** and click **Next**.

144784

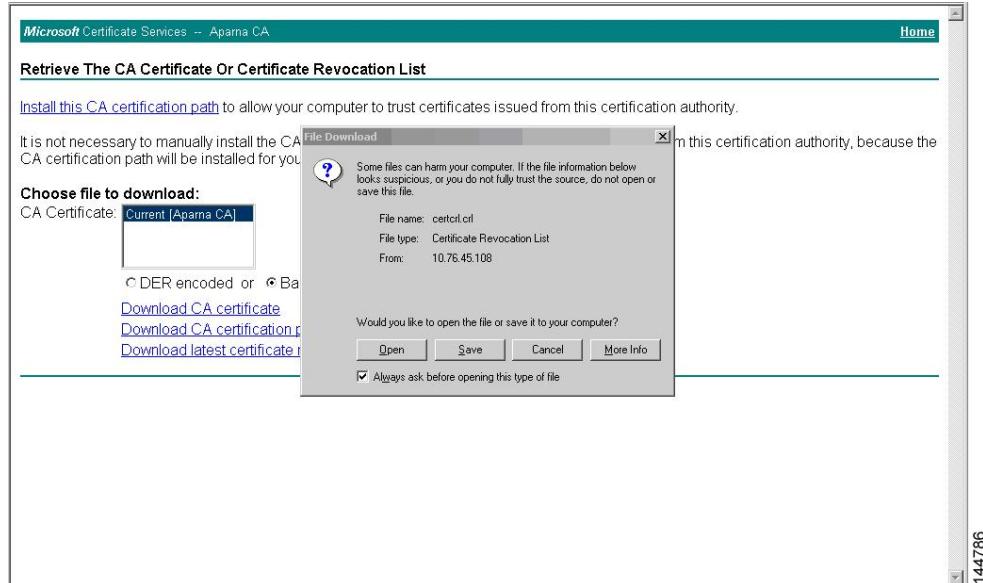
Step 2

Click **Download latest certificate revocation list**.

144785

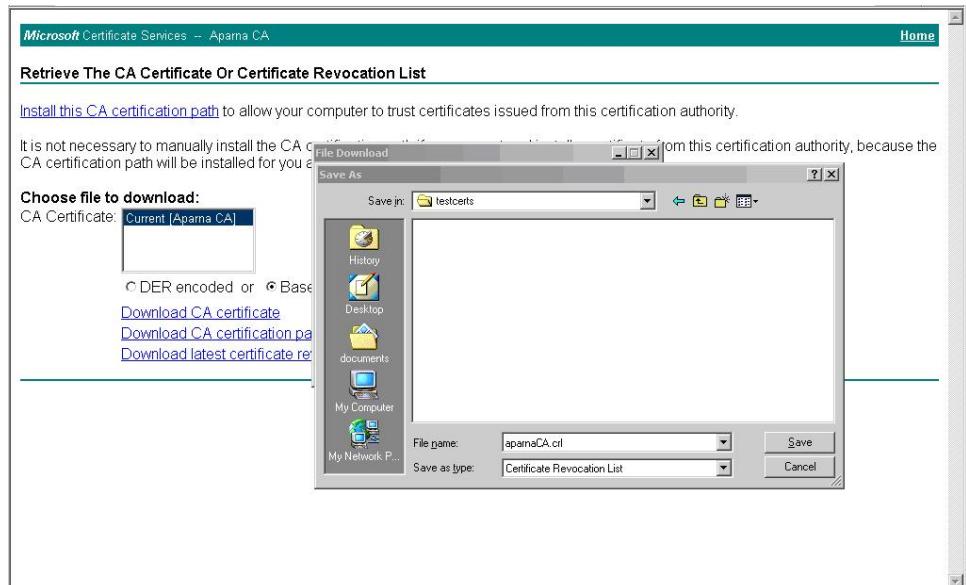
Downloading the CRL

Step 3 In the File Download dialog box, click Save.



144786

Step 4 In the Save As dialog box, enter the destination file name and click Save.



144787

- Step 5** Enter the Microsoft Windows **type** command to display the CRL.

```
D:\testcerts>type aparnaCA.crl
-----BEGIN X509 CRL-----
MIIGBTCCBaa8CAQEWQJk0ZlIhcNAQEFBQAvgZAxDaeBgkghki9w0BCQEWEWFc
Yw5ka2uAY2z1zY28uY29tM0QswuQYDUQQGEwJjtjE5MBAGA1UECBMJS2FybmF0YWt
h
MRIwEAYDVUQQHEw1CYW5nYWxvcm0xDj0MBgNUBaoTBUNpc2NvMRMwEQYDVUQQLEwp
ZXRzdG9yWd1MRIwEAYDVUQQDBw1BcGFybmEgQ0EXDTA1MTxMjA0M2yWnFoXDTA1
MTEoOTE2NTYwNFOwggsxMbsCmEbCaEAAAATXDTA1MDgxNjIxNTIxOuowGwIK
TN5GTgAAAAAAxcNMDUwODE2MjE1Mj15WjAbAgpMxTCAAAAAAAAAEw0wNTA4MTYv
MTUuNDFaMBsCCnxpnsIAAAAAAAUXDTA1MDgxNjIxNTI1MlowGwIKM93AAAAAA
BhcNMDUwNjA0WjAbAgpwsE/AAAAAAAHHFw0wNTA4MTYyMTUzMTUaMBsC
Cx2bERYAAAAAAgXDTA1MDgxNjIxNTMxNuowQIKUggCMAAAAAAAxCrCNMDUwNj13
MjM0NzA2UjAMM0GA1uAFQQDCgECMCKCC1Nj-UyAAAAAAQoXDTA1MDyvNzIzNdcv
MlowDdAKBgNUHREwbaBa:jApAgpTvRc8AAAAAAALFw0wNTA3MDQxODA0MDFaMauw
CgYDUR0UBAMKAQyWgwiKWR56zgAAAAADBeNMDUwODE2MjE1MzE1WjApAgpP9Uu
AAAAAAANFw0wNTA2MjkyMjA3Mj0aMhwCgYDUR0UBAMKAQewGwIKXat3EvRAHHAA
DhcNMDUwNzE0MDazMzU2WjAbAgpdsIPNAAAAAAAPFw0wNTA4MTYyMTUzMTUaMBsC
C12xQNMMAAAAABXDTA1MDgxNjIxNTMxNuowQIKKx1i8GwAAAAAAERcNMDUwNzA2
MjExMjEuWjAMM0GA1uAFQQDCgECMBSCChbT48AAAAABIXDTA1MDgxNjIxNTMx
NuowGwIKJhw5JAIAAAAExcNMDUwODE2MjE1MzE1WjAbAgomK1ICAAAAAAUFW0w
NTA3MTQuMDMzBaMBsCCiY0/>IAAAAABXDTA1MDcxNDawMz10NuowGwIKJjWw
AAAAAAAPhcnMDUwNzE0MDazMTUwXjAbAgomSFBAAAAAAAxFw0wNTA3MTQwMDMy
MjUaMBsCCion1cAAAAABgXDTA1MDgxNjIxNTMxNuowGwIKP4jL9wAAAAAAAGReN
MDUwODE2MjE1Mz19fAAAAAAaFw0wNTA4MTYyMTUzMTUaMBsCCnJb
idgAAAAAAABsXDTA1MDgxNjIxNTMxNuowGwIKc1q1eAAAAAAAHBcNMDUwODE2MjE1
MzE1WjAbAg0uHRRHAAAAAAAdFw0wNTA4MTYyMTUzMTUaMBsCChsnFuEAAAAAAAB4x
DTA1MDgxNjIxNTMxNuowGwIKFpxFtQAAAARHxcNMDUwODE3MTg2MDQyWjAbAgpI
bOgLAaaaaAgFw0wNTA4MTcxODMwNDNaMBsCClyko6oAAAAACEXDTA1MDgxNzE4
MzH0M1owGwIKGqUcjcgAAAAAA1xcNMDUwOT1MtcwnzA2WjhB Ago/CExdAAAAAAA/
Fw0wNTA5MDgyMDI0MzJaMBsCCj9hm34AAAAAAEIXDIA1MDkwODIxNDA0OFowGwIK
YxPEYwAAAAAAUhcNMDUwOTE5MtczNzE4WjAbAgp80GHjAAAAAAABgFw0wNTA5MjAx
NzUjNTzMBsCCnxu41EAAAAAAQEXDTA1MDk0MDE4NTIzMFnwGwIKCj00oQAAAAAA
dBcNMDUwMTEyMDQzNDQyWqA1MDMwHwYDUR0jbBwgwFoAUyjyRoMbwCNMRU20yRhQ
GgsWbHEwEAYJKwYBBAGCNxUBAMCAQwDQYJKoZIhcNAQEFBQADQ0ALy91DCrhI
HoCuBm9NruzVjjejqeu168CuacFP3rkM8VjZyputc32R/VuU6axgrAC/SbsEa
nxpJt5xJndy
-----END X509 CRL-----
D:\testcerts>
```

Importing the CRL

To import the CRL to the trust point corresponding to the CA, follow these steps:

Procedure

- Step 1** Copy the CRL file to the Cisco NX-OS device bootflash.

```
Device-1# copy tftp:aparnaCA.crl bootflash:aparnaCA.crl
```

- Step 2** Configure the CRL.

```
Device-1# configure terminal
Device-1(config)# crypto ca crl request myCA bootflash:aparnaCA.crl
Device-1(config) #
```

- Step 3** Display the contents of the CRL.

```
Device-1(config)# show crypto ca crl myCA
Trustpoint: myCA
CRL:
Certificate Revocation List (CRL):
Version 2 (0x1)
```

Importing the CRL

```

Signature Algorithm: sha1WithRSAEncryption
Issuer: /emailAddress=admin@yourcompany.com/C=IN/ST=Karnatak
Yourcompany/OU=netstorage/CN=Aparna CA
    Last Update: Nov 12 04:36:04 2005 GMT
    Next Update: Nov 19 16:56:04 2005 GMT
CRL extensions:
    X509v3 Authority Key Identifier:
        keyid:27:28:F2:46:83:1B:AC:23:4C:45:4D:8E:C9:18:50:1
        1.3.6.1.4.1.311.21.1:
        ...
Revoked Certificates:
    Serial Number: 611B09A1000000000002
        Revocation Date: Aug 16 21:52:19 2005 GMT
    Serial Number: 4CDE464E000000000003
        Revocation Date: Aug 16 21:52:29 2005 GMT
    Serial Number: 4CFC2B42000000000004
        Revocation Date: Aug 16 21:52:41 2005 GMT
    Serial Number: 6C699EC2000000000005
        Revocation Date: Aug 16 21:52:52 2005 GMT
    Serial Number: 6CCF7DDC000000000006
        Revocation Date: Jun 8 00:12:04 2005 GMT
    Serial Number: 70CC4FFF000000000007
        Revocation Date: Aug 16 21:53:15 2005 GMT
    Serial Number: 4D9B1116000000000008
        Revocation Date: Aug 16 21:53:15 2005 GMT
    Serial Number: 52A802300000000000009
        Revocation Date: Jun 27 23:47:06 2005 GMT
    CRL entry extensions:
        X509v3 CRL Reason Code:
            CA Compromise
    Serial Number: 5349AD4600000000000A
        Revocation Date: Jun 27 23:47:22 2005 GMT
    CRL entry extensions:
        X509v3 CRL Reason Code:
            CA Compromise
    Serial Number: 53BD173C00000000000B
        Revocation Date: Jul 4 18:04:01 2005 GMT
    CRL entry extensions:
        X509v3 CRL Reason Code:
            Certificate Hold
    Serial Number: 591E7ACE00000000000C
        Revocation Date: Aug 16 21:53:15 2005 GMT
    Serial Number: 5D3FD52E00000000000D
        Revocation Date: Jun 29 22:07:25 2005 GMT
    CRL entry extensions:
        X509v3 CRL Reason Code:
            Key Compromise
    Serial Number: 5DAB771300000000000E
        Revocation Date: Jul 14 00:33:56 2005 GMT
    Serial Number: 5DAE53CD00000000000F
        Revocation Date: Aug 16 21:53:15 2005 GMT
    Serial Number: 5DB140D3000000000010
        Revocation Date: Aug 16 21:53:15 2005 GMT
    Serial Number: 5E2D7C1B000000000011
        Revocation Date: Jul 6 21:12:10 2005 GMT
    CRL entry extensions:
        X509v3 CRL Reason Code:
            Cessation Of Operation
    Serial Number: 16DB4F8F000000000012
        Revocation Date: Aug 16 21:53:15 2005 GMT
    Serial Number: 261C3924000000000013
        Revocation Date: Aug 16 21:53:15 2005 GMT
    Serial Number: 262B5202000000000014
        Revocation Date: Jul 14 00:33:10 2005 GMT

```

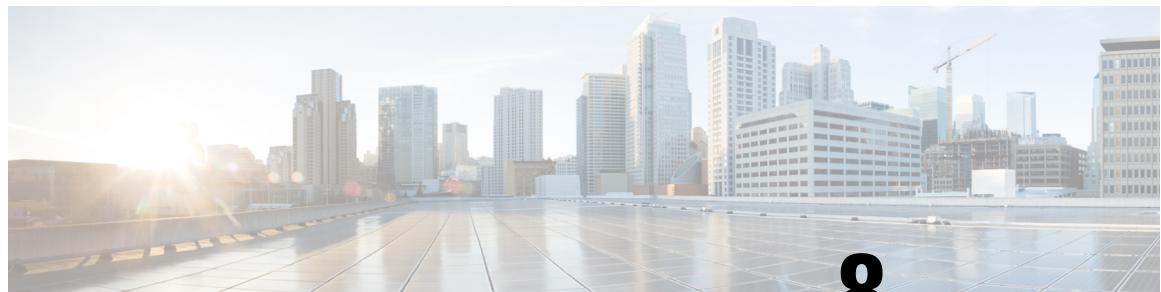
```

Serial Number: 2634C7F20000000000015
    Revocation Date: Jul 14 00:32:45 2005 GMT
Serial Number: 2635B0000000000000016
    Revocation Date: Jul 14 00:31:51 2005 GMT
Serial Number: 2648504000000000000017
    Revocation Date: Jul 14 00:32:25 2005 GMT
Serial Number: 2A2763570000000000018
Revocation Date: Aug 16 21:53:15 2005 GMT
Serial Number: 3F88CBF70000000000019
    Revocation Date: Aug 16 21:53:15 2005 GMT
Serial Number: 6E4B5F5F000000000001A
    Revocation Date: Aug 16 21:53:15 2005 GMT
Serial Number: 725B89D8000000000001B
    Revocation Date: Aug 16 21:53:15 2005 GMT
Serial Number: 735A8878000000000001C
    Revocation Date: Aug 16 21:53:15 2005 GMT
Serial Number: 148511C7000000000001D
    Revocation Date: Aug 16 21:53:15 2005 GMT
Serial Number: 14A71701000000000001E
    Revocation Date: Aug 16 21:53:15 2005 GMT
Serial Number: 14FC45B5000000000001F
    Revocation Date: Aug 17 18:30:42 2005 GMT
Serial Number: 486CE80B0000000000020
    Revocation Date: Aug 17 18:30:43 2005 GMT
Serial Number: 4CA4A3AA0000000000021
    Revocation Date: Aug 17 18:30:43 2005 GMT
Serial Number: 1AA55C8E000000000002F
    Revocation Date: Sep 5 17:07:06 2005 GMT
Serial Number: 3F0845DD000000000003F
    Revocation Date: Sep 8 20:24:32 2005 GMT
Serial Number: 3F619B7E0000000000042
    Revocation Date: Sep 8 21:40:48 2005 GMT
Serial Number: 6313C4630000000000052
    Revocation Date: Sep 19 17:37:18 2005 GMT
Serial Number: 7C3861E30000000000060
    Revocation Date: Sep 20 17:52:56 2005 GMT
Serial Number: 7C6EE3510000000000061
    Revocation Date: Sep 20 18:52:30 2005 GMT
Serial Number: 0A338EA1000000000074    <-- Revoked identity certificate
    Revocation Date: Nov 12 04:34:42 2005 GMT
Signature Algorithm: sha1WithRSAEncryption
0b:cb:dd:43:0a:b8:62:1e:80:95:06:6f:4d:ab:0c:d8:8e:32:
44:8e:a7:94:97:af:02:b9:a6:9c:14:fd:eb:90:cf:18:c9:96:
29:bb:57:37:d9:1f:d5:bd:4e:9a:4b:18:2b:00:2f:d2:6e:c1:
1a:9f:1a:49:b7:9c:58:24:d7:72

```

- Note** The identity certificate for the device that was revoked (serial number 0A338EA1000000000074) is listed at the end.

Importing the CRL



CHAPTER 8

Configuring Access Control Lists

This chapter contains the following sections:

- [Information About ACLs, on page 131](#)
- [Configuring IP ACLs, on page 139](#)
- [Configuring ACL Using HTTP Methods to Redirect Requests, on page 149](#)
- [Information About VLAN ACLs, on page 151](#)
- [Configuring VACLs, on page 151](#)
- [Configuration Examples for VACL, on page 154](#)
- [Configuring the LOU Threshold, on page 154](#)
- [Configuring ACL TCAM Region Sizes, on page 155](#)
- [Configuring ACLs on Virtual Terminal Lines, on page 158](#)

Information About ACLs

An access control list (ACL) is an ordered set of rules that you can use to filter traffic. Each rule specifies a set of conditions that a packet must satisfy to match the rule. When the switch determines that an ACL applies to a packet, it tests the packet against the conditions of all rules. The first match determines whether the packet is permitted or denied. If there is no match, the switch applies the applicable default rule. The switch continues processing packets that are permitted and drops packets that are denied.

You can use ACLs to protect networks and specific hosts from unnecessary or unwanted traffic. For example, you could use ACLs to disallow HTTP traffic from a high-security network to the Internet. You could also use ACLs to allow HTTP traffic but only to specific sites, using the IP address of the site to identify it in an IP ACL.

IP ACL Types and Applications

The Cisco Nexus device supports IPv4 for security traffic filtering. The switch allows you to use IP access control lists (ACLs) as port ACLs, VLAN ACLs, and Router ACLs as shown in the following table.

Table 10: Security ACL Applications

Application	Supported Interfaces	Types of ACLs Supported
Port ACL	An ACL is considered a port ACL when you apply it to one of the following: <ul style="list-style-type: none"> • Ethernet interface • Ethernet port-channel interface When a port ACL is applied to a trunk port, the ACL filters traffic on all VLANs on the trunk port.	IPv4 ACLs IPv6 ACLs
Router ACL	<ul style="list-style-type: none"> • VLAN interfaces <p>Note You must enable VLAN interfaces globally before you can configure a VLAN interface.</p> <ul style="list-style-type: none"> • Physical Layer 3 interfaces • Layer 3 Ethernet subinterfaces • Layer 3 Ethernet port-channel interfaces • Layer 3 Ethernet port-channel subinterfaces • Tunnels • Management interfaces 	IPv4 ACLs IPv6 ACLs
VLAN ACL (VACL)	An ACL is a VACL when you use an access map to associate the ACL with an action and then apply the map to a VLAN.	IPv4 ACLs
VTY ACL	VTYs	IPv4 ACLs IPv6 ACLs

Application Order

When the device processes a packet, it determines the forwarding path of the packet. The path determines which ACLs that the device applies to the traffic. The device applies the ACLs in the following order:

1. Port ACL
2. Ingress VACL
3. Ingress Router ACL
4. Egress Router ACL
5. Egress VACL

Rules

You can create rules in access-list configuration mode by using the **permit** or **deny** command. The switch allows traffic that matches the criteria in a permit rule and blocks traffic that matches the criteria in a deny rule. You have many options for configuring the criteria that traffic must meet in order to match the rule.

Source and Destination

In each rule, you specify the source and the destination of the traffic that matches the rule. You can specify both the source and destination as a specific host, a network or group of hosts, or any host.

Protocols

IPv4, IPv6, and MAC ACLs allow you to identify traffic by protocol. For your convenience, you can specify some protocols by name. For example, in an IPv4 ACL, you can specify ICMP by name.

You can specify any protocol by the integer that represents the Internet protocol number.

Implicit Rules

IP and MAC ACLs have implicit rules, which means that although these rules do not appear in the running configuration, the switch applies them to traffic when no other rules in an ACL match.

All IPv4 ACLs include the following implicit rule:

```
deny ip any any
```

This implicit rule ensures that the switch denies unmatched IP traffic.

All IPv6 ACLs include the following implicit rule:

```
deny ipv6 any any
```

```
permit icmp any any nd-na
permit icmp any any nd-ns
permit icmp any any router-advertisement
permit icmp any any router-solicitation
```

Unless you configure an IPv6 ACL with a rule that denies ICMPv6 neighbor discovery messages, the first four rules ensure that the device permits neighbor discovery advertisement and solicitation messages. The fifth rule ensures that the device denies unmatched IPv6 traffic.



Note

If you explicitly configure an IPv6 ACL with a **deny ipv6 any any** rule, the implicit permit rules can never permit traffic. If you explicitly configure a **deny ipv6 any any** rule but want to permit ICMPv6 neighbor discovery messages, explicitly configure a rule for all five implicit rules.

All MAC ACLs include the following implicit rule:

```
deny any any protocol
```

This implicit rule ensures that the device denies the unmatched traffic, regardless of the protocol specified in the Layer 2 header of the traffic.

Additional Filtering Options

You can identify traffic by using additional options. IPv4 ACLs support the following additional filtering options:

- Layer 4 protocol
- TCP and UDP ports
- ICMP types and codes
- IGMP types
- Precedence level
- Differentiated Services Code Point (DSCP) value
- TCP packets with the ACK, FIN, PSH, RST, SYN, or URG bit set
- Established TCP connections

MAC ACLs support the following additional filtering options:

- Layer 3 protocol
- VLAN ID
- Class of Service (CoS)

Sequence Numbers

The Cisco Nexus device supports sequence numbers for rules. Every rule that you enter receives a sequence number, either assigned by you or assigned automatically by the device. Sequence numbers simplify the following ACL tasks:

- Adding new rules between existing rules—By specifying the sequence number, you specify where in the ACL a new rule should be positioned. For example, if you need to insert a rule between rules numbered 100 and 110, you could assign a sequence number of 105 to the new rule.
- Removing a rule—Without using a sequence number, removing a rule requires that you enter the whole rule, as follows:

```
switch(config-acl)# no permit tcp 10.0.0.0/8 any
```

However, if the same rule had a sequence number of 101, removing the rule requires only the following command:

```
switch(config-acl)# no 101
```

- Moving a rule—With sequence numbers, if you need to move a rule to a different position within an ACL, you can add a second instance of the rule using the sequence number that positions it correctly, and then you can remove the original instance of the rule. This action allows you to move the rule without disrupting traffic.

