Cisco Nexus 5000 Series NX-OS Security Configuration Guide, Release 5.0(3)N1(1)

CONTENTS

Preface

This preface describes the audience, organization, and conventions of the *Cisco Nexus 5000 Series NX-OS Security Configuration Guide*. It also provides information on how to obtain related documentation.

Audience

This publication is for experienced network administrators who configure and maintain Cisco NX-OS software.

Document Organization

This document is organized into the following chapters:

Chapter	Description
New and Changed Information	Describes the new and changed information for the new Cisco NX-OS software software releases.
Overview	Describes the security features supported by the Cisco NX-OS software.
Configuring AAA	Describes how to configure authentication, authorization, and accounting (AAA) features.
Configuring RADIUS	Describes how to configure the RADIUS security protocol.
Configuring TACACS+	Describes how to configure the TACACS+ security protocol.
Configuring SSH and Telnet	Describes how to configure Secure Shell (SSH) and Telnet.

Chapter	Description
Configuring IP ACLs	Describes how to configure IP access control lists.
Configuring DHCP Snooping	Describes how to configure DHCP snooping.

Document Conventions

This document uses the following conventions:

Note Means *reader take note*. Notes contain helpful suggestions or references to material not covered in the manual.

Caution Means *reader be careful*. In this situation, you might do something that could result in equipment damage or loss of data.

Related Documentation for Nexus 5000 Series NX-OS Software

Cisco NX-OS documentation is available at the following URL:

http://www.cisco.com/en/US/products/ps9670/tsd_products_support_series_home.htmll

The documentation set for the Cisco Nexus 5000 