If you enter a rule without a sequence number, the device adds the rule to the end of the ACL and assigns a sequence number that is 10 greater than the sequence number of the preceding rule to the rule. For example, if the last rule in an ACL has a sequence number of 225 and you add a rule without a sequence number, the device assigns the sequence number 235 to the new rule.

In addition, the device allows you to reassign sequence numbers to rules in an ACL. Resequencing is useful when an ACL has rules numbered contiguously, such as 100 and 101, and you need to insert one or more rules between those rules.

Logical Operators and Logical Operation Units

IP ACL rules for TCP and UDP traffic can use logical operators to filter traffic based on port numbers.

The Cisco Nexus device stores operator-operand couples in registers called logical operation units (LOUs) to perform operations (greater than, less than, not equal to, and range) on the TCP and UDP ports specified in an IP ACL.



Note

The range operator is inclusive of boundary values.

These LOUs minimize the number of ternary content addressable memory (TCAM) entries needed to perform these operations. A maximum of two LOUs are allowed for each feature on an interface. For example an ingress RACL can use two LOUs, and a QoS feature can use two LOUs. If an ACL feature requires more than two arithmetic operations, the first two operations use LOUs, and the remaining access control entries (ACEs) get expanded.

The following guidelines determine when the device stores operator-operand couples in LOUs:

- If the operator or operand differs from other operator-operand couples that are used in other rules, the couple is stored in an LOU.

For example, the operator-operand couples "gt 10" and "gt 11" would be stored separately in half an LOU each. The couples "gt 10" and "lt 10" would also be stored separately.

- Whether the operator-operand couple is applied to a source port or a destination port in the rule affects LOU usage. Identical couples are stored separately when one of the identical couples is applied to a source port and the other couple is applied to a destination port.

For example, if a rule applies the operator-operand couple "gt 10" to a source port and another rule applies a "gt 10" couple to a destination port, both couples would also be stored in half an LOU, resulting in the use of one whole LOU. Any additional rules using a "gt 10" couple would not result in further LOU usage.

ACL TCAM Regions

You can change the size of the ACL ternary content addressable memory (TCAM) regions in the hardware.

The IPv4 TCAMs are single wide.

You can create IPv6 port ACLs, VLAN ACL, router ACLs, and you can match IPv6 addresses for QoS. However, Cisco NX-OS cannot support all of them simultaneously. You must remove or reduce the size of the existing TCAMs to enable these new IPv6 TCAMs.

TCAM region sizes have the following guidelines and limitations:

- To revert to the default ACL TCAM size, use the **no hardware profile team region** command. You no longer need to use the **write erase command** and reload the switch.
- Depending upon the platform, each TCAM region might have a different minimum/maximum/aggregate size restriction.

- The default size of the ARPACL TCAM is zero. Before you use the ARP ACLs in a Control Policing Plane (CoPP) policy, you must set the size of this TCAM to a non-zero size.
- You must set the VACL and egress VLAN ACL (E-VACL) size to the same value.
- Both IPv4 and IPv6 addresses cannot coexist, even in a double-wide TCAM.
- IPv6 PACL TCAM is not supported for Cisco NX-OS 3000 Series switches.
- The total TCAM depth is 2000 for ingress and 1000 for egress, which can be carved in 256 entries blocks.
- After TCAM carving, you must reload the switch.
- All existing TCAMs cannot be set to size 0.
- By default, all IPv6 TCAMs are disabled (the TCAM size is set to 0).

Table 11: TCAM Sizes by ACL Region

TCAM ACL Region	Default Size	Minimum Size	Incremental Size	Maximum Size
SUP (ingress)	128 x 2	128 x 2	N/A	128 x 2
SPAN (ingress)	128	128	N/A	128
ARPACL (ingress)	0	0	128	128
PACL (ingress)	384	ARPACL disabled = 128 ARPACL enabled = 256	256	1664 (combined)
VACL (ingress)	512	0	256	
RACL (ingress)	512	256	256	
QOS (ingress)	256	256	256	
PACL_IPV6 (ingress)	0	0	256 x 2	
VACL_IPV6 (ingress)	0	0	256 x 2	
RACL_IPV6 (ingress)	0	0	256 x 2	
QOS_IPV6 (ingress)	0	0	256 x 2	

TCAM ACL Region	Default Size	Minimum Size	Incremental Size	Maximum Size
E-VACL (egress)	512	0	256	1024 (combined)
E-RACL (egress)	512	0	256	
E-VACL_IPV6 (egress)	0	0	256 x 2	
E-RACL_IPV6 (egress)	0	0	256 x 2	
QOSLBL (pre-lookup)	256	256	256	512(combined)
IPSG (pre-lookup)	256	256	256	
SUP_IPV6 (pre-lookup)	128 x 2	256 x 2	N/A	256 x 2

Licensing Requirements for ACLs

The following table shows the licensing requirements for this feature:

Product	License Requirement
Cisco NX-OS	No license is required to use ACLs.

Prerequisites for ACLs

IP ACLs have the following prerequisites:

- You must be familiar with IP addressing and protocols to configure IP ACLs.
- You must be familiar with the interface types that you want to configure with ACLs.

VACLs have the following prerequisite:

- Ensure that the IP ACL that you want to use in the VACL exists and is configured to filter traffic in the manner that you need for this application.

Guidelines and Limitations for ACLs

IP ACLs have the following configuration guidelines and limitations:

- You cannot configure the set-vlan option on the tap-aggregation policy. The set-vlan and strip-vlan options are specific to OpenFlow.
- As an enhancement to HTTP method match, the tcp-option-length option has been added to the ACE syntax to specify the length of the TCP options header in the packets. You can configure up to 4 tcp-option-lengths in the ACEs, which includes the TCP option length of 0. If you do not configure the

Default ACL Settings

tcp-option-length option, the length is considered as 0. It means that only the packets without the TCP options header can match this ACE. This feature gives more flexibility in such a way that the HTTP method can be matched even on the packets that have the variable length TCP options header.

- We recommend that you perform ACL configuration using the Session Manager. This feature allows you to verify ACL configuration and confirm that the resources required by the configuration are available prior to committing them to the running configuration. This is especially useful for ACLs that include more than about 1000 rules.
- Only 62 unique ACLs can be configured. Each ACL takes one label. If same ACL is configured on multiple interfaces, the same label is shared; but if each ACL has unique entries, the ACL labels are not shared and that label limit is 62.
- Packets that fail the Layer 3 maximum transmission unit check and therefore require fragmenting.
- IPv4 packets that have IP options (additional IP packet header fields following the destination address field).
- When you apply an ACL that uses time ranges, the device updates the ACL entries whenever a time range referenced in an ACL entry starts or ends. Updates that are initiated by time ranges occur on a best-effort priority. If the device is especially busy when a time range causes an update, the device may delay the update by up to a few seconds.
- To apply an IP ACL to a VLAN interface, you must have enabled VLAN interfaces globally.
- To use the **match-local-traffic** option for all inbound and outbound traffic, you must first enable the ACL in the software.
- An RACL applied on a Layer 3 physical or logical interface does not match multicast traffic. If multicast traffic must be blocked, use a PACL instead.
- You cannot configure egress RACLS on L3 port channels.
- IPv4 ACL logging in the egress direction is not supported.

VACLs have the following configuration:

- We recommend that you perform ACL configurations using the Session Manager. This feature allows you to verify ACL configuration and confirm that the resources required by the configuration are available prior to committing them to the running configuration.
- ACL statistics are not supported if the DHCP snooping feature is enabled.
- If an IPv4 ACL, applied as a VLAN ACL, contains one or more ACEs with logical operators for TCP/UDP port numbers, the port numbers are matched in the ingress direction but ignored in the egress direction.
- One VLAN access map can match only one IP ACL.
- An IP ACL can have multiple permit/deny ACEs.
- One VLAN can have only one access map applied.

Default ACL Settings

The following table lists the default settings for IP ACLs parameters.

Table 12: Default IP ACLs Parameters

Parameters	Default
IP ACLs	No IP ACLs exist by default.
ACL rules	Implicit rules apply to all ACLs.

The following table lists the default settings for VACL parameters.

Table 13: Default VACL Parameters

Parameters	Default
VACLS	No IP ACLs exist by default.
ACL rules	Implicit rules apply to all ACLs.

Configuring IP ACLs

Creating an IP ACL

You can create an IPv4 or IPv6 ACL on the switch and add rules to it.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# {ip ipv6} access-list <i>name</i>	Creates the IP ACL and enters IP ACL configuration mode. The <i>name</i> argument can be up to 64 characters.
Step 3	switch(config-acl)# [sequence-number] {permit deny} protocol source destination	Creates a rule in the IP ACL. You can create many rules. The <i>sequence-number</i> argument can be a whole number between 1 and 4294967295. The permit and deny commands support many ways of identifying traffic. For more information, see the <i>Command Reference</i> for the specific Cisco Nexus device.
Step 4	(Optional) switch(config-acl)# statistics	Specifies that the switch maintains global statistics for packets that match the rules in the ACL.
Step 5	(Optional) switch# show {ip ipv6} access-lists <i>name</i>	Displays the IP ACL configuration.

	Command or Action	Purpose
Step 6	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

This example shows how to create an IPv4 ACL:

```
switch# configure terminal
switch(config)# ip access-list acl-01
switch(config-acl)# permit ip 192.168.2.0/24 any
switch(config-acl)# statistics
```

This example shows how to create an IPv6 ACL:

```
switch# configure terminal
switch(config)# ipv6 access-list acl-01-ipv6
switch(config-ipv6-acl)# permit tcp 2001:0db8:85a3::/48 2001:0db8:be03:2112::/64
```

Configuring IPv4 ACL Logging

To configure the IPv4 ACL logging process, you first create the access list, then enable filtering of IPv4 traffic on an interface using the specified ACL, and finally configure the ACL logging process parameters.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	ip access-list name Example: switch(config)# ip access-list logging-test switch(config-acl)#	Creates an IPv4 ACL and enters IP ACL configuration mode. The <i>name</i> argument can be up to 64 characters.
Step 3	{permit deny} ip source-address destination-address log Example: switch(config-acl)# permit ip any 10.30.30.0/24 log	Creates an ACL rule that permits or denies IPv4 traffic matching its conditions. To enable the system to generate an informational logging message about each packet that matches the rule, you must include the log keyword. The <i>source-address</i> and <i>destination-address</i> arguments can be the IP address with a network wildcard, the IP address and variable-length subnet mask, the host address, or any to designate any address.

	Command or Action	Purpose
Step 4	exit Example: switch(config-acl)# exit switch(config)#	Updates the configuration and exits IP ACL configuration mode.
Step 5	interface ethernet slot/port Example: switch(config)# interface ethernet 1/1 switch(config-if)#	Enters interface configuration mode.
Step 6	ip access-group name in Example: switch(config-if)# ip access-group logging-test in	Enables the filtering of IPv4 traffic on an interface using the specified ACL. You can apply an ACL to inbound traffic.
Step 7	exit Example: switch(config-if)# exit switch(config)#	Updates the configuration and exits interface configuration mode.
Step 8	logging ip access-list cache interval interval Example: switch(config)# logging ip access-list cache interval 490	Configures the log-update interval (in seconds) for the ACL logging process. The default value is 300 seconds. The range is from 5 to 86400 seconds.
Step 9	logging ip access-list cache entries number-of-flows Example: switch(config)# logging ip access-list cache entries 8001	Specifies the maximum number of flows to be monitored by the ACL logging process. The default value is 8000. The range of values supported is from 0 to 1048576.
Step 10	logging ip access-list cache threshold threshold Example: switch(config)# logging ip access-list cache threshold 490	If the specified number of packets is logged before the expiry of the alert interval, the system generates a syslog message.
Step 11	hardware rate-limiter access-list-log packets Example: switch(config)# hardware rate-limiter access-list-log 200	Configures rate limits in packets per second for packets copied to the supervisor module for ACL logging. The range is from 0 to 30000.
Step 12	acllog match-log-level severity-level Example: switch(config)# acllog match-log-level 5	Specifies the minimum severity level to log ACL matches. The default is 6 (informational). The range is from 0 (emergency) to 7 (debugging).

	Command or Action	Purpose
Step 13	(Optional) show logging ip access-list cache [detail] Example: switch(config)# show logging ip access-list cache	Displays information on the active logged flows, such as source IP and destination IP addresses, source port and destination port information, source interfaces. No other information of active flows will be displayed specifically all the unsupported options.

Changing an IP ACL

You can add and remove rules in an existing IPv4 or IPv6 ACL. You cannot change existing rules. Instead, to change a rule, you can remove it and recreate it with the desired changes.

If you need to add more rules between existing rules than the current sequence numbering allows, you can use the **resequence** command to reassign sequence numbers.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# {ip ipv6} access-list name	Enters IP ACL configuration mode for the ACL that you specify by name.
Step 3	switch(config)# ip access-list name	Enters IP ACL configuration mode for the ACL that you specify by name.
Step 4	switch(config-acl)# [<i>sequence-number</i>] { permit deny } <i>protocol source destination</i>	<p>Creates a rule in the IP ACL. Using a sequence number allows you to specify a position for the rule in the ACL. Without a sequence number, the rule is added to the end of the rules. The <i>sequence-number</i> argument can be a whole number between 1 and 4294967295.</p> <p>The permit and deny commands support many ways of identifying traffic. For more information, see the <i>Command Reference</i> for your Cisco Nexus device.</p>
Step 5	(Optional) switch(config-acl)# no { <i>sequence-number</i> { permit deny } <i>protocol source destination</i> }	<p>Removes the rule that you specified from the IP ACL.</p> <p>The permit and deny commands support many ways of identifying traffic. For more information, see the <i>Command Reference</i> for your Cisco Nexus device.</p>
Step 6	(Optional) switch(config-acl)# [no] statistics	Specifies that the switch maintains global statistics for packets that match the rules in the ACL.

	Command or Action	Purpose
		The no option stops the switch from maintaining global statistics for the ACL.
Step 7	(Optional) switch# show ip access-lists name	Displays the IP ACL configuration.
Step 8	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Related Topics[Changing Sequence Numbers in an IP ACL](#), on page 143

Removing an IP ACL

You can remove an IP ACL from the switch.

Before you remove an IP ACL from the switch, be sure that you know whether the ACL is applied to an interface. The switch allows you to remove ACLs that are currently applied. Removing an ACL does not affect the configuration of interfaces where you have applied the ACL. Instead, the switch considers the removed ACL to be empty.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# no {ip ipv6} access-list name	Removes the IP ACL that you specified by name from the running configuration.
Step 3	switch(config)# no ip access-list name	Removes the IP ACL that you specified by name from the running configuration.
Step 4	(Optional) switch# show running-config	Displays the ACL configuration. The removed IP ACL should not appear.
Step 5	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Changing Sequence Numbers in an IP ACL

You can change all the sequence numbers assigned to the rules in an IP ACL.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	(Optional) switch# show {ip ipv6} access-lists name	Displays the IP ACL configuration.

Applying an IP ACL to mgmt0

	Command or Action	Purpose
Step 3	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Applying an IP ACL to mgmt0

You can apply an IPv4 or IPv6 ACL to the management interface (mgmt0).

Before you begin

Ensure that the ACL that you want to apply exists and that it is configured to filter traffic in the manner that you need for this application.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	interface mgmt port Example: switch(config)# interface mgmt0 switch(config-if)#	Enters configuration mode for the management interface.
Step 3	ip access-group access-list {in out} Example: switch(config-if)#ip access-group acl-120 out	Applies an IPv4 or IPv6 ACL to the Layer 3 interface for traffic flowing in the direction specified. You can apply one router ACL per direction.
Step 4	(Optional) show running-config aclmgr Example: switch(config-if)# show running-config aclmgr	Displays the ACL configuration.
Step 5	(Optional) copy running-config startup-config Example: switch(config-if)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Related Topics

- Creating an IP ACL

Applying an IP ACL as a Port ACL

You can apply an IPv4 ACL to a physical Ethernet interface or a PortChannel. ACLs applied to these interface types are considered port ACLs.



Note Some configuration parameters when applied to an PortChannel are not reflected on the configuration of the member ports.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# interface {ethernet [chassis/]slot/port port-channel channel-number}	Enters interface configuration mode for the specified interface.
Step 3	(Optional) switch# show running-config	Displays the ACL configuration.
Step 4	(Optional) switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Applying an IP ACL as a Router ACL

You can apply an IPv4 or IPv6 ACL to any of the following types of interfaces:

- Physical Layer 3 interfaces and subinterfaces
- Layer 3 Ethernet port-channel interfaces and subinterfaces
- VLAN interfaces
- Tunnels
- Management interfaces

ACLs applied to these interface types are considered router ACLs.

Before you begin

Ensure that the ACL you want to apply exists and that it is configured to filter traffic in the manner that you need for this application.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.

	Command or Action	Purpose
Step 2	Enter one of the following commands: <ul style="list-style-type: none">• switch(config)# interface ethernet <i>slot/port[.number]</i>• switch(config)# interface port-channel <i>channel-number[.number]</i>• switch(config)# interface tunnel <i>tunnel-number</i>• switch(config)# interface vlan <i>vlan-ID</i>• switch(config)# interface mgmt <i>port</i>	Enters configuration mode for the interface type that you specified.
Step 3	Enter one of the following commands: <ul style="list-style-type: none">• switch(config-if)# ip access-group <i>access-list {in out}</i>• switch(config-if)# ipv6 traffic-filter <i>access-list {in out}</i>	Applies an IPv4 or IPv6 ACL to the Layer 3 interface for traffic flowing in the direction specified. You can apply one router ACL per direction.
Step 4	(Optional) switch(config-if)# show running-config aclmgr	Displays the ACL configuration.
Step 5	(Optional) switch(config-if)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Verifying the IP ACL Configuration

To display IP ACL configuration information, perform one of the following tasks.

Command	Purpose
show hardware access-list tcam region	Displays the TCAM sizes that will be applicable on the next reload of the device.
show ip access-lists	Displays the IPv4 ACL configuration.
show ipv6 access-lists	Displays the IPv6 ACL configuration.
show logging ip access-list cache [detail]	Displays information on the active logged flows, such as source IP and destination IP addresses, source port and destination port information, and source interfaces. No other information of active flows will be displayed specifically all the unsupported options.

Command	Purpose
show logging ip access-list status	Displays the deny maximum flow count, the current effective log interval, and the current effective threshold value.
show running-config acllog	Displays the ACL log running configuration.
show running-config aclmgr [all]	Displays the ACL running configuration, including the IP ACL configuration and the interfaces to which IP ACLs are applied. Note This command displays the user-configured ACLs in the running configuration. The all option displays both the default (CoPP-configured) and user-configured ACLs in the running configuration.
show startup-config acllog	Displays the ACL log startup configuration.
show startup-config aclmgr [all]	Displays the ACL startup configuration. Note This command displays the user-configured ACLs in the startup configuration. The all option displays both the default (CoPP-configured) and user-configured ACLs in the startup configuration.

Monitoring and Clearing IP ACL Statistics

Use the **show ip access-lists** or **show ipv6 access-list** command to display statistics about an IP ACL, including the number of packets that have matched each rule. For detailed information about the fields in the output from this command, see the *Command Reference* for your Cisco Nexus device.



Note The mac access-list is applicable to non-IPv4 and non-IPv6 traffic only.

Procedure

- switch# **show {ip | ipv6} access-lists name**
Displays IP ACL configuration. If the IP ACL includes the **statistics** command, then the **show ip access-lists** and **show ipv6 access-list** command output includes the number of packets that have matched each rule.
- switch#**show ip access-lists name**
Displays IP ACL configuration. If the IP ACL includes the **statistics** command, then the **show ip access-lists** command output includes the number of packets that have matched each rule.
- switch# **clear {ip | ipv6} access-list counters [access-list-name]**
Clears statistics for all IP ACLs or for a specific IP ACL.
- switch# **clear ip access-list counters [access-list-name]**
Clears statistics for all IP ACLs or for a specific IP ACL.

Triggering the RACL Consistency Checker

You can manually trigger the RACL consistency checker to compare the hardware and software configuration of the ingress and egress RACLs of a module and display the results. To manually trigger the RACL consistency checker and display the results, use the following command in any mode:

Procedure

	Command or Action	Purpose
Step 1	show consistency-checker racl module slot	Starts an RACL consistency check on the specified module and displays the results.

Example

This example shows how to trigger an RACL consistency check and display the results:

```
switch# show consistency-checker racl module 1
Validates RACL on up interfaces:
Consistency Check: FAILED

Found consistencies for following Interfaces:
  Ethernet1/9 (in)
  Ethernet1/9 (out)
  Ethernet1/17 (in)
  Ethernet1/17 (out)

Found inconsistencies for following Interfaces and EID:
  Ethernet1/3 (in)
  Ethernet1/3 (out)
```

Configuring ACL Using HTTP Methods to Redirect Requests

**Note**

As an enhancement to HTTP method match, the `tcp-option-length` option has been added to the ACE syntax to specify the length of the TCP options header in the packets. You can configure up to 4 `tcp-option-lengths` in the ACEs, which includes the TCP option length of 0. If you do not configure the `tcp-option-length` option, the length is considered as 0. It means that only the packets without the TCP options header can match this ACE. This feature gives more flexibility in such a way that the HTTP method can be matched even on the packets that have the variable length TCP options header.

The following HTTP methods can be redirected:

- connect
- delete
- get
- head
- post
- put
- trace

Configure the ACL CLI to redirect specific HTTP methods to a server.

Before you begin

- Create an IP access list.
- Enable the double wide TCAM for the IFACL region using the CLI **hardware profile team region ifacl 512 double-wide** command . This command applies to the global configuration and only on Trident2 based Cisco Nexus 3000 Series switches. Reload the switch for this configuration to take into effect.
- Enable tap-aggregation feature to redirect the packets to another interface using the CLI **hardware profile tap-aggregation** command. This command applies to global configuration. Reload the switch for this configuration to take into effect.

Procedure

	Command or Action	Purpose
Step 1	<code>switch# configure terminal</code>	Enters global configuration mode.
Step 2	<code>switch(config-acl)# permit protocol source any http-method ?</code> Example: <pre>switch(config-acl)# permit tcp 1.1.1.1/32 any http-method ? connect Match http packets with</pre>	Configures the ACL CLI to redirect specific HTTP methods to a server.

Configuring ACL Using HTTP Methods to Redirect Requests

	Command or Action	Purpose
	CONNECT method [0x434f4e4e] delete Match http packets with DELETE method [0x44454c45] get Match http packets with GET method [0x47455420] head Match http packets with HEAD method [0x48454144] post Match http packets with POST method [0x504f5354] put Match http packets with PUT method [0x50555420] trace Match http packets with TRACE method [0x54524143]	
Step 3	(Optional) switch# show ip access-lists name	Displays the IP ACL configuration.
Step 4	(Optional) switch# show run interface <x/y>	Displays the interface configuration.

Example

In the following example, an Ethernet interface 1/33 is receiving HTTP traffic. Ethernet interface 1/34 is the egress interface. Enable mode **tap-aggregation** on the egress interface. Create an ACL to match the traffic. Configure the redirect HTTP get method that matches the ACL to Ethernet interface 1/34. Apply the ACL to the port where the HTTP traffic is received. Any HTTP get traffic that hits the ACL on Ethernet 1/33 is redirected to the destination interface, for example, Ethernet 1/34. The same steps can be used for the other listed methods.

Troubleshooting Information—In case the ACL is not hit or the packets are not redirected, ensure that double wide TCAM is enabled. Ensure that tap aggregation is enabled. Ensure both source and destination ports are in STP forwarding state in the same VLAN. Ensure that the ACL is programmed in TCAM using the **sh platform afm info attachment interface <interface>** command. The HTTP redirect feature does not work on Layer 3 ports.

```

switch# configure terminal
switch(config)# interface Ethernet 1/33

L3-QI2-CR-one (config)## interface Ethernet 1/34
L3-QI2-CR-one (config-if) # mode tap-aggregation
switch(config)# ip access-list http-redirect-acl
switch(config-acl) # 10 permit tcp 10.1.1.1/32 10.2.2.2/32 http-method get redirect e1/34
switch(config-acl) # 10 permit tcp any any http-method get tcp-option-length 8 redirect e1/34
switch(config-acl) # 20 permit tcp any any http-method post redirect e1/34
switch(config-acl) # statistics per-entry

switch(config)# interface Ethernet 1/33
switch(config-if) # ip port access-group http-redirect-acl in

switch(config)# show ip access-lists
switch(config)# show run int 1/34
switch(config)# show hardware access-list interface 1/34

```

Information About VLAN ACLs

A VLAN ACL (VACL) is one application of an IP ACL. You can configure VACLS to apply to all packets that are bridged within a VLAN. VACLS are used strictly for security packet filtering. VACLS are not defined by direction (ingress or egress).

VACLS and Access Maps

VACLS use access maps to link an IP ACL to an action. The switch takes the configured action on packets that are permitted by the VACL.

VACLS and Actions

In access map configuration mode, you use the **action** command to specify one of the following actions:

- Forward—Sends the traffic to the destination determined by normal operation of the switch.
- Drop—Drops the traffic.

Statistics

The Cisco Nexus device can maintain global statistics for each rule in a VACL. If a VACL is applied to multiple VLANs, the maintained rule statistics are the sum of packet matches (hits) on all the interfaces on which that VACL is applied.

**Note**

The Cisco Nexus device does not support interface-level VACL statistics.

For each VLAN access map that you configure, you can specify whether the switch maintains statistics for that VACL. This allows you to turn VACL statistics on or off as needed to monitor traffic filtered by a VACL or to help troubleshoot VLAN access-map configuration.

Configuring VACLS

Creating or Changing a VACL

You can create or change a VACL. Creating a VACL includes creating an access map that associates an IP ACL with an action to be applied to the matching traffic.

Procedure

	Command or Action	Purpose
Step 1	<code>switch# configure terminal</code>	Enters global configuration mode.

Removing a VACL

	Command or Action	Purpose
Step 2	switch(config)# vlan access-map map-name	Enters access map configuration mode for the access map specified.
Step 3	switch(config-access-map)# match ip address ip-access-list	Specifies an IPv4 and IPv6 ACL for the map.
Step 4	switch(config-access-map)# action {drop forward}	Specifies the action that the switch applies to traffic that matches the ACL.
Step 5	(Optional) switch(config-access-map)# [no] statistics	Specifies that the switch maintains global statistics for packets matching the rules in the VACL. The no option stops the switch from maintaining global statistics for the VACL.
Step 6	(Optional) switch(config-access-map)# show running-config	Displays the ACL configuration.
Step 7	(Optional) switch(config-access-map)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Removing a VACL

You can remove a VACL, which means that you will delete the VLAN access map.

Be sure that you know whether the VACL is applied to a VLAN. The switch allows you to remove VACLS that are currently applied. Removing a VACL does not affect the configuration of VLANs where you have applied the VACL. Instead, the switch considers the removed VACL to be empty.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# no vlan access-map map-name	Removes the VLAN access map configuration for the specified access map.
Step 3	(Optional) switch(config)# show running-config	Displays ACL configuration.
Step 4	(Optional) switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Applying a VACL to a VLAN

You can apply a VACL to a VLAN.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# [no] vlan filter map-name vlan-list list	Applies the VACL to the VLANs by the list that you specified. The no option unapplies the VACL. The vlan-list command can specify a list of up to 32 VLANs, but multiple vlan-list commands can be configured to cover more than 32 VLANs.
Step 3	(Optional) switch(config)# show running-config	Displays ACL configuration.
Step 4	(Optional) switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Verifying VACL Configuration

To display VACL configuration information, perform one of the following tasks:

Command or Action	Purpose
switch# show running-config aclmgr	Displays ACL configuration, including VACL-related configuration.
switch# show vlan filter	Displays information about VACLS that are applied to a VLAN.
switch# show vlan access-map	Displays information about VLAN access maps.

Displaying and Clearing VACL Statistics

To display or clear VACL statistics, perform one of the following tasks:

Procedure

- switch# **show vlan access-list**

Displays VACL configuration. If the VLAN access-map includes the **statistics** command, then the **show vlan access-list** command output includes the number of packets that have matched each rule.

- switch# **clear vlan access-list counters**

Clears statistics for all VACLS or for a specific VACL.

Configuration Examples for VACL

The following example shows how to configure a VACL to forward traffic permitted by an IP ACL named acl-ip-01 and how to apply the VACL to VLANs 50 through 82:

```
switch# configure terminal
switch(config)# vlan access-map acl-ip-map
switch(config-access-map)# match ip address acl-ip-01
switch(config-access-map)# action forward
switch(config-access-map)# exit
switch(config)# vlan filter acl-ip-map vlan-list 50-82
```

Configuring the LOU Threshold

You can configure the LOU threshold. When the number of expanded ACEs exceeds this threshold, the device stores them in an LOU register. Otherwise, the device stores these ACEs as TCAM entries. This configuration takes effect only for the next ACL configuration. All existing ACL configurations either in TCAM or LOU register are not affected by this configuration. In order for the changes to take effect, you have to use the **copy r s** command and reload the box.


Note

The expanded ACEs are not stored if the TCAM or all 24 LOU registers are full.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# hardware profile tcam lou-threshold value	Configures the LOU threshold and the LOU expansion threshold takes effect for the new policies. It is recommended to save the configuration and reload so that the threshold takes effect on the already existing policies. The threshold values range from 1 to 100, and the default LOU threshold value is 1.

Example

This example shows how to configure the LOU threshold:

```
switch# configure terminal
switch(config)# hardware profile tcam lou-threshold 20
switch(config)# copy running-config startup-config
```

```
switch(config)# reload
LOU expansion threshold changed to 20
```

Configuring ACL TCAM Region Sizes

You can change the size of the ACL ternary content addressable memory (TCAM) regions in the hardware.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config) #</pre>	Enters global configuration mode.
Step 2	hardware profile team region {arpacl {ipv6-e-racl e-racl} ifacl ipsg {ipv6-qos qos} qoslbl {ipv6-racl racl} {ipv6-span span } {ipv6-span-l2 span } {spanv6 span } {spanv6-12 span} vACL } {fhs} tcam_size	Changes the ACL TCAM region size. <ul style="list-style-type: none"> • arpacl—Configures the size of the Address Resolution Protocol (ARP) ACL (ARPAACL) TCAM region. • e-racl—Configures the size of the egress router ACL (ERACL) TCAM region. • e-vacl—Configures the size of the egress VLAN ACL (EVACL) TCAM region. • ifacl—Configures the size of the interface ACL (ifacl) TCAM region. The maximum number of entries is 1500. • ipsg—Configures the size of the IP Source Guard (IPSG) TCAM region. • qos—Configures the size of the quality of service (QoS) TCAM region. • qoslbl—Configures the size of the QoS Label (qoslbl) TCAM region. • racl—Configures the size of the router ACL (RACL) TCAM region. • vacl—Configures the size of the VLAN ACL (VACL) TCAM region. • • tcam_size—TCAM size. The range is from 0 to 2,14,74, 83, 647 entries. For FHS, the range is from 0-4096.

	Command or Action	Purpose
		Note vac1 and e-vac1 TCAM regions should be set to the same size.
Step 3	copy running-config startup-config Example: switch(config)# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.
Step 4	switch(config)# show hardware profile tcam region Example: switch(config)# show hardware profile tcam region	Displays the TCAM sizes that will be applicable on the next reload of the switch.
Step 5	switch(config)# reload Example: switch(config)# reload	Copies the running configuration to the startup configuration. Note The new size values are effective only upon the next reload after saving the copy running-config to startup-config .

Example

The following example shows how to change the size of the RACL TCAM region:

```
switch(config)# hardware profile tcam region racl 256
[SUCCESS] New tcam size will be applicable only at boot time.
You need to 'copy run start' and 'reload'

switch(config)# copy running-config startup-config
switch(config)# reload
WARNING: This command will reboot the system
Do you want to continue? (y/n) [n] y
```

The following example shows the error message you see when you set the ARP ACL TCAM value to a value other than 0 or 128, and then shows how to change the size of the ARP ACL TCAM region:

```
switch(config)# hardware profile tcam region arpacl 200
ARPACL size can be either 0 or 128

switch(config)# hardware profile tcam region arpacl 128
To start using ARPACL tcam, IFACL tcam size needs to be changed.
Changing IFACL tcam size to 256
[SUCCESS] New tcam size will be applicable only at boot time.
You need to 'copy run start' and 'reload'
```

The following example shows how to configure the TCAM VLAN ACLs on a switch:

```
switch# configure sync
Enter configuration commands, one per line. End with CNTL/Z.
switch(config-sync)# switch-profile s5010
Switch-Profile started, Profile ID is 1
```

```

switch(config-sync-sp)# hardware profile tcam region vACL 512
switch(config-sync-sp)# hardware profile tcam region e-vACL 512
switch(config-sync-sp)#

switch(config)# hardware profile tcam region ipv6-span 512
Warning: Please save config and reload the system for the configuration to take effect
switch(config)# hardware profile tcam region spanv6 qualify udf udf1
[SUCCESS] Changes to UDF qualifier set will be applicable only after reboot.

```

This example shows how to display the TCAM region sizes to verify your changes:

```

switch(config)# show hardware profile tcam region
    sup size = 16
    vACL size = 640
    iFACL size = 496
    QoS size = 256
    RbACL size = 0
    SPAN size = 0
    RaACL size = 1536
    e-RaACL size = 256
    e-vACL size = 640
    QoSlbl size = 0
    ipSG size = 0
    ARPACL size = 0
    IPv6-RaACL size = 0
    IPv6-e-RaACL size = 0
    IPv6-SUP size = 0
    IPv6-QoS size = 0

switch(config)# show hardware profile tcam region
    sup size = 16
    vACL size = 640
    iFACL size = 496
    QoS size = 256
    RbACL size = 0
    SPAN size = 0
    RaACL size = 1536
    e-RaACL size = 256
    e-vACL size = 640
    QoSlbl size = 0
    ARPACL size = 0
    IPv6-RaACL size = 0
    IPv6-e-RaACL size = 0
    IPv6-SUP size = 0
    IPv6-QoS size = 0

```



Note On Cisco Nexus 3000 Series switches, you must carve the switch RACL TCAM regions in order to make IGMP and PIM work on Layer 3 interfaces. Some system default Multicast ACLs that are installed in the RACL regions are required for IGMP and PIM to work on Layer 3 interfaces.



Note If the config-control property is set to YES in the XML hierarchy definition file, then it is possible for the memory object to use a faulty bit map to report the error.

Reverting to the Default TCAM Region Sizes

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	switch(config)# no hardware profile tcam region {arpacl e-racl} ifacl ipsg qos qoslbl racl} vACL } tcam_size	Reverts the configuration to the default ACL TCAM size.
Step 3	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.
Step 4	switch(config)# reload	Reloads the switch.

Example

The following example shows how to revert to the default RACL TCAM region sizes:

```
switch(config)# no hardware profile tcam region racl 256
[SUCCESS] New tcam size will be applicable only at boot time.
You need to 'copy run start' and 'reload'

switch(config)# copy running-config startup-config
switch(config)# reload
WARNING: This command will reboot the system
Do you want to continue? (y/n) [n] y
```

Configuring ACLs on Virtual Terminal Lines

To restrict incoming and outgoing connections for IPv4 or IPv6 between a Virtual Terminal (VTY) line and the addresses in an access list, use the **access-class** command in line configuration mode. To remove access restrictions, use the **no** form of this command.

Follow these guidelines when configuring ACLs on VTY lines:

- Set identical restrictions on all VTY lines because a user can connect to any of them.
- Statistics per entry is not supported for ACLs on VTY lines.

Before you begin

Be sure that the ACL that you want to apply exists and is configured to filter traffic for this application.

Procedure

	Command or Action	Purpose
Step 1	switch# configure terminal	Enters global configuration mode.
Step 2	switch(config)# line vty Example: switch(config)# line vty switch(config-line)#	Enters line configuration mode.
Step 3	switch(config-line)# access-class access-list-number {in out} Example: switch(config-line)# access-class ozi2 in switch(config-line)#access-class ozi3 out switch(config) #	Specifies inbound or outbound access restrictions.
Step 4	(Optional) switch(config-line)# no access-class access-list-number {in out} Example: switch(config-line)# no access-class ozi2 in switch(config-line)# no access-class ozi3 out switch(config) #	Removes inbound or outbound access restrictions.
Step 5	switch(config-line)# exit Example: switch(config-line)# exit switch#	Exits line configuration mode.
Step 6	(Optional) switch# show running-config aclmgr Example: switch# show running-config aclmgr	Displays the running configuration of the ACLs on the switch.
Step 7	(Optional) switch# copy running-config startup-config Example: switch# copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to apply the access-class ozi2 command to the in-direction of the vty line.

Verifying ACLs on VTY Lines

```
switch# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
switch(config)# line vty
switch(config-line)# access-class ozi2 in
switch(config-line)# exit
switch#
```

Verifying ACLs on VTY Lines

To display the ACL configurations on VTY lines, perform one of the following tasks:

Command	Purpose
show running-config aclmgr	Displays the running configuration of the ACLs configured on the switch.
show users	Displays the users that are connected.
show access-lists <i>access-list-name</i>	Display the statistics per entry.

Configuration Examples for ACLs on VTY Lines

The following example shows the connected users on the console line (ttyS0) and the VTY lines (pts/0 and pts/1).

```
switch# show users
NAME      LINE          TIME        IDLE          PID COMMENT
admin     ttyS0        Aug 27 20:45   .
admin     pts/0         Aug 27 20:06 00:46  14176 (172.18.217.82) session=ssh
admin     pts/1         Aug 27 20:52   .
14425 *
14584 (10.55.144.118)
```

The following example shows how to allow vty connections to all IPv4 hosts except 172.18.217.82 and how to deny vty connections to any IPv4 host except 10.55.144.118, 172.18.217.79, 172.18.217.82, 172.18.217.92:

```
switch# show running-config aclmgr
!Time: Fri Aug 27 22:01:09 2010
version 5.0(2)N1(1)
ip access-list ozi
 10 deny ip 172.18.217.82/32 any
 20 permit ip any any
ip access-list ozi2
 10 permit ip 10.55.144.118/32 any
 20 permit ip 172.18.217.79/32 any
 30 permit ip 172.18.217.82/32 any
 40 permit ip 172.18.217.92/32 any

line vty
  access-class ozi in
  access-class ozi2 out
```

The following example shows how to configure the IP access list by enabling per-entry statistics for the ACL:

```
switch# configure terminal
Enter configuration commands, one per line.
End with CNTL/Z.
switch(config)# ip access-list ozi2
switch(config-acl)# statistics per-entry
switch(config-acl)# deny tcp 172.18.217.83/32 any
```

```
switch(config-acl)# exit  
  
switch(config)# ip access-list ozi  
switch(config-acl)# statistics per-entry  
switch(config-acl)# permit ip 172.18.217.20/24 any  
switch(config-acl)# exit  
switch#
```

The following example shows how to apply the ACLs on VTY in and out directions:

```
switch(config)# line vty  
switch(config-line)# ip access-class ozi in  
switch(config-line)# access-class ozi2 out  
switch(config-line)# exit  
switch#
```

The following example shows how to remove the access restrictions on the VTY line:

```
switch# configure terminal  
Enter configuration commands, one per line. End  
with CNTL/Z.  
switch(config)# line vty  
switch(config-line)# no access-class ozi2 in  
switch(config-line)# no ip access-class ozi2 in  
switch(config-line)# exit  
switch#
```




CHAPTER 9

Configuring DHCP Snooping

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- [Information About the DHCPv6 Relay Agent, on page 165](#)
- [Licensing Requirements for DHCP Snooping, on page 166](#)
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Information About DHCP Snooping

DHCP snooping acts like a firewall between untrusted hosts and trusted DHCP servers. DHCP snooping performs the following activities:

- Validates DHCP messages received from untrusted sources and filters out invalid messages.
- Builds and maintains the DHCP snooping binding database, which contains information about untrusted hosts with leased IP addresses.
- Uses the DHCP snooping binding database to validate subsequent requests from untrusted hosts.

DHCP snooping is enabled on a per-VLAN basis. By default, the feature is inactive on all VLANs. You can enable the feature on a single VLAN or a range of VLANs.

Feature Enabled and Globally Enabled

When you are configuring DHCP snooping, it is important that you understand the difference between enabling the DHCP snooping feature and globally enabling DHCP snooping.

Feature Enablement

The DHCP snooping feature is disabled by default. When the DHCP snooping feature is disabled, you cannot configure it or any of the features that depend on DHCP snooping. The commands to configure DHCP snooping and its dependent features are unavailable when DHCP snooping is disabled.

When you enable the DHCP snooping feature, the switch begins building and maintaining the DHCP snooping binding database. Features dependent on the DHCP snooping binding database can now make use of it and can therefore also be configured.

Enabling the DHCP snooping feature does not globally enable it. You must separately enable DHCP snooping globally.

Disabling the DHCP snooping feature removes all DHCP snooping configuration from the switch. If you want to disable DHCP snooping and preserve the configuration, globally disable DHCP snooping but do not disable the DHCP snooping feature.

Global Enablement

After DHCP snooping is enabled, DHCP snooping is globally disabled by default. Global enablement is a second level of enablement that allows you to have separate control of whether the switch is actively performing DHCP snooping that is independent from enabling the DHCP snooping binding database.

When you globally enable DHCP snooping, on each untrusted interface of VLANs that have DHCP snooping enabled, the switch begins validating DHCP messages that are received and used the DHCP snooping binding database to validate subsequent requests from untrusted hosts.

When you globally disable DHCP snooping, the switch stops validating DHCP messages and validating subsequent requests from untrusted hosts. It also removes the DHCP snooping binding database. Globally disabling DHCP snooping does not remove any DHCP snooping configuration or the configuration of other features that are dependent upon the DHCP snooping feature.

Trusted and Untrusted Sources

You can configure whether DHCP snooping trusts traffic sources. An untrusted source might initiate traffic attacks or other hostile actions. To prevent such attacks, DHCP snooping filters messages from untrusted sources.

In an enterprise network, a trusted source is a switch that is under your administrative control. These switches include the switches, routers, and servers in the network. Any switch beyond the firewall or outside the network is an untrusted source. Generally, host ports are treated as untrusted sources.

In a service provider environment, any switch that is not in the service provider network is an untrusted source (such as a customer switch). Host ports are untrusted sources.

In a Cisco Nexus device, you indicate that a source is trusted by configuring the trust state of its connecting interface.

The default trust state of all interfaces is untrusted. You must configure DHCP server interfaces as trusted. You can also configure other interfaces as trusted if they connect to switches (such as switches or routers) inside your network. You usually do not configure host port interfaces as trusted.



Note For DHCP snooping to function properly, you must connect all DHCP servers to the switch through trusted interfaces.

DHCP Snooping Binding Database

Using information extracted from intercepted DHCP messages, DHCP snooping dynamically builds and maintains a database. The database contains an entry for each untrusted host with a leased IP address if the host is associated with a VLAN that has DHCP snooping enabled. The database does not contain entries for hosts that are connected through trusted interfaces.



Note The DHCP snooping binding database is also referred to as the DHCP snooping binding table.

DHCP snooping updates the database when the switch receives specific DHCP messages. For example, the feature adds an entry to the database when the switch receives a DHCPACK message from the server. The feature removes the entry in the database when the IP address lease expires or the switch receives a DHCPRELEASE message from the host.

Each entry in the DHCP snooping binding database includes the MAC address of the host, the leased IP address, the lease time, the binding type, and the VLAN number and interface information associated with the host.

You can remove entries from the binding database by using the **clear ip dhcp snooping binding** command.

Information About the DHCPv6 Relay Agent

DHCPv6 Relay Agent

You can configure the device to run a DHCPv6 relay agent, which forwards DHCPv6 packets between clients and servers. This feature is useful when clients and servers are not on the same physical subnet. Relay agents receive DHCPv6 messages and then generate a new DHCPv6 message to send out on another interface. The relay agent sets the gateway address (giaddr field of the DHCPv6 packet) and forwards it to the DHCPv6 server.

VRF Support for the DHCPv6 Relay Agent

You can configure the DHCPv6 relay agent to forward DHCPv6 broadcast messages from clients in a virtual routing and forwarding (VRF) instance to DHCPv6 servers in a different VRF. By using a single DHCPv6 server to provide DHCPv6 support to clients in multiple VRFs, you can conserve IP addresses by using a single IP address pool rather than one for each VRF.

Licensing Requirements for DHCP Snooping

This feature does not require a license. Any feature not included in a license package is bundled with the Cisco NX-OS system images and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Prerequisites for DHCP Snooping

You should be familiar with DHCP before you configure DHCP snooping or the DHCP relay agent.

Guidelines and Limitations for DHCP Snooping

Consider the following guidelines and limitations when configuring DHCP snooping:

- Starting with Release 7.0(3)I2(1), the same MAC address is permitted in the static DHCP binding across multiple IP and ports whereas in releases prior to 7.0(3)I2(1), the unsupported DHCP static binding configuration is rejected with an error.
- The DHCP snooping database can store 2000 bindings.
- DHCP snooping is not active until you enable the feature, enable DHCP snooping globally, and enable DHCP snooping on at least one VLAN.
- Before globally enabling DHCP snooping on the switch, make sure that the switches that act as the DHCP server and the DHCP relay agent are configured and enabled.
- If a VLAN ACL (VACL) is configured on a VLAN that you are configuring with DHCP snooping, ensure that the VACL permits DHCP traffic between DHCP servers and DHCP hosts.
- DHCP snooping and DHCP relay feature are not supported on the same VLAN.
- DHCP snooping should not be followed by DHCP relay in the network (DHCP snooping does not work when the DHCP relay is configured on the same Nexus device).
- When you configure DHCPv6 server addresses on an interface, a destination interface cannot be used with global IPv6 addresses.

Default Settings for DHCP Snooping

This table lists the default settings for DHCP snooping parameters.

Table 14: Default DHCP Snooping Parameters

Parameters	Default
DHCP snooping feature	Disabled
DHCP snooping globally enabled	No

Parameters	Default
DHCP snooping VLAN	None
DHCP snooping Option 82 support	Disabled
DHCP snooping trust	Untrusted
VRF support for the DHCP relay agent	Disabled
VRF support for the DHCPv6 relay agent	Disabled
DHCP relay agent	Disabled
DHCPv6 relay agent	Disabled
DHCPv6 relay option type cisco	Disabled

Configuring DHCP Snooping

Minimum DHCP Snooping Configuration

1. Enable the DHCP snooping feature.
- 2.

Procedure

	Command or Action	Purpose
Step 1	Enable the DHCP snooping feature.	When the DHCP snooping feature is disabled, you cannot configure DHCP snooping. For details, see Enabling or Disabling the DHCP Snooping Feature, on page 167 .
Step 2	Enable DHCP snooping globally.	For details, see Enabling or Disabling DHCP Snooping Globally, on page 168 .
Step 3	Enable DHCP snooping on at least one VLAN.	By default, DHCP snooping is disabled on all VLANs. For details, see Enabling or Disabling DHCP Snooping on a VLAN, on page 169 .
Step 4	Ensure that the DHCP server is connected to the switch using a trusted interface.	For details, see Configuring an Interface as Trusted or Untrusted, on page 171 .

Enabling or Disabling the DHCP Snooping Feature

You can enable or disable the DHCP snooping feature on the switch. By default, DHCP snooping is disabled.

Enabling or Disabling DHCP Snooping Globally**Before you begin**

If you disable the DHCP snooping feature, all DHCP snooping configuration is lost. If you want to turn off DHCP snooping and preserve the DHCP snooping configuration, disable DHCP globally.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[no] feature dhcp Example: switch(config)# feature dhcp	Enables the DHCP snooping feature. The no option disables the DHCP snooping feature and erases all DHCP snooping configuration.
Step 3	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Shows the DHCP snooping configuration.
Step 4	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Enabling or Disabling DHCP Snooping Globally

You can enable or disable the DHCP snooping globally on the switch. Globally disabling DHCP snooping stops the switch from performing any DHCP snooping but preserves DCHP snooping configuration.

Before you begin

Ensure that you have enabled the DHCP snooping feature. By default, DHCP snooping is globally disabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[no] ip dhcp snooping Example: switch(config)# ip dhcp snooping	Enables DHCP snooping globally. The no option disables DHCP snooping.

	Command or Action	Purpose
Step 3	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Shows the DHCP snooping configuration.
Step 4	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Enabling or Disabling DHCP Snooping on a VLAN

You can enable or disable DHCP snooping on one or more VLANs.

Before you begin

By default, DHCP snooping is disabled on all VLANs.

Ensure that DHCP snooping is enabled.



Note If a VACL is configured on a VLAN that you are configuring with DHCP snooping, ensure that the VACL permits DHCP traffic between DHCP servers and DHCP hosts.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[no] ip dhcp snooping vlan <i>vlan-list</i> Example: switch(config)# ip dhcp snooping vlan 100,200,250-252	Enables DHCP snooping on the VLANs specified by <i>vlan-list</i> . The no option disables DHCP snooping on the VLANs specified.
Step 3	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Shows the DHCP snooping configuration.
Step 4	(Optional) copy running-config startup-config Example:	Copies the running configuration to the startup configuration.

Enabling or Disabling Option 82 Data Insertion and Removal

	Command or Action	Purpose
	switch(config)# copy running-config startup-config	

Enabling or Disabling Option 82 Data Insertion and Removal

You can enable or disable the insertion and removal of Option 82 information for DHCP packets forwarded without the use of the DHCP relay agent. By default, the device does not include Option 82 information in DHCP packets.



Note DHCP relay agent support for Option 82 is configured separately.

Before you begin

Ensure that the DHCP feature is enabled.

Procedure

	Command or Action	Purpose
Step 1	config t Example: switch# config t switch(config)#[/td> <td>Enters global configuration mode.</td>	Enters global configuration mode.
Step 2	[no] ip dhcp snooping information option Example: switch(config)# ip dhcp snooping information option	Enables the insertion and removal of Option 82 information for DHCP packets. The no option disables the insertion and removal of Option 82 information.
Step 3	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Displays the DHCP configuration.
Step 4	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Enabling or Disabling Strict DHCP Packet Validation

You can enable or disable the strict validation of DHCP packets by the DHCP snooping feature. By default, strict validation of DHCP packets is disabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[no] ip dhcp packet strict-validation Example: switch(config)# ip dhcp packet strict-validation	Enables the strict validation of DHCP packets by the DHCP snooping feature. The no option disables strict DHCP packet validation.
Step 3	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Shows the DHCP snooping configuration.
Step 4	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring an Interface as Trusted or Untrusted

You can configure whether an interface is a trusted or untrusted source of DHCP messages. You can configure DHCP trust on the following types of interfaces:

- Layer 2 Ethernet interfaces
- Layer 2 port-channel interfaces

Before you begin

By default, all interfaces are untrusted.

Ensure that DHCP snooping is enabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	Enter one of the following commands: • interface ethernet port/slot	• Enters interface configuration mode, where <i>port / slot</i> is the Layer 2 Ethernet interface

Enabling or Disabling the DHCP Relay Agent

	Command or Action	Purpose
	<ul style="list-style-type: none"> • interface port-channel <i>channel-number</i> <p>Example:</p> <pre>switch(config)# interface ethernet 2/1 switch(config-if)# </pre>	<p>that you want to configure as trusted or untrusted for DHCP snooping.</p> <ul style="list-style-type: none"> Enters interface configuration mode, where <i>port / slot</i> is the Layer 2 port-channel interface that you want to configure as trusted or untrusted for DHCP snooping.
Step 3	[no] ip dhcp snooping trust	Configures the interface as a trusted interface for DHCP snooping. The no option configures the port as an untrusted interface.
Step 4	(Optional) show running-config dhcp	Shows the DHCP snooping configuration.
Step 5	(Optional) copy running-config startup-config	Copies the running configuration to the startup configuration.

Enabling or Disabling the DHCP Relay Agent

You can enable or disable the DHCP relay agent. By default, the DHCP relay agent is enabled.

Before you begin

Ensure that the DHCP feature is enabled.

Procedure

	Command or Action	Purpose
Step 1	config t	Enters global configuration mode.
	<p>Example:</p> <pre>switch# config t switch(config)# </pre>	
Step 2	[no] ip dhcp relay	Enables the DHCP relay agent. The no option disables the relay agent.
	<p>Example:</p> <pre>switch(config)# ip dhcp relay </pre>	
Step 3	(Optional) show ip dhcp relay	Displays the DHCP relay configuration.
	<p>Example:</p> <pre>switch(config)# show ip dhcp relay </pre>	

	Command or Action	Purpose
Step 4	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Displays the DHCP configuration.
Step 5	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Enabling or Disabling Option 82 for the DHCP Relay Agent

You can enable or disable the device to insert and remove Option 82 information on DHCP packets forwarded by the relay agent.

By default, the DHCP relay agent does not include Option 82 information in DHCP packets.

Before you begin

Ensure that the DHCP feature is enabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[no] ip dhcp relay information option Example: switch(config)# ip dhcp relay information option	Enables the DHCP relay agent to insert and remove Option 82 information on the packets that it forwards. The Option 82 information is in binary ifindex format by default. The no option disables this behavior.
Step 3	(Optional) [no] ip dhcp relay information sub-option circuit-id format-type string Example: switch(config)# ip dhcp relay information sub-option circuit-id format-type string	Configures Option 82 to use encoded string format instead of the default binary ifindex format.
Step 4	(Optional) show ip dhcp relay Example: switch(config)# show ip dhcp relay	Displays the DHCP relay configuration.

	Command or Action	Purpose
Step 5	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Displays the DHCP configuration.
Step 6	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Configuring DHCP Server Addresses on an Interface

You can configure DHCP server IP addresses on an interface. When an inbound DHCP BOOTREQUEST packet arrives on the interface, the relay agent forwards the packet to all DHCP server IP addresses specified. The relay agent forwards replies from all DHCP servers to the host that sent the request.

Before you begin

Ensure that the DHCP feature is enabled.

Ensure that the DHCP server is correctly configured.

Determine the IP address for each DHCP server that you want to configure on the interface.

If the DHCP server is in a different VRF instance than the interface, ensure that you have enabled VRF support.



Note If an ingress router ACL is configured on an interface that you are configuring with a DHCP server address, ensure that the router ACL permits DHCP traffic between DHCP servers and DHCP hosts.

Procedure

	Command or Action	Purpose
Step 1	config t Example: switch# config t switch(config)#	Enters global configuration mode.
Step 2	Do one of the following options: <ul style="list-style-type: none">• interface ethernet slot/port[.number]• interface vlan vlan-id• interface port-channel channel-id[.subchannel-id] Example: switch(config)# interface ethernet 2/3 switch(config-if)#	<ul style="list-style-type: none">• Enters interface configuration mode, where <i>slot/port</i> is the physical Ethernet interface that you want to configure with a DHCP server IP address. If you want to configure a subinterface, include the <i>number</i> argument to specify the subinterface number.• Enters interface configuration mode, where <i>vlan-id</i> is the ID of the VLAN that you

	Command or Action	Purpose
		want to configure with a DHCP server IP address. • Enters interface configuration mode, where <i>channel-id</i> is the ID of the port channel that you want to configure with a DHCP server IP address. If you want to configure a subchannel, include the <i>subchannel-id</i> argument to specify the subchannel ID.
Step 3	ip dhcp relay address <i>IP-address</i> Example: switch(config-if)# ip dhcp relay address 10.132.7.120	Configures an IP address for a DHCP server to which the relay agent forwards BOOTREQUEST packets received on this interface. To configure more than one IP address, use the ip dhcp relay address command once per address.
Step 4	(Optional) show ip dhcp relay address Example: switch(config-if)# show ip dhcp relay address	Displays all the configured DHCP server addresses.
Step 5	(Optional) show running-config dhcp Example: switch(config-if)# show running-config dhcp	Displays the DHCP configuration.
Step 6	(Optional) copy running-config startup-config Example: switch(config-if)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Creating a DHCP Static Binding

You can create a static DHCP source binding to a Layer 2 interface.

Before you begin

Ensure that you have enabled the DHCP snooping feature.

Procedure

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

	Command or Action	Purpose
	switch# configure terminal switch(config) #	
Step 2	ip source binding IP-address MAC-address vlan <i>vlan-id</i> {interface ethernet <i>slot/port</i> port-channel <i>channel-no</i>} Example: switch(config) # ip source binding 10.5.22.7 001f.28bd.0013 vlan 100 interface ethernet 2/3	Binds the static source address to the Layer 2 Ethernet interface.
Step 3	(Optional) show ip dhcp snooping binding Example: switch(config) # ip dhcp snooping binding	Shows the DHCP snooping static and dynamic bindings.
Step 4	(Optional) show ip dhcp snooping binding dynamic Example: switch(config) # ip dhcp snooping binding dynamic	Shows the DHCP snooping dynamic bindings.
Step 5	(Optional) copy running-config startup-config Example: switch(config) # copy running-config startup-config	Copies the running configuration to the startup configuration.

Example

The following example shows how to create a static IP source entry associated with VLAN 100 on Ethernet interface 2/3:

```
switch# configure terminal
switch(config) # ip source binding 10.5.22.7 001f.28bd.0013 vlan 100 interface ethernet 2/3
switch(config) #
```

Configuring DHCPv6 Relay Agent

Enabling or Disabling the DHCPv6 Relay Agent

Before you begin

Ensure that the DHCP feature is enabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.
Step 2	[no] ipv6 dhcp relay Example: switch(config)# ipv6 dhcp relay	Enables the DHCPv6 relay agent. The no option disables the relay agent.
Step 3	(Optional) show ipv6 dhcp relay [interface interface] Example: switch(config)# show ipv6 dhcp relay	Displays the DHCPv6 relay configuration.
Step 4	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Displays the DHCP configuration.
Step 5	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Enabling or Disabling VRF Support for the DHCPv6 Relay Agent

You can configure the device to support the relaying of DHCPv6 requests that arrive on an interface in one VRF to a DHCPv6 server in a different VRF.

Before you begin

Ensure that the DHCP feature is enabled.

Ensure that the DHCPv6 relay agent is enabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.

	Command or Action	Purpose
Step 2	[no] ipv6 dhcp relay option vpn Example: switch(config)# ipv6 dhcp relay option vpn	Enables VRF support for the DHCPv6 relay agent. The no option disables this behavior.
Step 3	[no] ipv6 dhcp relay option type cisco Example: switch(config)# ipv6 dhcp relay option type cisco	Causes the DHCPv6 relay agent to insert virtual subnet selection (VSS) details as part of the vendor-specific option. The no option causes the DHCPv6 relay agent to insert VSS details as part of the VSS option (68), which is defined in RFC-6607. This command is useful when you want to use DHCPv6 servers that do not support RFC-6607 but allocate IPv6 addresses based on the client VRF name.
Step 4	(Optional) show ipv6 dhcp relay [interface interface] Example: switch(config)# show ipv6 dhcp relay	Displays the DHCPv6 relay configuration.
Step 5	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Displays the DHCP configuration.
Step 6	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring the DHCPv6 Relay Source Interface

You can configure the source interface for the DHCPv6 relay agent. By default, the DHCPv6 relay agent uses the relay agent address as the source address of the outgoing packet. Configuring the source interface enables you to use a more stable address (such as the loopback interface address) as the source address of relayed messages.

Before you begin

Ensure that the DHCP feature is enabled.

Ensure that the DHCPv6 relay agent is enabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.
Step 2	[no] ipv6 dhcp relay source-interface interface Example: switch(config)# ipv6 dhcp relay source-interface loopback 2	Configures the source interface for the DHCPv6 relay agent. Note The DHCPv6 relay source interface can be configured globally, per interface, or both. When both the global and interface levels are configured, the interface-level configuration overrides the global configuration.
Step 3	(Optional) show ipv6 dhcp relay [interface interface] Example: switch(config)# show ipv6 dhcp relay	Displays the DHCPv6 relay configuration.
Step 4	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Displays the DHCP configuration.
Step 5	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Verifying the DHCP Snooping Configuration

To display DHCP snooping configuration information, perform one of the following tasks. For detailed information about the fields in the output from these commands, see the System Management Configuration Guide for your Cisco Nexus device.

Command	Purpose
show running-config dhcp	Displays the DHCP snooping configuration.
show ip dhcp relay	Displays the DHCP relay configuration.

Command	Purpose
show ipv6 dhcp relay [interface <i>interface</i>]	Displays the DHCPv6 relay global or interface-level configuration.
show ip dhcp snooping	Displays general information about DHCP snooping.

Displaying DHCP Bindings

Use the **show ip dhcp snooping binding** command to display the DHCP static and dynamic binding table. Use the **show ip dhcp snooping binding dynamic** to display the DHCP dynamic binding table.

For detailed information about the fields in the output from this command, see the *System Management Configuration Guide* for your Cisco Nexus device.

This example shows how to create a static DHCP binding and then verify the binding using the **show ip dhcp snooping binding** command.

```
switch# configuration terminal
switch(config)# ip source binding 10.20.30.40 0000.1111.2222 vlan 400 interface port-channel
500

switch(config)# show ip dhcp snooping binding
MacAddress          IPAddress          LeaseSec      Type        VLAN  Interface
-----  -----  -----  -----  -----
00:00:11:11:22:22  10.20.30.40       infinite     static      400   port-channel500
```

Clearing the DHCP Snooping Binding Database

You can remove entries from the DHCP snooping binding database, including a single entry, all entries associated with an interface, or all entries in the database.

Before you begin

Ensure that DHCP snooping is enabled.

Procedure

	Command or Action	Purpose
Step 1	(Optional) clear ip dhcp snooping binding Example: switch# clear ip dhcp snooping binding	Clears all entries from the DHCP snooping binding database.
Step 2	(Optional) clear ip dhcp snooping binding interface ethernet slot/port[.subinterface-number] Example:	Clears entries associated with a specific Ethernet interface from the DHCP snooping binding database.

	Command or Action	Purpose
	switch# clear ip dhcp snooping binding interface ethernet 1/4	
Step 3	(Optional) clear ip dhcp snooping binding interface port-channel channel-number[.subchannel-number] Example: switch# clear ip dhcp snooping binding interface port-channel 72	Clears entries associated with a specific port-channel interface from the DHCP snooping binding database.
Step 4	(Optional) clear ip dhcp snooping binding vlan vlan-id mac mac-address ip ip-address interface {ethernet slot/port[.subinterface-number] port-channel channel-number[.subchannel-number]} Example: switch# clear ip dhcp snooping binding vlan 23 mac 0060.3aeb.54f0 ip 10.34.54.9 interface ethernet 2/11	Clears a single, specific entry from the DHCP snooping binding database.
Step 5	(Optional) show ip dhcp snooping binding Example: switch# show ip dhcp snooping binding	Displays the DHCP snooping binding database.

Clearing DHCP Relay Statistics

Use the **clear ip dhcp relay statistics** command to clear the global DHCP relay statistics.

Use the **clear ip dhcp relay statistics interface interface** command to clear the DHCP relay statistics for a particular interface.

Use the **clear ip dhcp relay statistics interface serverip ip-address [use-vrf vrf-name]** command to clear the DHCP relay statistics at the server level for a particular interface.

Clearing DHCPv6 Relay Statistics

Use the **clear ipv6 dhcp relay statistics** command to clear the global DHCPv6 relay statistics.

Use the **clear ipv6 dhcp relay statistics interface interface** command to clear the DHCPv6 relay statistics for a particular interface.

Use the **clear ipv6 dhcp relay statistics interface server-ip ip-address [use-vrf vrf-name]** command to clear the DHCPv6 relay statistics at the server level for a particular interface.

Monitoring DHCP

Use the **show ip dhcp snooping statistics** command to monitor DHCP snooping.

Use the **show ip dhcp relay statistics [interface *interface* [serverip *ip-address* [use-vrf *vrf-name*]]]** command to monitor DHCP relay statistics at the global, server, or interface level.

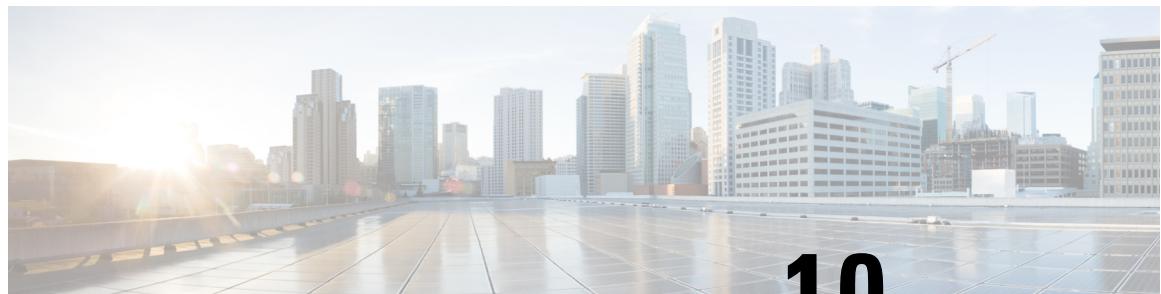
Use the (Optional) **show ip dhcp snooping statistics vlan [*vlan-id*] interface [ethernet|port-channel][*id*]** command to know the exact statistics about snooping statistics per interface under a vlan.

Configuration Examples for DHCP Snooping

The following example shows how to enable DHCP snooping on two VLANs, with Option 82 support enabled and Ethernet interface 2/5 trusted because the DHCP server is connected to that interface:

```
feature dhcp
ip dhcp snooping
ip dhcp snooping info option

interface Ethernet 2/5
    ip dhcp snooping trust
    ip dhcp snooping vlan 1
    ip dhcp snooping vlan 50
```



CHAPTER 10

Configuring Dynamic ARP Inspection

This chapter contains the following sections:

- [Information About DAI, on page 183](#)
- [Licensing Requirements for DAI, on page 186](#)
- [Prerequisites for DAI, on page 186](#)
- [Guidelines and Limitations for DAI, on page 187](#)
- [Default Settings for DAI, on page 187](#)
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Information About DAI

ARP

ARP provides IP communication within a Layer 2 broadcast domain by mapping an IP address to a MAC address. For example, host B wants to send information to host A but does not have the MAC address of host A in its ARP cache. In ARP terms, host B is the sender and host A is the target.

To get the MAC address of host A, host B generates a broadcast message for all hosts within the broadcast domain to obtain the MAC address associated with the IP address of host A. All hosts within the broadcast domain receive the ARP request, and host A responds with its MAC address.

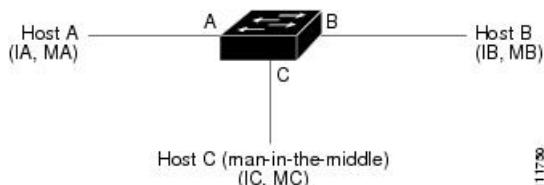
ARP Spoofing Attacks

ARP spoofing attacks and ARP cache poisoning can occur because ARP allows a reply from a host even if an ARP request was not received. After the attack, all traffic from the device under attack flows through the attacker's computer and then to the router, switch, or host.

An ARP spoofing attack can affect hosts, switches, and routers connected to your Layer 2 network by sending false information to the ARP caches of the devices connected to the subnet. Sending false information to an ARP cache is known as ARP cache poisoning. Spoof attacks can also intercept traffic intended for other hosts on the subnet.

Figure 4: ARP Cache Poisoning

This figure shows an example of ARP cache poisoning.



Hosts A, B, and C are connected to the device on interfaces A, B, and C, which are on the same subnet. Their IP and MAC addresses are shown in parentheses; for example, host A uses IP address IA and MAC address MA. When host A needs to send IP data to host B, it broadcasts an ARP request for the MAC address associated with IP address IB. When the device and host B receive the ARP request, they populate their ARP caches with an ARP binding for a host with the IP address IA and a MAC address MA; for example, IP address IA is bound to MAC address MA. When host B responds, the device and host A populate their ARP caches with a binding for a host with the IP address IB and the MAC address MB.

Host C can poison the ARP caches of the device, host A, and host B by broadcasting two forged ARP responses with bindings: one for a host with an IP address of IA and a MAC address of MC and another for a host with the IP address of IB and a MAC address of MC. Host B and the device then use the MAC address MC as the destination MAC address for traffic intended for IA, which means that host C intercepts that traffic. Likewise, host A and the device use the MAC address MC as the destination MAC address for traffic intended for IB.

Because host C knows the true MAC addresses associated with IA and IB, it can forward the intercepted traffic to those hosts by using the correct MAC address as the destination. This topology, in which host C has inserted itself into the traffic stream from host A to host B, is an example of a *man-in-the-middle* attack.

DAI and ARP Spoofing Attacks

DAI ensures that only valid ARP requests and responses are relayed. When DAI is enabled and properly configured, a Cisco Nexus device performs these activities:

- Intercepts all ARP requests and responses on untrusted ports
- Verifies that each of these intercepted packets has a valid IP-to-MAC address binding before updating the local ARP cache or before forwarding the packet to the appropriate destination
- Drops invalid ARP packets

DAI can determine the validity of an ARP packet based on valid IP-to-MAC address bindings stored in a Dynamic Host Configuration Protocol (DHCP) snooping binding database. This database is built by DHCP snooping if DHCP snooping is enabled on the VLANs and on the device. It can also contain static entries that you create. If the ARP packet is received on a trusted interface, the device forwards the packet without any checks. On untrusted interfaces, the device forwards the packet only if it is valid.

You can configure DAI to drop ARP packets when the IP addresses in the packets are invalid or when the MAC addresses in the body of the ARP packets do not match the addresses specified in the Ethernet header.

Interface Trust States and Network Security

DAI associates a trust state with each interface on the device. Packets that arrive on trusted interfaces bypass all DAI validation checks, and packets that arrive on untrusted interfaces go through the DAI validation process.

In a typical network configuration, the guidelines for configuring the trust state of interfaces are as follows:

Untrusted

Interfaces that are connected to hosts

Trusted

Interfaces that are connected to devices

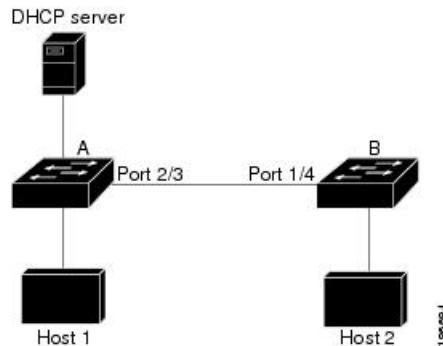
With this configuration, all ARP packets that enter the network from a device bypass the security check. No other validation is needed at any other place in the VLAN or in the network.



Caution Use the trust state configuration carefully. Configuring interfaces as untrusted when they should be trusted can result in a loss of connectivity.

Figure 5: ARP Packet Validation on a VLAN Enabled for DAI

The following figure, assume that both device A and device B are running DAI on the VLAN that includes host 1 and host 2. If host 1 and host 2 acquire their IP addresses from the DHCP server connected to device A, only device A binds the IP-to-MAC address of host 1. If the interface between device A and device B is untrusted, the ARP packets from host 1 are dropped by device B and connectivity between host 1 and host 2 is lost.



If you configure interfaces as trusted when they should be untrusted, you may open a security hole in a network. If device A is not running DAI, host 1 can easily poison the ARP cache of device B (and host 2, if you configured the link between the devices as trusted). This condition can occur even though device B is running DAI.

DAI ensures that hosts (on untrusted interfaces) connected to a device that runs DAI do not poison the ARP caches of other hosts in the network; however, DAI does not prevent hosts in other portions of the network from poisoning the caches of the hosts that are connected to a device that runs DAI.

If some devices in a VLAN run DAI and other devices do not, the guidelines for configuring the trust state of interfaces on a device that runs DAI becomes the following:

Untrusted

Interfaces that are connected to hosts or to devices that *are not* running DAI

Trusted

Interfaces that are connected to devices that *are* running DAI

To validate the bindings of packets from devices that do not run DAI, configure ARP ACLs on the device that runs DAI. When you cannot determine the bindings, isolate at Layer 3 the devices that run DAI from devices that do not run DAI.



Note Depending on your network setup, you may not be able to validate a given ARP packet on all devices in the VLAN.

Logging DAI Packets

Cisco NX-OS maintains a buffer of log entries about DAI packets processed. Each log entry contains flow information, such as the receiving VLAN, the port number, the source and destination IP addresses, and the source and destination MAC addresses.

You can also specify the type of packets that are logged. By default, a Cisco Nexus device logs only packets that DAI drops.

If the log buffer overflows, the device overwrites the oldest DAI log entries with newer entries. You can configure the maximum number of entries in the buffer.



Note Cisco NX-OS does not generate system messages about DAI packets that are logged.

Licensing Requirements for DAI

This table shows the licensing requirements for DAI.

Product	License Requirement
Cisco NX-OS	DAI requires no license. Any feature not included in a license package is bundled with the Cisco NX-OS system images and is provided at no extra charge to you.

Prerequisites for DAI

- You must enable the DHCP feature before you can configure DAI.

Guidelines and Limitations for DAI

DAI has the following configuration guidelines and limitations:

- DAI is an ingress security feature; it does not perform any egress checking.
- DAI is not effective for hosts connected to devices that do not support DAI or that do not have this feature enabled. Because man-in-the-middle attacks are limited to a single Layer 2 broadcast domain, you should separate the domain with DAI from domains without DAI. This separation secures the ARP caches of hosts in the domain with DAI.
- DAI depends on the entries in the DHCP snooping binding database to verify IP-to-MAC address bindings in incoming ARP requests and ARP responses. If you want DAI to use static IP-MAC address bindings to determine if ARP packets are valid, DHCP snooping needs only to be enabled. If you want DAI to use dynamic IP-MAC address bindings to determine if ARP packets are valid, you must configure DHCP snooping on the same VLANs on which you configure DAI.
- When you use the **feature dhcp** command to enable the DHCP feature, there is a delay of approximately 30 seconds before the I/O modules receive the DHCP or DAI configuration. This delay occurs regardless of the method that you use to change from a configuration with the DHCP feature disabled to a configuration with the DHCP feature enabled. For example, if you use the Rollback feature to revert to a configuration that enables the DHCP feature, the I/O modules receive the DHCP and DAI configuration approximately 30 seconds after you complete the rollback.
- DAI is supported on access ports, trunk ports, port-channel ports, and private VLAN ports.
- The DAI trust configuration of a port channel determines the trust state of all physical ports that you assign to the port channel. For example, if you have configured a physical port as a trusted interface and then you add that physical port to a port channel that is an untrusted interface, the physical port becomes untrusted.
- When you remove a physical port from a port channel, the physical port does not retain the DAI trust state configuration of the port channel.
- When you change the trust state on the port channel, the device configures a new trust state on all the physical ports that comprise the channel.
- If you want DAI to use static IP-MAC address bindings to determine if ARP packets are valid, ensure that DHCP snooping is enabled and that you have configured the static IP-MAC address bindings.
- If you want DAI to use dynamic IP-MAC address bindings to determine if ARP packets are valid, ensure that DHCP snooping is enabled.

Default Settings for DAI

This table lists the default settings for DAI parameters.

Table 15: Default DAI Parameters

Parameters	Default
DAI	Disabled on all VLANs.

Parameters	Default
Interface trust state	All interfaces are untrusted.
Validation checks	No checks are performed.
Log buffer	When DAI is enabled, all denied or dropped ARP packets are logged. The number of entries in the log is 32. The number of system messages is limited to 5 per second. The logging-rate interval is 1 second.
Per-VLAN logging	All denied or dropped ARP packets are logged.

Configuring DAI

Enabling or Disabling DAI on VLANs

You can enable or disable DAI on VLANs. By default, DAI is disabled on all VLANs.

Before you begin

If you are enabling DAI, ensure the following:

- Ensure that the DHCP feature is enabled.
- The VLANs on which you want to enable DAI are configured.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config) #</pre>	Enters global configuration mode.
Step 2	[no] ip arp inspection vlan list Example: <pre>switch(config)# ip arp inspection vlan 13</pre>	Enables DAI for the specified list of VLANs. The no option disables DAI for the specified VLANs.
Step 3	(Optional) show ip arp inspection vlan list Example: <pre>switch(config)# show ip arp inspection vlan 13</pre>	Shows the DAI status for the specified list of VLANs.

	Command or Action	Purpose
Step 4	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring the DAI Trust State of a Layer 2 Interface

You can configure the DAI interface trust state of a Layer 2 interface. By default, all interfaces are untrusted. A device forwards ARP packets that it receives on a trusted Layer 2 interface but does not check them. On untrusted interfaces, the device intercepts all ARP requests and responses and verifies that the intercepted packets have valid IP-MAC address bindings before updating the local cache and forwarding the packet to the appropriate destination. If the device determines that packets have invalid bindings, it drops the packets and logs them according to the logging configuration.

Before you begin

If you are enabling DAI, ensure that the DHCP feature is enabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	interface type number / slot Example: switch(config)# interface ethernet 2/1 switch(config-if)#	Enters interface configuration mode.
Step 3	[no] ip arp inspection trust Example: switch(config-if)# ip arp inspection trust	Configures the interface as a trusted ARP interface. The no option configures the interface as an untrusted ARP interface.
Step 4	(Optional) show ip arp inspection interface type number / slot Example: switch(config-if)# show ip arp inspection interface ethernet 2/1	Displays the trust state and the ARP packet rate for the specified interface.

	Command or Action	Purpose
Step 5	(Optional) copy running-config startup-config Example: switch(config-if)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Enabling or Disabling Additional Validation

You can enable or disable additional validation of ARP packets. By default, no additional validation of ARP packets is enabled. When no additional validation is configured, the source MAC address and the source IP address check against the IP-to-MAC binding entry for ARP packets are done by using the Ethernet source MAC address (not the ARP sender MAC address) and the ARP sender IP address.

DAI intercepts, logs, and discards ARP packets with invalid IP-to-MAC address bindings. You can enable additional validation on the destination MAC address, the sender and target IP addresses, and the source MAC address.

You can use the following keywords with the **ip arp inspection validate** command to implement additional validations:

dst-mac

Checks the destination MAC address in the Ethernet header against the target MAC address in the ARP body for ARP responses. When enabled, packets with different MAC addresses are classified as invalid and are dropped.

ip

Checks the ARP body for invalid and unexpected IP addresses. Addresses include 0.0.0.0, 255.255.255.255, and all IP multicast addresses. Sender IP addresses are checked in all ARP requests and responses, and target IP addresses are checked only in ARP responses.

src-mac

Checks the source MAC address in the Ethernet header against the sender MAC address in the ARP body for ARP requests and responses. When enabled, packets with different MAC addresses are classified as invalid and are dropped.

When enabling additional validation, follow these guidelines:

- You must specify at least one of the keywords. You can specify one, two, or all three keywords.
- Each **ip arp inspection validate** command that you enter replaces the configuration from any previous commands. If you enter an **ip arp inspection validate** command to enable src-mac and dst-mac validations, and a second **ip arp inspection validate** command to enable ip validation, the src-mac and dst-mac validations are disabled when you enter the second command.

Procedure

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

	Command or Action	Purpose
	switch# configure terminal switch(config)#	
Step 2	[no] ip arp inspection validate {[src-mac] [dst-mac] [ip]} Example: switch(config)# ip arp inspection validate src-mac dst-mac ip	Enables additional DAI validation, or if you use the no option, disables additional DAI validation.
Step 3	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Displays the DHCP snooping configuration, including the DAI configuration.
Step 4	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring the DAI Logging Buffer Size

You can configure the DAI logging buffer size. The default buffer size is 32 messages.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config)#	Enters global configuration mode.
Step 2	[no] ip arp inspection log-buffer entries number Example: switch(config)# ip arp inspection log-buffer entries 64	Configures the DAI logging buffer size. The no option reverts to the default buffer size, which is 32 messages. The buffer size can be between 1 and 1024 messages.
Step 3	(Optional) show running-config dhcp Example: switch(config)# show running-config dhcp	Displays the DHCP snooping configuration, including the DAI configuration.
Step 4	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring DAI Log Filtering

You can configure how the device determines whether to log a DAI packet. By default, the device logs DAI packets that are dropped.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config) #</pre>	Enters global configuration mode.
Step 2	Enter one of the following commands: <ul style="list-style-type: none">• ip arp inspection vlan <i>vlan-list</i> logging dhcp-bindings all• ip arp inspection vlan <i>vlan-list</i> logging dhcp-bindings none• ip arp inspection vlan <i>vlan-list</i> logging dhcp-bindingspermit• no ip arp inspection vlan <i>vlan-list</i> logging dhcp-bindings {all none permit} Example: <pre>switch(config)# ip arp inspection vlan 100 dhcp-bindings permit</pre>	Configures DAI log filtering, as follows. The no option removes DAI log filtering. <ul style="list-style-type: none">• Logs all packets that match DHCP bindings.• Does not log packets that match DHCP bindings.• Logs packets permitted by DHCP bindings.• Removes DAI log filtering.
Step 3	(Optional) show running-config dhcp Example: <pre>switch(config)# show running-config dhcp</pre>	Displays the DHCP snooping configuration, including the DAI configuration.
Step 4	(Optional) copy running-config startup-config Example: <pre>switch(config)# copy running-config startup-config</pre>	Copies the running configuration to the startup configuration.

Verifying the DAI Configuration

To display the DAI configuration information, perform one of the following tasks.

Command	Purpose
show ip arp inspection	Displays the status of DAI.
show ip arp inspection interface ethernet	Displays the trust state.

Command	Purpose
show ip arp inspection vlan	Displays the DAI configuration for a specific VLAN.
show arp access-lists	Displays ARP ACLs.
show ip arp inspection log	Displays the DAI log configuration.

Monitoring and Clearing DAI Statistics

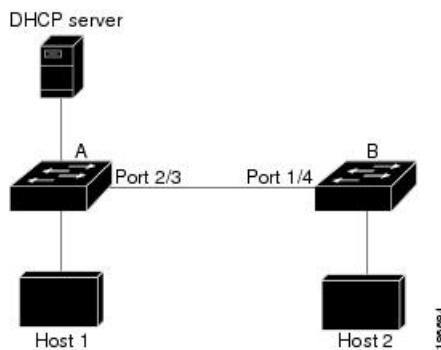
Configuration Examples for DAI

Example 1-Two Devices Support DAI

These procedures show how to configure DAI when two devices support DAI.

Figure 6: Two Devices Supporting DAI

The following figure shows the network configuration for this example. Host 1 is connected to device A, and Host 2 is connected to device B. Both devices are running DAI on VLAN 1 where the hosts are located. A DHCP server is connected to device A. Both hosts acquire their IP addresses from the same DHCP server. Device A has the bindings for Host 1 and Host 2, and device B has the binding for Host 2. Device A Ethernet interface 2/3 is connected to the device B Ethernet interface 1/4.



DAI depends on the entries in the DHCP snooping binding database to verify IP-to-MAC address bindings in incoming ARP requests and ARP responses. Make sure to enable DHCP snooping to permit ARP packets that have dynamically-assigned IP addresses.

- This configuration does not work if the DHCP server is moved from device A to a different location.
- To ensure that this configuration does not compromise security, configure Ethernet interface 2/3 on device A and Ethernet interface 1/4 on device B as trusted.

Configuring Device A

To enable DAI and configure Ethernet interface 2/3 on device A as trusted, follow these steps:

Configuring Device A**Procedure**

- Step 1** While logged into device A, verify the connection between device A and device B.

```
switchA# show cdp neighbors
Capability Codes: R - Router, T - Trans-Bridge, B - Source-Route-Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater,
                  V - VoIP-Phone, D - Remotely-Managed-Device,
                  s - Supports-STP-Dispute
Device ID          Local Intrfce   Hldtme  Capability Platform      Port ID
switchB           Ethernet2/3    177     R S I       WS-C2960-24TC Ethernet1/4
switchA#
```

- Step 2** Enable DAI on VLAN 1 and verify the configuration.

```
switchA# config t
switchA(config)# ip arp inspection vlan 1
switchA(config)# show ip arp inspection vlan 1
Source Mac Validation : Disabled
Destination Mac Validation : Disabled
IP Address Validation : Disabled
Vlan : 1
-----
Configuration : Enabled
Operation State : Active
switchA(config)#

```

- Step 3** Configure Ethernet interface 2/3 as trusted.

```
switchA(config)# interface ethernet 2/3
switchA(config-if)# ip arp inspection trust
switchA(config-if)# exit
switchA(config)# exit
switchA# show ip arp inspection interface ethernet 2/3
Interface      Trust State   Rate (pps)   Burst Interval
-----          -----        -----        -----
Ethernet2/3    Trusted      15            5
```

- Step 4** Verify the bindings.

```
switchA# show ip dhcp snooping binding
MacAddress      IpAddress      LeaseSec   Type      VLAN Interface
-----          -----        -----        -----
00:60:0b:00:12:89 10.0.0.1      0          dhcp-snooping 1   Ethernet2/3
switchA#
```

- Step 5** Check the statistics before and after DAI processes any packets.

```
switchA# show ip arp inspection statistics vlan 1
Vlan : 1
-----
ARP Req Forwarded = 0
ARP Res Forwarded = 0
ARP Req Dropped = 0
ARP Res Dropped = 0
DHCP Drops = 0
DHCP Permits = 0
SMAC Fails-ARP Req = 0
SMAC Fails-ARP Res = 0
```

```
DMAC Fails-ARP Res = 0
IP Fails-ARP Req = 0
IP Fails-ARP Res = 0
switchA#
```

If host 1 sends out two ARP requests with an IP address of 10.0.0.1 and a MAC address of 0002.0002.0002, both requests are permitted, and are shown as follows:

```
switchA# show ip arp inspection statistics vlan 1
Vlan : 1
-----
ARP Req Forwarded = 2
ARP Res Forwarded = 0
ARP Req Dropped = 0
ARP Res Dropped = 0
DHCP Drops = 0
DHCP Permits = 2
SMAC Fails-ARP Req = 0
SMAC Fails-ARP Res = 0
DMAC Fails-ARP Res = 0
IP Fails-ARP Req = 0
IP Fails-ARP Res = 0
```

If host 1 tries to send an ARP request with an IP address of 10.0.0.3, the packet is dropped and an error message is logged.

```
00:12:08: %SW_DAI-4-DHCP_SNOOPING_DENY: 2 Invalid ARPs (Req) on Ethernet2/3, vlan 1.([0002.0002.0002/10.0.0.3/0000.0000.0000/0.0.0.0/02:42:35 UTC Fri Jul 13 2008])
```

The statistics display as follows:

```
switchA# show ip arp inspection statistics vlan 1
switchA#
Vlan : 1
-----
ARP Req Forwarded = 2
ARP Res Forwarded = 0
ARP Req Dropped = 2
ARP Res Dropped = 0
DHCP Drops = 2
DHCP Permits = 2
SMAC Fails-ARP Req = 0
SMAC Fails-ARP Res = 0
DMAC Fails-ARP Res = 0
IP Fails-ARP Req = 0
IP Fails-ARP Res = 0
switchA#
```

Configuring Device B

To enable DAI and configure Ethernet interface 1/4 on device B as trusted, follow these steps:

Procedure

- Step 1** While logged into device B, verify the connection between device B and device A.

Configuring Device B

```

switchB# show cdp neighbors
Capability Codes: R - Router, T - Trans-Bridge, B - Source-Route-Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater,
                  V - VoIP-Phone, D - Remotely-Managed-Device,
                  s - Supports-STP-Dispute
Device ID          Local Intrfce   Hldtme  Capability Platform      Port ID
switchA           Ethernet1/4    120     R S I       WS-C2960-24TC Ethernet2/3
switchB#

```

Step 2 Enable DAI on VLAN 1, and verify the configuration.

```

switchB# config t
switchB(config)# ip arp inspection vlan 1
switchB(config)# show ip arp inspection vlan 1
Source Mac Validation : Disabled
Destination Mac Validation : Disabled
IP Address Validation : Disabled
Vlan : 1
-----
Configuration : Enabled
Operation State : Active
switchB(config)#

```

Step 3 Configure Ethernet interface 1/4 as trusted.

```

switchB(config)# interface ethernet 1/4
switchB(config-if)# ip arp inspection trust
switchB(config-if)# exit
switchB(config)# exit
switchB# show ip arp inspection interface ethernet 1/4
Interface      Trust State    Rate (pps)    Burst Interval
-----          -----          -----          -----
Ethernet1/4    Trusted        15            5
switchB#

```

Step 4 Verify the list of DHCP snooping bindings.

```

switchB# show ip dhcp snooping binding
MacAddress      IpAddress        LeaseSec    Type        VLAN  Interface
-----          -----          -----        -----      ----  -----
00:01:00:01:00:01 10.0.0.2      4995       dhcp-snooping 1    Ethernet1/4
switchB#

```

Step 5 Check the statistics before and after DAI processes any packets.

```

switchB# show ip arp inspection statistics vlan 1
Vlan : 1
-----
ARP Req Forwarded = 0
ARP Res Forwarded = 0
ARP Req Dropped = 0
ARP Res Dropped = 0
DHCP Drops = 0
DHCP Permits = 0
SMAC Fails-ARP Req = 0
SMAC Fails-ARP Res = 0
DMAC Fails-ARP Res = 0
IP Fails-ARP Req = 0
IP Fails-ARP Res = 0
switchB#

```

If Host 2 sends out an ARP request with the IP address 10.0.0.2 and the MAC address 0001.0001.0001, the packet is forwarded and the statistics are updated.

```
switchB# show ip arp inspection statistics vlan 1
Vlan : 1
-----
ARP Req Forwarded = 1
ARP Res Forwarded = 0
ARP Req Dropped = 0
ARP Res Dropped = 0
DHCP Drops = 0
DHCP Permits = 1
SMAC Fails-ARP Req = 0
SMAC Fails-ARP Res = 0
DMAC Fails-ARP Res = 0
IP Fails-ARP Req = 0
IP Fails-ARP Res = 0
switchB#
```

If Host 2 attempts to send an ARP request with the IP address 10.0.0.1, DAI drops the request and logs the following system message:

```
00:18:08: %SW_DAI-4-DHCP_SNOOPING_DENY: 1 Invalid ARPs (Req) on Ethernet1/4, vlan 1.([0001.0001.0001/10.0.0.1/0000.0000.0000/0.0.0.0/01:53:21 UTC Fri Jun 13 2008])
```

The statistics display as follows:

```
switchB# show ip arp inspection statistics vlan 1
Vlan : 1
-----
ARP Req Forwarded = 1
ARP Res Forwarded = 0
ARP Req Dropped = 1
ARP Res Dropped = 0
DHCP Drops = 1
DHCP Permits = 1
SMAC Fails-ARP Req = 0
SMAC Fails-ARP Res = 0
DMAC Fails-ARP Res = 0
IP Fails-ARP Req = 0
IP Fails-ARP Res = 0
switchB#
```




CHAPTER 11

Configuring Unicast RPF

This chapter describes how to configure rate limits for egress traffic on Cisco NX-OS devices.

This chapter includes the following sections:

- [About Unicast RPF, on page 199](#)
- [Licensing Requirements for Unicast RPF, on page 201](#)
- [Guidelines and Limitations for Unicast RPF, on page 201](#)
- [Default Settings for Unicast RPF, on page 202](#)
- [Configuring Unicast RPF, on page 202](#)
- [Configuration Examples for Unicast RPF, on page 204](#)
- [Verifying the Unicast RPF Configuration, on page 204](#)

About Unicast RPF

The Unicast RPF feature reduces problems that are caused by the introduction of malformed or forged (spoofed) IPv4 or IPv6 source addresses into a network by discarding IPv4 or IPv6 packets that lack a verifiable IP source address. For example, a number of common types of Denial-of-Service (DoS) attacks, including Smurf and Tribal Flood Network (TFN) attacks, can take advantage of forged or rapidly changing source IPv4 or IPv6 addresses to allow attackers to thwart efforts to locate or filter the attacks. Unicast RPF deflects attacks by forwarding only the packets that have source addresses that are valid and consistent with the IP routing table.

When you enable Unicast RPF on an interface, the switch examines all ingress packets received on that interface to ensure that the source address and source interface appear in the routing table and match the interface on which the packet was received. This examination of source addresses relies on the Forwarding Information Base (FIB).



Note

Unicast RPF is an ingress function and is applied only on the ingress interface of a switch at the upstream end of a connection.

Unicast RPF verifies that any packet received at a switch interface arrives on the best return path (return route) to the source of the packet by doing a reverse lookup in the FIB. If the packet was received from one of the best reverse path routes, the packet is forwarded as normal. If there is no reverse path route on the same interface from which the packet was received, the source address might have been modified by the attacker. If Unicast RPF does not find a reverse path for the packet, the packet is dropped.



Note With Unicast RPF, all equal-cost “best” return paths are considered valid, which means that Unicast RPF works where multiple return paths exist, if each path is equal to the others in terms of the routing cost (number of hops, weights, and so on) and as long as the route is in the FIB. Unicast RPF also functions where Enhanced Interior Gateway Routing Protocol (EIGRP) variants are being used and unequal candidate paths back to the source IP address exist.

Unicast RPF Process

Unicast RPF has several key implementation principles:

- The packet must be received at an interface that has the best return path (route) to the packet source (a process called *symmetric routing*). There must be a route in the FIB that matches the route to the receiving interface. Static routes, network statements, and dynamic routing add routes to the FIB.
- IP source addresses at the receiving interface must match the routing entry for the interface.
- Unicast RPF is an input function and is applied only on the input interface of a device at the upstream end of a connection.

You can use Unicast RPF for downstream networks, even if the downstream network has other connections to the Internet.



Caution Be careful when using optional BGP attributes, such as weight and local preference, because an attacker can modify the best path back to the source address. Modification would affect the operation of Unicast RPF.

When a packet is received at the interface where you have configured Unicast RPF and ACLs, the Cisco NX-OS software performs the following actions:

Procedure

-
- Step 1** Checks the input ACLs on the inbound interface.
 - Step 2** Uses Unicast RPF to verify that the packet has arrived on the best return path to the source, which it does by doing a reverse lookup in the FIB table.
 - Step 3** Conducts a FIB lookup for packet forwarding.
 - Step 4** Checks the output ACLs on the outbound interface.
 - Step 5** Forwards the packet.
-

Licensing Requirements for Unicast RPF

Product	License Requirement
Cisco NX-OS	Unicast RPF requires no license. Any feature not included in a license package is bundled with the Cisco NX-OS system images and is provided at no extra charge to you. For an explanation of the Cisco NX-OS licensing scheme, see the <i>Cisco NX-OS Licensing Guide</i> .

Guidelines and Limitations for Unicast RPF

Unicast RPF has the following configuration guidelines and limitations:

- The following platforms support uRPF:
 - You must apply Unicast RPF at the interface downstream from the larger portion of the network, preferably at the edges of your network.
 - The further downstream that you apply Unicast RPF, the finer the granularity you have in mitigating address spoofing and in identifying the sources of spoofed addresses. For example, applying Unicast RPF on an aggregation device helps to mitigate attacks from many downstream networks or clients and is simple to administer, but it does not help identify the source of the attack. Applying Unicast RPF at the network access server helps limit the scope of the attack and trace the source of the attack; however, deploying Unicast RPF across many sites does add to the administration cost of operating the network.
 - The more entities that deploy Unicast RPF across Internet, intranet, and extranet resources means that the better the chances of mitigating large-scale network disruptions throughout the Internet community, and the better the chances are of tracing the source of an attack.
 - Unicast RPF will not inspect IP packets that are encapsulated in tunnels, such as generic routing encapsulation (GRE) tunnels. You must configure Unicast RPF at a home gateway so that Unicast RPF processes network traffic only after the tunneling and encryption layers have been stripped off the packets.
 - You can use Unicast RPF in any “single-homed” environment where there is only one access point out of the network or one upstream connection. Networks that have one access point provide symmetric routing, which means that the interface where a packet enters the network is also the best return path to the source of the IP packet.
 - Do not use Unicast RPF on interfaces that are internal to the network. Internal interfaces are likely to have routing asymmetry, which means that multiple routes to the source of a packet exist. You should configure Unicast RPF only where there is natural or configured symmetry. Do not configure strict Unicast RPF.
 - Unicast RPF allows packets with 0.0.0.0 source and 255.255.255.255 destination to pass so that the Bootstrap Protocol (BOOTP) and the Dynamic Host Configuration Protocol (DHCP) can operate correctly.



Note

If you are familiar with the Cisco IOS CLI, be aware that the Cisco NX-OS commands for this feature might differ from the Cisco IOS commands that you would use.

Default Settings for Unicast RPF

This table lists the default settings for Unicast RPF parameters.

Table 16: Default Unicast RPF Parameter Settings

Parameters	Default
Unicast RPF	Disabled for all switches except the Cisco Nexus 3100 platform switches in N3K mode

Configuring Unicast RPF

You can configure one the following Unicast RPF modes on an ingress interface:

Strict Unicast RPF mode

A strict mode check is successful when Unicast RPF finds a match in the FIB for the packet source address and the ingress interface through which the packet is received matches one of the Unicast RPF interfaces in the FIB match. If this check fails, the packet is discarded. You can use this type of Unicast RPF check where packet flows are expected to be symmetrical.

Loose Unicast RPF mode

A loose mode check is successful when a lookup of a packet source address in the FIB returns a match and the FIB result indicates that the source is reachable through at least one real interface. The ingress interface through which the packet is received is not required to match any of the interfaces in the FIB result.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.
Step 2	interface ethernet slot/port Example: switch(config) # interface ethernet 2/3 switch(config-if) #	Specifies an Ethernet interface and enters interface configuration mode.
Step 3	{ip ipv6} address ip-address/length Example: switch(config-if) # ip address 172.23.231.240/23	Specifies an IPv4 or IPv6 address for the interface.
Step 4	{ip ipv6} verify unicast source reachable-via Example:	Configures Unicast RPF on the interface for both IPv4 and IPv6.

	Command or Action	Purpose
	<pre>switch(config-if) # ip verify unicast source reachable-via any</pre>	<p>Note</p> <ul style="list-style-type: none"> When you enable Unicast RPF for IPv4 or IPv6 (using the ip or ipv6 keyword), Unicast RPF is enabled for both IPv4 and IPv6. <p>Note You can configure only one version of the available IPv4 and IPv6 Unicast RPF command on an interface. When you configure one version, all the mode changes must be done by this version and all other versions will be blocked by that interface.</p>
Step 5	exit Example: <pre>switch(config-if) # exit switch(config) #</pre>	Exits interface configuration mode.
Step 6	(Optional) show ip interface ethernet slot/port Example: <pre>switch(config) # show ip interface ethernet 1/54 grep -i "unicast reverse path forwarding" IP unicast reverse path forwarding: none</pre>	Displays the IP information for an interface and verifies if Unicast RPF is enabled.
Step 7	(Optional) show running-config interface ethernet slot/port Example: <pre>switch(config) # show running-config interface ethernet 2/3</pre>	Displays the configuration for an interface in the running configuration.
Step 8	(Optional) copy running-config startup-config Example: <pre>switch(config) # copy running-config startup-config</pre>	Copies the running configuration to the startup configuration.

Configuration Examples for Unicast RPF

The following example shows how to configure loose Unicast RPF for IPv4 packets:

```
interface Ethernet2/3
ip address 172.23.231.240/23
ip verify unicast source reachable-via any allow-default
```

The following example shows how to configure loose Unicast RPF for IPv6 packets:

```
interface Ethernet2/3
ipv6 address 2001:0DB8:c18:1::3/64
ipv6 verify unicast source reachable-via any allow-default
```

The following example shows how to configure strict Unicast RPF for IPv4 packets:

```
interface Ethernet2/2
ip address 172.23.231.240/23
ip verify unicast source reachable-via rx
```

The following example shows how to configure strict Unicast RPF for IPv6 packets:

```
interface Ethernet2/2
ipv6 address 2001:0DB8:c18:1::3/64
ipv6 verify unicast source reachable-via rx
```

Verifying the Unicast RPF Configuration

To display Unicast RPF configuration information, perform one of the following tasks:

Command	Purpose
show running-config interface ethernet slot/port	Displays the interface configuration in the running configuration.
show running-config ip [all]	Displays the IPv4 configuration in the running configuration.
show running-config ipv6 [all]	Displays the IPv6 configuration in the running configuration.
show startup-config interface ethernet slot/port	Displays the interface configuration in the startup configuration.
show ip interface ethernet slot/port	Displays the IP information for an interface and verifies if the unicast RPF is enabled or disabled.
show startup-config ip	Displays the IP configuration in the startup configuration.



CHAPTER 12

Configuring Control Plane Policing

This chapter contains the following sections:

- [Information About CoPP, on page 205](#)
- [Control Plane Protection, on page 207](#)
- [CoPP Policy Templates, on page 208](#)
- [CoPP Class Maps, on page 219](#)
- [Packets Per Second Credit Limit, on page 219](#)
- [CoPP and the Management Interface, on page 219](#)
- [Licensing Requirements for CoPP, on page 220](#)
- [Guidelines and Limitations for CoPP, on page 220](#)
- [Upgrade Guidelines for CoPP, on page 221](#)
- [Configuring CoPP, on page 221](#)
- [CoPP Show Commands, on page 225](#)
- [Displaying the CoPP Configuration Status, on page 226](#)
- [Monitoring CoPP, on page 226](#)
- [Disabling and Reenabling the Rate Limit on CoPP Classes, on page 227](#)
- [Clearing the CoPP Statistics, on page 228](#)
- [CoPP Configuration Examples, on page 229](#)
- [Sample CoPP Configuration, on page 230](#)
- [Example: Changing or Reapplying the Default CoPP Policy Using the Setup Utility, on page 234](#)
- [Preventing CoPP Overflow by Splitting ICMP Pings, on page 235](#)
- [Additional References for CoPP, on page 236](#)

Information About CoPP

Control Plane Policing (CoPP) protects the control plane and separates it from the data plane, which ensures network stability, reachability, and packet delivery.

This feature allows a policy map to be applied to the control plane. This policy map looks like a normal QoS policy and is applied to all traffic destined to any of the IP addresses of the router or Layer 3 switch. A common attack vector for network devices is the denial-of-service (DoS) attack, where excessive traffic is directed at the device interfaces.

The Cisco NX-OS device provides CoPP to prevent DoS attacks from impacting performance. Such attacks, which can be perpetrated either inadvertently or maliciously, typically involve high rates of traffic destined to the supervisor module or CPU itself.

The supervisor module divides the traffic that it manages into three functional components or planes:

Data plane

Handles all the data traffic. The basic functionality of a Cisco NX-OS device is to forward packets from one interface to another. The packets that are not meant for the switch itself are called the transit packets. These packets are handled by the data plane.

Control plane

Handles all routing protocol control traffic. These protocols, such as the Border Gateway Protocol (BGP) and the Open Shortest Path First (OSPF) Protocol, send control packets between devices. These packets are destined to router addresses and are called control plane packets.

Management plane

Runs the components meant for Cisco NX-OS device management purposes such as the command-line interface (CLI) and Simple Network Management Protocol (SNMP).

The supervisor module has both the management plane and control plane and is critical to the operation of the network. Any disruption or attacks to the supervisor module will result in serious network outages. For example, excessive traffic to the supervisor module could overload and slow down the performance of the entire Cisco NX-OS device. Another example is a DoS attack on the supervisor module that could generate IP traffic streams to the control plane at a very high rate, forcing the control plane to spend a large amount of time in handling these packets and preventing the control plane from processing genuine traffic.

Examples of DoS attacks are as follows:

- Internet Control Message Protocol (ICMP) echo requests
- IP fragments
- TCP SYN flooding

These attacks can impact the device performance and have the following negative effects:

- Reduced service quality (such as poor voice, video, or critical applications traffic)
- High route processor or switch processor CPU utilization
- Route flaps due to loss of routing protocol updates or keepalives
- Unstable Layer 2 topology
- Slow or unresponsive interactive sessions with the CLI
- Processor resource exhaustion, such as the memory and buffers
- Indiscriminate drops of incoming packets



Caution

It is important to ensure that you protect the supervisor module from accidental or malicious attacks by configuring control plane protection.

Control Plane Protection

To protect the control plane, the Cisco NX-OS device segregates different packets destined for the control plane into different classes. Once these classes are identified, the Cisco NX-OS device polices the packets, which ensures that the supervisor module is not overwhelmed.

Control Plane Packet Types

Different types of packets can reach the control plane:

Receive packets

Packets that have the destination address of a router. The destination address can be a Layer 2 address (such as a router MAC address) or a Layer 3 address (such as the IP address of a router interface). These packets include router updates and keepalive messages. Multicast packets can also be in this category where packets are sent to multicast addresses that are used by a router.

Exception packets

Packets that need special handling by the supervisor module. For example, if a destination address is not present in the Forwarding Information Base (FIB) and results in a miss, the supervisor module sends an ICMP unreachable packet back to the sender. Another example is a packet with IP options set.

Redirected packets

Packets that are redirected to the supervisor module. Features such as Dynamic Host Configuration Protocol (DHCP) snooping or dynamic Address Resolution Protocol (ARP) inspection redirect some packets to the supervisor module.

Glean packets

If a Layer 2 MAC address for a destination IP address is not present in the FIB, the supervisor module receives the packet and sends an ARP request to the host.

All of these different packets could be maliciously used to attack the control plane and overwhelm the Cisco NX-OS device. CoPP classifies these packets to different classes and provides a mechanism to individually control the rate at which the supervisor module receives these packets.

Classification for CoPP

For effective protection, the Cisco NX-OS device classifies the packets that reach the supervisor modules to allow you to apply different rate controlling policies based on the type of the packet. For example, you might want to be less strict with a protocol packet such as Hello messages but more strict with a packet that is sent to the supervisor module because the IP option is set.

Rate Controlling Mechanisms

Once the packets are classified, the Cisco NX-OS device has different mechanisms to control the rate at which packets arrive at the supervisor module.

The policing rate is specified in terms of packets per second (PPS). Each classified flow can be policed individually by specifying a policing rate limit in PPS.

CoPP Policy Templates

When you bring up your Cisco NX-OS device for the first time, the Cisco NX-OS software installs the default copp-system-policy to protect the supervisor module from DoS attacks. You can choose the CoPP policy template for your deployment scenario by specifying CoPP policy options from the initial setup utility:

- Default—Layer 2 and Layer 3 policy which provides a good balance of policing between switched and routed traffic bound to CPU.
- Layer 2—Layer 2 policy which gives more preference to the Layer 2 traffic (eg BPDU) bound to the CPU
- Layer 3—Layer 3 policy which gives more preference to the Layer 3 traffic (eg BGP, RIP, OSPF etc) bound to the CPU

If you do not select an option or choose not to execute the setup utility, the Cisco NX-OS software applies the Default policing. Cisco recommends starting with the default policy and later modifying the CoPP policies as required.

The default copp-system-policy policy has optimized values suitable for basic device operations. You must add specific class and access-control list (ACL) rules that meet your DoS protection requirements.

You can switch across default, Layer 2 and Layer 3 templates by entering the setup utility again using the setup command.

Default CoPP Policy

This policy is applied to the switch by default. It has the classes with police rates that should suit most network installations. You cannot modify this policy template, but you can modify the CoPP configuration on the device. After you run the setup utility and set up the default CoPP policy profile, all modifications that were made to the CoPP policy will be removed.

This policy has the following configuration:

```
policy-map type control-plane copp-system-policy
  class copp-s-default
    police pps 400
  class copp-s-ping
    police pps 100
  class copp-s-l3destmiss
    police pps 100
  class copp-s-glean
    police pps 500
  class copp-s-l3mtufail
    police pps 100
  class copp-s-ttl1
    police pps 100
  class copp-s-ip-options
    police pps 100
  class copp-s-ip-nat
    police pps 100
  class copp-s-ipmcmiss
    police pps 400
  class copp-s-ipmc-g-hit
    police pps 400
  class copp-s-ipmc-rpf-fail-g
```

```

police pps 400
class copp-s-ipmc-rpf-fail-sg
    police pps 400
class copp-s-dhcpreq
    police pps 300
class copp-s-dhcprep
    police pps 300
class copp-s-igmp
    police pps 400
class copp-s-routingProto2
    police pps 1300
class copp-s-eigrp
    police pps 200
class copp-s-pimreg
    police pps 200
class copp-s-pimaautorp
    police pps 200
class copp-s-routingProto1
    police pps 1000
class copp-s-arp
    police pps 200
class copp-s-ptp
    police pps 1000
class copp-s-bpdu
    police pps 12000
class copp-s-cdp
    police pps 400
class copp-s-lacp
    police pps 400
class copp-s-lldp
    police pps 200
class copp-icmp
    police pps 200
class copp-telnet
    police pps 500
class copp-ssh
    police pps 500
class copp-snmp
    police pps 500
class copp-ntp
    police pps 100
class copp-tacacsradius
    police pps 400
class copp-stftp
    police pps 400
class copp-ftp
    police pps 100
class copp-http
    police pps 100

```

This is the default CoPP policy profile for Cisco Nexus 34180YC.

```

sh policy-map int control-plane
    Control Plane

        Service-policy input: copp-system-p-policy-strict

            class-map copp-system-p-class-13uc-data (match-any)
                match exception glean
                set cos 1
                police cir 250 pps , bc 32 packets
                module 1 :
                    transmitted 0 packets;
                    dropped 0 packets;

```

Default CoPP Policy

```

class-map copp-system-p-class-critical (match-any)
  match access-group name copp-system-p-acl-bgp
  match access-group name copp-system-p-acl-rip
  match access-group name copp-system-p-acl-vpc
  match access-group name copp-system-p-acl-bgp6
  match access-group name copp-system-p-acl-ospf
  match access-group name copp-system-p-acl-rip6
  match access-group name copp-system-p-acl-eigrp
  match access-group name copp-system-p-acl-ospf6
  match access-group name copp-system-p-acl-eigrp6
  match access-group name copp-system-p-acl-auto-rp
  match access-group name copp-system-p-acl-mac-l3-isis
  set cos 7
  police cir 19000 pps , bc 128 packets
  module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-important (match-any)
  match access-group name copp-system-p-acl-hsrp
  match access-group name copp-system-p-acl-vrrp
  match access-group name copp-system-p-acl-hsrp6
  match access-group name copp-system-p-acl-vrrp6
  match access-group name copp-system-p-acl-mac-lldp
  set cos 6
  police cir 3000 pps , bc 256 packets
  module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-openflow (match-any)
  match access-group name copp-system-p-acl-openflow
  set cos 5
  police cir 2000 pps , bc 32 packets
  module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-multicast-router (match-any)
  match access-group name copp-system-p-acl-pim
  match access-group name copp-system-p-acl-msdp
  match access-group name copp-system-p-acl-pim6
  match access-group name copp-system-p-acl-pim-reg
  match access-group name copp-system-p-acl-pim6-reg
  match access-group name copp-system-p-acl-pim-mdt-join
  set cos 6
  police cir 3000 pps , bc 128 packets
  module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-multicast-host (match-any)
  match access-group name copp-system-p-acl-mld
  set cos 1
  police cir 2000 pps , bc 128 packets
  module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-l3mc-data (match-any)
  match exception multicast rpf-failure
  match exception multicast dest-miss
  set cos 1
  police cir 3000 pps , bc 32 packets

```

```

module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-normal (match-any)
    match access-group name copp-system-p-acl-mac-dot1x
    match protocol arp
    set cos 1
    police cir 1500 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-ndp (match-any)
    match access-group name copp-system-p-acl-ndp
    set cos 6
    police cir 1500 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-normal-dhcp (match-any)
    match access-group name copp-system-p-acl-dhcp
    match access-group name copp-system-p-acl-dhcp6
    set cos 1
    police cir 300 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-normal-dhcp-relay-response (match-any)
    match access-group name copp-system-p-acl-dhcp-relay-response
    match access-group name copp-system-p-acl-dhcp6-relay-response
    set cos 1
    police cir 400 pps , bc 64 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-normal-igmp (match-any)
    match access-group name copp-system-p-acl-igmp
    set cos 3
    police cir 6000 pps , bc 64 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-redirect (match-any)
    match access-group name copp-system-p-acl-ptp
    match access-group name copp-system-p-acl-ptp-12
    match access-group name copp-system-p-acl-ptp-uc
    set cos 1
    police cir 1500 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-exception (match-any)
    match exception ip option
    match exception ip icmp unreachable
    match exception ipv6 option
    match exception ipv6 icmp unreachable
    set cos 1
    police cir 50 pps , bc 32 packets

```

Default CoPP Policy

```

module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-exception-diag (match-any)
    match exception ttl-failure
    match exception mtu-failure
    set cos 1
    police cir 50 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-management (match-any)
    match access-group name copp-system-p-acl-ftp
    match access-group name copp-system-p-acl-ntp
    match access-group name copp-system-p-acl-ssh
    match access-group name copp-system-p-acl-http
    match access-group name copp-system-p-acl-ntp6
    match access-group name copp-system-p-acl-sftp
    match access-group name copp-system-p-acl-snmp
    match access-group name copp-system-p-acl-ssh6
    match access-group name copp-system-p-acl-tftp
    match access-group name copp-system-p-acl-https
    match access-group name copp-system-p-acl-snmp6
    match access-group name copp-system-p-acl-tftp6
    match access-group name copp-system-p-acl-radius
    match access-group name copp-system-p-acl-tacacs
    match access-group name copp-system-p-acl-telnet
    match access-group name copp-system-p-acl-radius6
    match access-group name copp-system-p-acl-tacacs6
    match access-group name copp-system-p-acl-telnet6
    set cos 2
    police cir 3000 pps , bc 512000 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-monitoring (match-any)
    match access-group name copp-system-p-acl-icmp
    match access-group name copp-system-p-acl-icmp6
    match access-group name copp-system-p-acl-traceroute
    set cos 1
    police cir 300 pps , bc 128 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-12-unpoliced (match-any)
    match access-group name copp-system-p-acl-mac-stp
    match access-group name copp-system-p-acl-mac-lacp
    match access-group name copp-system-p-acl-mac-cfsoe
    match access-group name copp-system-p-acl-mac-sdp-srp
    match access-group name copp-system-p-acl-mac-12-tunnel
    match access-group name copp-system-p-acl-mac-cdp-udld-vtp
    set cos 7
    police cir 20000 pps , bc 8192 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-undesirable (match-any)
    match access-group name copp-system-p-acl-undesirable
    match exception multicast sg-rpf-failure

```

```
set cos 0
police cir 15 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-fcoe (match-any)
    match access-group name copp-system-p-acl-mac-fcoe
    set cos 6
    police cir 1500 pps , bc 128 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-nat-flow (match-any)
    match exception nat-flow
    set cos 7
    police cir 100 pps , bc 64 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-13mcv6-data (match-any)
    match exception multicast ipv6-rpf-failure
    match exception multicast ipv6-dest-miss
    set cos 1
    police cir 3000 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-undesirablev6 (match-any)
    match exception multicast ipv6-sg-rpf-failure
    set cos 0
    police cir 15 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map copp-system-p-class-l2-default (match-any)
    match access-group name copp-system-p-acl-mac-undesirable
    set cos 0
    police cir 50 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;

class-map class-default (match-any)
    set cos 0
    police cir 50 pps , bc 32 packets
module 1 :
    transmitted 0 packets;
    dropped 0 packets;
```

Layer 2 CoPP Policy

You cannot modify this policy template, but you can modify the CoPP configuration on the device. After you run the setup utility and set up the Layer 2 CoPP policy profile, all modifications that were made to the CoPP policy will be removed.

This policy has the following configuration:

```
policy-map type control-plane copp-system-policy
    class copp-s-default
        police pps 400
    class copp-s-ping
        police pps 100
    class copp-s-l3destmiss
        police pps 100
    class copp-s-glean
        police pps 500
    class copp-s-l3mtufail
        police pps 100
    class copp-s-ttl1
        police pps 100
    class copp-s-ip-options
        police pps 100
    class copp-s-ip-nat
        police pps 100
    class copp-s-ipmcmiss
        police pps 400
    class copp-s-ipmc-g-hit
        police pps 400
    class copp-s-ipmc-rpf-fail-g
        police pps 400
    class copp-s-ipmc-rpf-fail-sg
        police pps 400
    class copp-s-dhcpreq
        police pps 300
    class copp-s-dhcprep
        police pps 300
    class copp-s-igmp
        police pps 400
    class copp-s-routingProto2
        police pps 1200
    class copp-s-eigrp
        police pps 200
    class copp-s-pimreg
        police pps 200
    class copp-s-pimautorp
        police pps 200
    class copp-s-routingProtocol
        police pps 900
    class copp-s-arp
        police pps 200
    class copp-s-ptp
        police pps 1000
    class copp-s-bpdu
        police pps 12300
    class copp-s-cdp
        police pps 400
    class copp-s-lacp
        police pps 400
    class copp-s-lldp
        police pps 200
    class copp-icmp
        police pps 200
    class copp-telnet
        police pps 500
    class copp-ssh
        police pps 500
    class copp-snmp
        police pps 500
    class copp-ntp
        police pps 100
    class copp-tacacsradius
```

```
police pps 400
class copp-stftp
    police pps 400
class copp-ftp
    police pps 100
class copp-http
    police pps 100
```

Layer 3 CoPP Policy

You cannot modify this policy template, but you can modify the CoPP configuration on the device. After you run the setup utility and set up the Layer 3 CoPP policy profile, all modifications that were made to the CoPP policy will be removed.

This policy has the following configuration:

```
policy-map type control-plane copp-system-policy
    class copp-s-default
        police pps 400
    class copp-s-ping
        police pps 100
    class copp-s-l3destmiss
        police pps 100
    class copp-s-glean
        police pps 500
    class copp-s-l3mtufail
        police pps 100
    class copp-s-ttl1
        police pps 100
    class copp-s-ip-options
        police pps 100
    class copp-s-ip-nat
        police pps 100
    class copp-s-ipmcmiss
        police pps 400
    class copp-s-ipmc-g-hit
        police pps 400
    class copp-s-ipmc-rpf-fail-g
        police pps 400
    class copp-s-ipmc-rpf-fail-sg
        police pps 400
    class copp-s-dhcpreq
        police pps 300
    class copp-s-dhcprep
        police pps 300
    class copp-s-igmp
        police pps 400
    class copp-s-routingProto2
        police pps 4000
    class copp-s-eigrp
        police pps 200
    class copp-s-pimreg
        police pps 200
    class copp-s-pimautorp
        police pps 200
    class copp-s-routingProto1
        police pps 4000
    class copp-s-arp
        police pps 200
    class copp-s-ptp
        police pps 1000
    class copp-s-bpdu
```

Static CoPP Classes

```

police pps 6000
class copp-s-cdp
  police pps 200
class copp-s-lacp
  police pps 200
class copp-s-lldp
  police pps 200
class copp-icmp
  police pps 200
class copp-telnet
  police pps 500
class copp-ssh
  police pps 500
class copp-snmp
  police pps 500
class copp-ntp
  police pps 100
class copp-tacacsradius
  police pps 400
class copp-stftp
  police pps 400
class copp-ftp
  police pps 100
class copp-http
  police pps 100

```

Static CoPP Classes

The following are the available static CoPP classes:

- **copp-s-default**

Catch-all CoPP class for traffic when copy-to-CPU is set for the packet and there is no match in other more specific CoPP classes for the packet.

```

class-map copp-s-default (match-any)
  police pps 400
    OutPackets 0
    DropPackets 0

```

- **copp-s-l2switched**

Catch-all CoPP class for Layer 2 traffic if there is no match in other explicit CoPP classes when CPU port is being selected for the packet.

```

class-map copp-s-l2switched (match-any)
  police pps 200
    OutPackets 0
    DropPackets 0

```

- **copp-s-l3destmiss**

Layer 3 traffic with a miss for the lookup in the hardware Layer 3 forwarding table.

```

class-map copp-s-l3destmiss (match-any)
  police pps 100
    OutPackets 0
    DropPackets 0

```

- **copp-s-glean**

Used in case of Layer 3 traffic to IP address in directly connected subnets with no ARP resolution present for the IP address to trigger ARP resolution in software.

```
class-map copp-s-glean (match-any)
police pps 500
  OutPackets 0
  DropPackets 0
```

- **copp-s-selfip**

Default CoPP class for packets that are coming to one of the router interface's IP addresses if there is no match in other more specific CoPP classes.

```
class-map copp-s-selfIp (match-any)
police pps 500
  OutPackets 4
  DropPackets 0
```

- **copp-s-l3mtufail**

Layer 3 packets with MTU check fail needing software processing for fragmentation or for generating ICMP message.

```
class-map copp-s-l3mtufail (match-any)
police pps 100
  OutPackets 0
  DropPackets 0
```

- **copp-s-ttl1**

Layer 3 packets coming to one of the router's interface IP addresses and with TTL=1.

```
class-map copp-s-ttl1 (match-any)
police pps 100
  OutPackets 0
  DropPackets 0
```

- **copp-s-ipmsmiss**

Multicast packets with lookup miss in hardware Layer 3 forwarding table for multicast forwarding lookup. These data packets can trigger the installation of the hardware forwarding table entries for hardware forwarding of multicast packets.

```
class-map copp-s-ipmcmiss (match-any)
police pps 400
  OutPackets 0
  DropPackets 0
```

- **copp-s-l3slowpath**

Layer 3 packets that are hitting other packet exception cases that need handing in software. For example, IP option packets.

```
class-map copp-s-l3slowpath (match-any)
police pps 100
  OutPackets 0
  DropPackets 0
```

- **copp-s-dhcpreq**

CoPP class for DHCP request packets. By default, this class is only used to program the CoPP rate for this class of packets. Copy to CPU is not enabled till DHCP snooping or relay is configured.

```
class-map copp-s-dhcpreq (match-any)
police pps 300
  OutPackets 0
  DropPackets 0
```

- **copp-s-dai**

CoPP class for ARP inspection intercepted packets. By default, this class is only used to program the CoPP rate for this class of packets. Copy to CPU is not enabled till the IP ARP inspection feature is configured.

```
class-map copp-s-dai (match-any)
police pps 300
OutPackets 0
DropPackets 0
```

• **copp-s-pimautorp**

This CoPP class is used to copy PIM auto-rp packets to the CPU (IP multicast groups 224.0.1.39 and 224.0.1.40)

```
class-map copp-s-pimautorp (match-any)
police pps 200
OutPackets 0
DropPackets 0
```

• **copp-s-arp**

CoPP class for ARP and ND request and reply packets that are being copied to the CPU.

```
class-map copp-s-arp (match-any)
police pps 200
OutPackets 0
DropPackets 0
```

• **copp-s-ptp**

CoPP class for Precision Time Protocol (PTP) packets.

```
class-map copp-s-ptp (match-any)
police pps 1000
OutPackets 0
DropPackets 0
```

• **copp-s-vxlan**

This CoPP class is used when the NV overlay feature is configured and when packets are being copied to the CPU for remote peer IP address learning.

```
class-map copp-s-vxlan (match-any)
police pps 1000
OutPackets 0
DropPackets 0
```

• **copp-s-bfd**

CoPP class for Bidirectional Forwarding Detection (BFD) packets that are being copied to the CPU (Packets with BFD protocol UDP ports, coming to router interface IP address).

```
class-map copp-s-bfd (match-any)
police pps 600
OutPackets 0
DropPackets 0
```

• **copp-s-bpdu**

CoPP class for BPDU class of packets that are being copied to the CPU. This includes STP, CDP, LLDP, LACP, and UDLD packets).

```
class-map copp-s-bpdu (match-any)
police pps 15000
OutPackets 100738
DropPackets 0
```

- **copp-s-dpss**

CoPP class that is used for programmability features, OnePK and Openflow, when the policy is configured with punt-to-CPU action. For example, data path service set, OpenFlow punt-to-controller action.

```
class-map copp-s-dpss (match-any)
police pps 1000
    OutPackets      0
    DropPackets     0
```

- **copp-s-mpls**

Used for the tap aggregation feature for MPLS label strip action. This class is used to copy the packets to the CPU to learn the MPLS label information and program for the label strip action.

```
class-map copp-s-mpls (match-any)
police pps 100
    OutPackets      0
    DropPackets     0
```

CoPP Class Maps

Classes within a policy are of two types:

- Static—These classes are part of every policy template and cannot be removed from the policy or CoPP configuration. Static classes would typically contain the traffic which is deemed critical to device operation and is required in the policy.
- Dynamic—These classes can be created, added or removed from a policy. Using dynamic classes, you can create classes/policing for CPU bound traffic (unicast) specific to their requirements.



Note

Classes with names copp-s-x are static classes.

ACLs can be associated with both static and dynamic classes.

Packets Per Second Credit Limit

The aggregate packets per second (PPS) for a given policy (sum of PPS of each class part of the policy) is capped by an upper PPS Credit Limit (PCL). If an increase in PPS of a given class causes a PCL exceed, the configuration is rejected. To increase the desired PPS, the additional PPS beyond PCL should be decreased from other class(es).

CoPP and the Management Interface

The Cisco NX-OS device supports only hardware-based CoPP which does not support the management interface (mgmt0). The out-of-band mgmt0 interface connects directly to the CPU and does not pass through the in-band traffic hardware where CoPP is implemented.

On the mgmt0 interface, ACLs can be configured to give or deny access to a particular type of traffic.

Licensing Requirements for CoPP

This feature does not require a license. Any feature not included in a license package is bundled with the Cisco NX-OS system images and is provided at no extra charge to you. For a complete explanation of the Cisco NX-OS licensing scheme, see the *Cisco NX-OS Licensing Guide*.

Guidelines and Limitations for CoPP

CoPP has the following configuration guidelines and limitations:

- In releases prior to 7.0(3)I2(1), the PIM-IGMP class-id was always set on the Layer 3 ports even though PIM was not enabled on the port for copp-s-igmp. Therefore, the IGMP packets would come to the CPU even if PIM was not enabled. Starting with Release 7.0(3)I2(1), the PIM_IGMP class-id is set on the port only when PIM is enabled. Since there is no need to punt IGMP packets to the CPU on the Layer 3 ports when PIM is not enabled, you have to configure feature pim and enable PIM on the port to get the packets on the copp-s-igmp queue.
- Cisco recommends that you choose the default, L2, or L3 policy, depending upon your deployment scenario and later modify the CoPP policies based on observed behavior.
- Customizing CoPP is an ongoing process. CoPP must be configured according to the protocols and features used in your specific environment as well as the supervisor features that are required by the server environment. As these protocols and features change, CoPP must be modified.
- The default police packets per second (PPS) value is changed to 900 for **copp-s-bfd** command with **write erase** command and reload for 6.0(2)U6(1) release.
- Cisco recommends that you continuously monitor CoPP. If drops occur, determine if CoPP dropped traffic unintentionally or in response to a malfunction or attack. In either event, analyze the situation and evaluate the need to use a different CoPP policy or modify the customized CoPP policy.
- The Cisco NX-OS software does not support egress CoPP or silent mode. CoPP is supported only on ingress (**service-policy output copp** cannot be applied to the control plane interface).
- The creation of new CoPP policies is not supported.
- When a new CoPP class-map is inserted into the CoPP policy-map with the **insert-before** option, the order of the class-maps is retained in the running-configuration. However, after you run the **write erase** command and reload the switch, the default CoPP policy is applied, and the class-maps are rearranged in the default order. When you copy the file to the running-configuration, it becomes a modify operation for the existing CoPP policy and the new class-maps are inserted at the end. Similarly, if there is change in the order of default class-maps in the file, it will not be effective. To preserve the order of the class-maps, copy the configuration to startup and reload.
- IPv6 and IPv4 CoPP ACL entries use different TCAM regions. For IPv6 CoPP to work, the IPv6 ACL SUP tcam region (ipv6-sup) needs to be carved to a non-zero size. For more information, see the [ACL TCAM Regions, on page 135](#) and [Configuring ACL TCAM Region Sizes, on page 155](#) topics.
- CoPP can have a maximum of 76 entries for all IPv4 CoPP ACLs, IPv6 CoPP ACLs, and ARP ACLs. The system is programmed with 72 static entries (20 internal, 43 IPv4 ACL, and 9 IPv6 ACL entries).

You can configure the remaining 4 entries. If you want to create more entries, you need to delete any unused static CoPP ACEs, and then create your additional entries.

- Starting with Release 6.0(2)U5(1), Cisco Nexus 3000 Series switches drop all the packets when the tunnel is not configured. The packets are also dropped when the tunnel is configured but the tunnel interface is not configured or the tunnel interface is in shut down state.

Point to Point tunnel (Source and Destination) – Cisco Nexus 3000 Series switches decapsulate all IP-in-IP packets destined to it when the command **feature tunnel** is configured and there is an operational tunnel interface configured with the tunnel source and the destination address that matches the incoming packets' outer source and destination addresses. If there is not a source and destination packet match or if the interface is in shutdown state, the packet is dropped.

Decapsulate Tunnel (Source only) - Cisco Nexus 3000 Series switches decapsulate all IP-in-IP packets destined to it when the command **feature tunnel** is configured and there is an operational tunnel interface configured with the tunnel source address that matches the incoming packets' outer destination addresses. If there is not a source packet match or if the interface is in shutdown state, the packet is dropped.

- If you use NXAPI over the front panel port, then you must increase the CoPP policy (for http) to allow 3000 PPS traffic, so that there is no packet drop, and the CLIs with a larger output return within the expected time.

Upgrade Guidelines for CoPP

CoPP has the following upgrade guidelines:

- If you upgrade from a Cisco NX-OS release that does not support the CoPP feature to a release that supports the CoPP feature, CoPP is automatically enabled with the default policy when the switch boots up. You must run the setup script after the upgrade to enable a different policy (default, l3, l2). Not configuring CoPP protection can leave your NX-OS device vulnerable to DoS attacks.
- If you upgrade from a Cisco NX-OS release that supports the CoPP feature to a Cisco NX-OS release that supports the CoPP feature with additional classes for new protocols, you must run the setup utility for the new CoPP classes to be available.
- Because the setup script modifies the policing rates corresponding to different flows coming into the CPU, we recommend that you run the setup script during a scheduled maintenance period and not during a time when there is traffic on the device.

Configuring CoPP

Configuring a Control Plane Class Map

You must configure control plane class maps for control plane policies.

You can classify traffic by matching packets based on existing ACLs. The permit and deny ACL keywords are ignored in the matching.

You can configure policies for IPv4 or IPv6 packets.

Before you begin

Ensure that you have configured the IP ACLs if you want to use ACE hit counters in the class maps.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config) #</pre>	Enters global configuration mode.
Step 2	class-map type control-plane match-any [class-map-name] Example: <pre>switch(config)# class-map type control-plane ClassMapA switch(config-cmap) #</pre>	Specifies a control plane class map and enters class map configuration mode. The default class matching is match-any. The name can be a maximum of 64 characters long and is case sensitive. Note You cannot use class-default, match-all, or match-any as class map names.
Step 3	(Optional) match access-group name [access-list-name] Example: <pre>switch(config-cmap) # match access-group name MyAccessList</pre>	Specifies matching for an IP ACL. You can repeat this step to match more than one IP ACL. Note The permit and deny ACL keywords are ignored in the CoPP matching.
Step 4	exit Example: <pre>switch(config-cmap) # exit switch(config) #</pre>	Exits class map configuration mode.
Step 5	(Optional) show class-map type control-plane [class-map-name] Example: <pre>switch(config) # show class-map type control-plane</pre>	Displays the control plane class map configuration.
Step 6	(Optional) copy running-config startup-config Example: <pre>switch(config) # copy running-config startup-config</pre>	Copies the running configuration to the startup configuration.

Configuring a Control Plane Policy Map

You must configure a policy map for CoPP, which includes policing parameters. If you do not configure a policer for a class, the default policer conform action is drop. The Cisco NX-OS software supports 1-rate 2-color and 2-rate 3-color policing.

You can configure policies for IPv4 or IPv6 packets.

Before you begin

Ensure that you have configured a control plane class map.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config)#</pre>	Enters global configuration mode.
Step 2	policy-map type control-plane <i>policy-map-name</i> Example: <pre>switch(config)# policy-map type control-plane copp-system-policy switch(config-pmap)#</pre>	Specifies a control plane policy map and enters the policy map configuration mode. The policy map name is case sensitive. Note The name of the policy-map cannot be changed. You can only use the copp-system-policy name for the policy-map. The system allows only a single type control-plane policy-map to be configured.
Step 3	police [pps] {pps-value} [bc] burst-size [bytes kbytes mbytes ms packets us] Example: <pre>switch(config-pmap-c)# police pps 100 bc 10</pre>	Specifies the rate limit in terms of packets per second (PPS) and the committed burst (BC). The PPS range is 0 - 20,000. The default PPS is 0. The BC range is from 0 to 512000000. The default BC size unit is bytes.
Step 4	police [cir] {cir-rate [rate-type]} OR police [cir] {cir-rate [rate-type]}[bc] burst-size [burst-size-type] OR police [cir] {cir-rate [rate-type]} conform transmit [violate drop] Example: <pre>switch(config-pmap-c)# police cir 3400 kbps bc 200 kbytes</pre>	You can specify the BC and conform action for the same CIR. The conform action options are as follows: <ul style="list-style-type: none"> • drop—Drops the packet. • transmit—Transmits the packet.
Step 5	exit Example: <pre>switch(config-pmap-c)# exit switch(config-pmap)#</pre>	Exits policy map class configuration mode.

	Command or Action	Purpose
Step 6	exit Example: switch(config-pmap)# exit switch(config)#	Exits policy map configuration mode.
Step 7	(Optional) show policy-map type control-plane [expand] [name class-map-name] Example: switch(config)# show policy-map type control-plane	Displays the control plane policy map configuration.
Step 8	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Copies the running configuration to the startup configuration.

Configuring the Control Plane Service Policy

Before you begin

Configure a control plane policy map.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: switch# configure terminal switch(config) #	Enters global configuration mode.
Step 2	control-plane Example: switch(config) # control-plane switch(config-cp) #	Enters control plane configuration mode.
Step 3	exit Example: switch(config-cp) # exit switch(config) #	Exits control plane configuration mode.
Step 4	(Optional) show running-config copp [all] Example: switch(config)# show running-config copp	Displays the CoPP configuration.

	Command or Action	Purpose
Step 5	(Optional) copy running-config startup-config Example: switch(config)# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

CoPP Show Commands

To display CoPP configuration information, enter one of the following show commands:

Command	Purpose
show ip access-lists [acl-name]	Displays all IPv4 ACLs configured in the system, including the CoPP ACLs.
show class-map type control-plane [class-map-name]	Displays the control plane class map configuration, including the ACLs that are bound to this class map.
show ipv6 access-lists	Displays all of the IPv6 ACLs configured on the device, including the CoPP IPv6 ACLs.
show arp access-lists	Displays all of the ARP ACLs configured on the device, including the CoPP ARP ACLs.
show policy-map type control-plane [expand] [name policy-map-name]	Displays the control plane policy map with associated class maps and PPS values.
show running-config copp [all]	Displays the CoPP configuration in the running configuration.
show running-config aclmgr [all]	Displays the user-configured access control lists (ACLs) in the running configuration. The all option displays both the default (CoPP-configured) and user-configured ACLs in the running configuration.
show startup-config copp [all]	Displays the CoPP configuration in the startup configuration.

Displaying the CoPP Configuration Status

Command	Purpose
show startup-config aclmgr [all]	Displays the user-configured access control lists (ACLs) in the startup configuration. The all option displays both the default (CoPP-configured) and user-configured ACLs in the startup configuration.

Displaying the CoPP Configuration Status

Procedure

	Command or Action	Purpose
Step 1	switch# show copp status	Displays the configuration status for the CoPP feature.

Example

This example shows how to display the CoPP configuration status:

```
switch# show copp status
```

Monitoring CoPP

Procedure

	Command or Action	Purpose
Step 1	switch# show policy-map interface control-plane	Displays packet-level statistics for all classes that are part of the applied CoPP policy. Statistics are specified in terms of OutPackets (packets admitted to the control plane) and DropPackets (packets dropped because of rate limiting).

Example

This example shows how to monitor CoPP:

```
switch# show policy-map interface control-plane
Control Plane

service-policy input: copp-system-policy-default
```

```

class-map copp-system-class-igmp (match-any)
match protocol igmp
police cir 1024 kbps , bc 65535 bytes
conformed 0 bytes; action: transmit
violated 0 bytes;
class-map copp-system-class-pim-hello (match-any)
match protocol pim
police cir 1024 kbps , bc 4800000 bytes
conformed 0 bytes; action: transmit
violated 0 bytes;
...

```

Disabling and Reenabling the Rate Limit on CoPP Classes

To transfer data at speeds higher than what is regulated by CoPP, you can disable the default rate limit on CoPP classes and set the rate to the maximum value allowed on the device. Although the packets are now directed to the CPU at the maximum possible rate, the rate of processing of these packets depends on the CPU capability. After data transfer, you must ensure that you reenable the rate limit on CoPP classes.



Important

Disabling the rate limit on CoPP classes can make the CPU vulnerable to overwhelming traffic.

Before you begin

Ensure that the CPU is protected and that excessive external traffic is not directed at device interfaces, the supervisor module or the CPU.

Procedure

	Command or Action	Purpose
Step 1	configure terminal Example: <pre>switch# configure terminal switch(config)#</pre>	Enters global configuration mode.
Step 2	copp rate-limit disable Example: <pre>switch(config)# copp rate-limit disable</pre>	Disables the default packets per second sent to the CPU and allows the maximum possible packet rate to the CPU on each queue. Important After you run this command, a warning appears to notify you that the CoPP rate-limit is disabled for all classes. Hence, the CPU is vulnerable to traffic attacks. Run the no copp rate-limit disable command as soon as possible.

	Command or Action	Purpose
Step 3	(Optional) show policy-map interface control-plane Example: switch(config)# show policy-map interface control-plane	Displays packet-level statistics for all classes that are part of the applied CoPP policy. Statistics are specified in terms of OutPackets (packets admitted to the control plane) and DropPackets (packets dropped because of rate limiting).
Step 4	no copp rate-limit disable Example: switch(config)# no copp rate-limit disable	Resets the rate limit of the packets sent to the CPU on each queue to the default value.
Step 5	exit Example: switch(config)# exit	Exits global configuration mode.

Clearing the CoPP Statistics

Procedure

	Command or Action	Purpose
Step 1	(Optional) switch# show policy-map interface control-plane	Displays the currently applied CoPP policy and per-class statistics.
Step 2	switch# clear copp statistics	Clears the CoPP statistics.

Example

This example shows how to clear the CoPP statistics for your installation:

```
switch# show policy-map interface control-plane
switch# clear copp statistics
```

CoPP Configuration Examples

Creating an IP ACL

```
ip access-list copp-sample-acl
permit udp any any eq 3333
permit udp any any eq 4444
```

The following example shows how to modify the CoPP Policy to drop all IP-in-IP (Protocol 4) packets immediately if there is not an operational tunnel that matches the incoming packet. Create copp-s-ipinip before the default copp-s-selfip policy as displayed in the following example.

```
ip access-list copp-s-ipinip
10 permit 4 any any
class-map type control-plane match-any copp-s-ipinip
match access-group name copp-s-ipinip
policy-map type control-plane copp-system-policy
class copp-s-ipinip
police pps 0
class copp-s-selfIp
police pps 500
class copp-s-default
police pps 400
```

Creating a Sample CoPP Class with an Associated IP ACL

The following example shows how to create a new CoPP class and associated ACL:

```
class-map type control-plane copp-sample-class
match access-group name copp-sample-acl
```

The following example shows how to add a class to a CoPP policy:

```
policy-map type control-plane copp-system-policy
Class copp-sample-class
Police pps 100
```

The following example shows how to modify the PPS for an existing class (copp-s-bpdu):

```
policy-map type control-plane copp-system-policy
Class copp-s-bpdu
Police pps <new_pps_value>
```

Creating a Dynamic Class (IPv6 ACL)

The following example shows how to create an IPv6 ACL

```
ipv6 access-list copp-system-acl-eigrp6
10 permit 88 any ff02::a/128
```

Associating an ACL with an Existing or New CoPP Class

The following example shows how to associate an ACL with an existing or new CoPP class:

```
class-map type control-plane copp-s-eigrp
match access-grp name copp-system-acl-eigrp6
```

Adding a Class to a CoPP Policy

The following example shows how to add a class to a CoPP policy, if the class has not already been added:

```
policy-map type control-plane copp-system-policy
class copp-s-eigrp
police pps 100
```

Creating an ARP ACL-Based Dynamic Class

ARP ACLs use ARP TCAM. The default size of this TCAM is 0. Before ARP ACLs can be used with CoPP, this TCAM needs to be carved for a non-zero size.

```
hardware profile tcam region arpaci 128
copy running-config startup-config
reload
```

Creating an ARP ACL

```
arp access-list copp-arp-acl
permit ip 20.1.1.1 255.255.255.0 mac any
```

The procedure to associate an ARP ACLs with a class, and adding that class to the CoPP policy, is the same as the procedure for IP ACLs.

Creating a CoPP Class and Associating an ARP ACL

```
class-map type control-plane copp-sample-class
match access-group name copp-arp-acl
```

Removing a Class from a CoPP Policy

```
policy-map type control-plane copp-system-policy
no class-abc
```

Removing a Class from the System

```
no class-map type control-plane copp-abc
```

Using the insert-before option to see if a packet matches multiple classes and the priority needs to be assigned to one of them

```
policy-map type control-plane copp-system-policy
class copp-ping insert-before copp-icmp
```

Sample CoPP Configuration

The following example shows a sample CoPP configuration with ACLs, classes, policies, and individual class policing:

```
IP access list copp-system-acl-eigrp
    10 permit eigrp any 224.0.0.10/32
IP access list copp-system-acl-icmp
    10 permit icmp any any
IP access list copp-system-acl-igmp
    10 permit igmp any any
IP access list copp-system-acl-ntp
    10 permit udp any any eq ntp
    20 permit udp any eq ntp any
```

```
IP access list copp-system-acl-pimreg
    10 permit pim any any
IP access list copp-system-acl-ping
    10 permit icmp any any echo
    20 permit icmp any any echo-reply
IP access list copp-system-acl-routingproto1
    10 permit tcp any gt 1024 any eq bgp
    20 permit udp any eq bgp any gt 1024
    30 permit udp any 224.0.0.0/24 eq rip
    40 permit tcp any gt 1024 any eq 639
    50 permit tcp any eq 639 any gt 1024
    70 permit ospf any any
    80 permit ospf any 224.0.0.5/32
    90 permit ospf any 224.0.0.6/32
IP access list copp-system-acl-routingproto2
    10 permit udp any 224.0.0.0/24 eq 1985
    20 permit 112 any 224.0.0.0/24
IP access list copp-system-acl-snmp
    10 permit udp any any eq snmp
    20 permit udp any any eq snmptrap
IP access list copp-system-acl-ssh
    10 permit tcp any any eq 22
    20 permit tcp any eq 22 any
IP access list copp-system-acl-stftp
    10 permit udp any any eq tftp
    20 permit udp any any eq 1758
    30 permit udp any eq tftp any
    40 permit udp any eq 1758 any
    50 permit tcp any any eq 115
    60 permit tcp any eq 115 any
IP access list copp-system-acl-tacacsradius
    10 permit tcp any any eq tacacs
    20 permit tcp any eq tacacs any
    30 permit udp any any eq 1812
    40 permit udp any any eq 1813
    50 permit udp any any eq 1645
    60 permit udp any any eq 1646
    70 permit udp any eq 1812 any
    80 permit udp any eq 1813 any
    90 permit udp any eq 1645 any
    100 permit udp any eq 1646 any
IP access list copp-system-acl-telnet
    10 permit tcp any any eq telnet
    20 permit tcp any any eq 107
    30 permit tcp any eq telnet any
    40 permit tcp any eq 107 any
IP access list copp-system-dhcp-relay
    10 permit udp any eq bootps any eq bootps
IP access list test
    statistics per-entry
    10 permit ip 1.2.3.4/32 5.6.7.8/32 [match=0]
    20 permit udp 11.22.33.44/32 any [match=0]
    30 deny udp 1.1.1.1/32 any [match=0]

IPv6 access list copp-system-acl-dhcpc6
    10 permit udp any any eq 546
IPv6 access list copp-system-acl-dhcps6
    10 permit udp any ff02::1:2/128 eq 547
    20 permit udp any ff05::1:3/128 eq 547
IPv6 access list copp-system-acl-eigrp6
    10 permit 88 any ff02::a/128
IPv6 access list copp-system-acl-v6routingProto2
    10 permit udp any ff02::66/128 eq 2029
    20 permit udp any ff02::fb/128 eq 5353
```

Sample CoPP Configuration

```

IPv6 access list copp-system-acl-v6routingproto1
  10 permit 89 any ff02::5/128
  20 permit 89 any ff02::6/128
  30 permit udp any ff02::9/128 eq 521

class-map type control-plane match-any copp-icmp
  match access-group name copp-system-acl-icmp
class-map type control-plane match-any copp-ntp
  match access-group name copp-system-acl-ntp
class-map type control-plane match-any copp-s-arp
class-map type control-plane match-any copp-s-bfd
class-map type control-plane match-any copp-s-bpdu
class-map type control-plane match-any copp-s-dai
class-map type control-plane match-any copp-s-default
class-map type control-plane match-any copp-s-dhcpreq
  match access-group name copp-system-acl-dhcps6
class-map type control-plane match-any copp-s-dhcprep
  match access-group name copp-system-acl-dhcp6
  match access-group name copp-system-dhcp-relay
class-map type control-plane match-any copp-s-eigrp
  match access-group name copp-system-acl-eigrp
  match access-group name copp-system-acl-eigrp6
class-map type control-plane match-any copp-s-glean
class-map type control-plane match-any copp-s-igmp
  match access-group name copp-system-acl-igmp
class-map type control-plane match-any copp-s-ipmcmiss
class-map type control-plane match-any copp-s-l2switched
class-map type control-plane match-any copp-s-l3destmiss
class-map type control-plane match-any copp-s-l3mtufail
class-map type control-plane match-any copp-s-l3slowpath
class-map type control-plane match-any copp-s-pimautorp
class-map type control-plane match-any copp-s-pimreg
  match access-group name copp-system-acl-pimreg
class-map type control-plane match-any copp-s-ping
  match access-group name copp-system-acl-ping
class-map type control-plane match-any copp-s-ptp
class-map type control-plane match-any copp-s-routingProto1
  match access-group name copp-system-acl-routingproto1
  match access-group name copp-system-acl-v6routingproto1
class-map type control-plane match-any copp-s-routingProto2
  match access-group name copp-system-acl-routingproto2
class-map type control-plane match-any copp-s-selfIp
class-map type control-plane match-any copp-s-ttl1
class-map type control-plane match-any copp-s-v6routingProto2
  match access-group name copp-system-acl-v6routingProto2
class-map type control-plane match-any copp-snmp
  match access-group name copp-system-acl-snmp
class-map type control-plane match-any copp-ssh
  match access-group name copp-system-acl-ssh
class-map type control-plane match-any copp-stftp
  match access-group name copp-system-acl-stftp
class-map type control-plane match-any copp-tacacsradius
  match access-group name copp-system-acl-tacacsradius
class-map type control-plane match-any copp-telnet
  match access-group name copp-system-acl-telnet
policy-map type control-plane copp-system-policy
  class copp-s-selfIp
    police pps 500
  class copp-s-default
    police pps 400
  class copp-s-l2switched
    police pps 200
  class copp-s-ping
    police pps 100

```

```
class copp-s-l3destmiss
    police pps 100
class copp-s-glean
    police pps 500
class copp-s-l3mtufail
    police pps 100
class copp-s-ttl1
    police pps 100
class copp-s-ipmcmiss
    police pps 400
class copp-s-l3slowpath
    police pps 100
class copp-s-dhcpreq
    police pps 300
class copp-s-dhcprep
    police pps 300
class copp-s-dai
    police pps 300
class copp-s-igmp
    police pps 400
class copp-s-routingProto2
    police pps 1300
class copp-s-v6routingProto2
    police pps 1300
class copp-s-eigrp
    police pps 200
class copp-s-pimreg
    police pps 200
class copp-s-pimaautorp
    police pps 200
class copp-s-routingProto1
    police pps 1000
class copp-s-arp
    police pps 200
class copp-s-ptp
    police pps 1000
class copp-s-bfd
    police pps 350
class copp-s-bpdu
    police pps 12000
class copp-icmp
    police pps 200
class copp-telnet
    police pps 500
class copp-ssh
    police pps 500
class copp-snmp
    police pps 500
class copp-ntp
    police pps 100
class copp-tacacsradius
    police pps 400
class copp-stftp
    police pps 400
control-plane
    service-policy input copp-system-policy
```

Example: Changing or Reapplying the Default CoPP Policy Using the Setup Utility

Example: Changing or Reapplying the Default CoPP Policy Using the Setup Utility

The following example shows how to change or reapply the default CoPP policy using the setup utility:

```
switch# setup

----- Basic System Configuration Dialog -----

This setup utility will guide you through the basic configuration of
the system. Setup configures only enough connectivity for management
of the system.

*Note: setup is mainly used for configuring the system initially,
when no configuration is present. So setup always assumes system
defaults and not the current system configuration values.

Press Enter at anytime to skip a dialog. Use ctrl-c at anytime
to skip the remaining dialogs.

Would you like to enter the basic configuration dialog (yes/no): yes

Create another login account (yes/no) [n]: n

Configure read-only SNMP community string (yes/no) [n]: n

Configure read-write SNMP community string (yes/no) [n]: n

Enter the switch name : switch

Continue with Out-of-band (mgmt0) management configuration? (yes/no) [y]: n

Configure the default gateway for mgmt? (yes/no) [y]: n

Enable the telnet service? (yes/no) [n]: y

Enable the ssh service? (yes/no) [y]: n

Configure the ntp server? (yes/no) [n]: n

Configure CoPP System Policy Profile ( default / 12 / 13 ) [default]: 12

The following configuration will be applied:
  switchname switch
  telnet server enable
  no ssh server enable
  policy-map type control-plane copp-system-policy ( 12 )

Would you like to edit the configuration? (yes/no) [n]: n

Use this configuration and save it? (yes/no) [y]: y

[ ##### ] 100%
```

Preventing CoPP Overflow by Splitting ICMP Pings

**Note**

This section applies only to Cisco Nexus 3000 Series switches and Cisco Nexus 3100 Series switches in N3K mode.

Some servers use ICMP pings to the default gateway to verify that the active NIC still has access to the aggregation switch. As a result, if the CoPP values are exceeded, CoPP starts dropping traffic for all networks. One malfunctioning server can send out thousands of ICMP pings, causing all servers in one aggregation block to lose their active NIC and start swapping NICs.

If your server is configured as such, you can minimize the CoPP overflow by splitting the ICMP pings based on subnets or groups of subnets. Then if a server malfunctions and overflows CoPP, the supervisor answers the ICMP pings only on some subnetworks.

The last entry in the class map or policy map should identify all of the ICMP pings in the networks that are not specified. If these counters increase, it means that a new network was added that was not specified in the existing ACLs for ICMP. In this case, you would need to update the ACLs related to ICMP.

**Note**

Per the default CoPP, ICMP pings fall under copp-system-p-class-monitoring.

The following example shows how to prevent CoPP overflow by splitting ICMP pings.

First, add the new ACLs that identify the networks you want to group together based on the findings of the investigations of the applications:

```
ip access-list copp-icmp-1
statistics per-entry
10 permit icmp 10.2.1.0 255.255.255.0 any
20 permit icmp 10.2.2.0 255.255.255.0 any
30 permit icmp 10.2.3.0 255.255.255.0 any
ip access-list copp-icmp-2
statistics per-entry
10 permit icmp 10.3.1.0 255.255.255.0 any
10 permit icmp 10.3.2.0 255.255.255.0 any
10 permit icmp 10.3.3.0 255.255.255.0 any
ip access-list copp-icmp-3
statistics per-entry
10 permit icmp 10.4.1.0 255.255.255.0 any
10 permit icmp 10.4.2.0 255.255.255.0 any
10 permit icmp 10.4.3.0 255.255.255.0 any
...
ip access-list copp-icmp-10
10 permit icmp any any
```

Add these ACLs to the new class maps for CoPP:

```
class-map type control-plane match-any copp-cm-icmp-1
match access-group name copp-icmp-1
class-map type control-plane match-any copp-cm-icmp-2
match access-group name copp-icmp-2
class-map type control-plane match-any copp-cm-icmp-3
match access-group name copp-icmp-3
...
```

Additional References for CoPP

```
class-map type control-plane match-any copp-cm-icmp-10
match access-group name copp-icmp-10
```

Modify the CoPP policy map by adding new policies with the above created class maps:

```
policy-map type control-plane copp-system-p-policy
class copp-cm-icmp-1
    police cir X pps bc X conform transmit violate drop
class copp-cm-icmp-2
    police cir X pps bc X conform transmit violate drop
class copp-cm-icmp-3
    police cir X pps bc X conform transmit violate drop
class copp-cm-icmp-4
    police cir X pps bc X conform transmit violate drop
class copp-cm-icmp-10
    police cir X pps bc X conform transmit violate drop
    police cir X pps bc X conform transmit violate drop
```

Delete ICMP from the existing class maps:

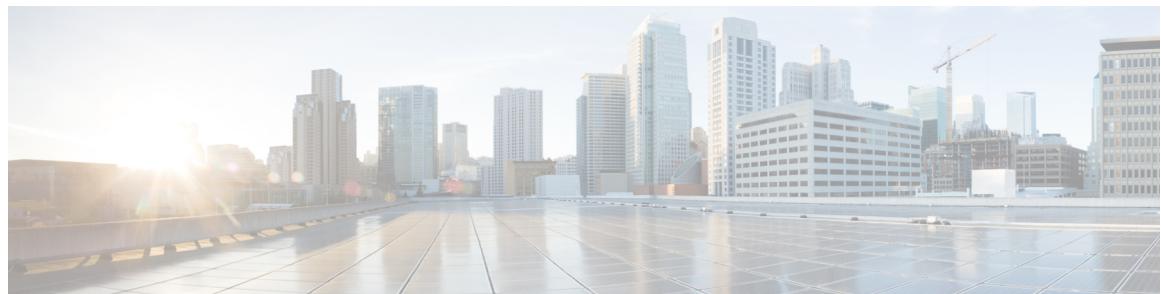
```
class-map type control-plane match-any copp-system-p-class-monitoring
no match access-grp name copp-system-p-acl-icmp
```

Additional References for CoPP

This section provides additional information related to implementing CoPP.

Related Documents

Related Topic	Document Title
Licensing	<i>Cisco NX-OS Licensing Guide</i>
Command reference	



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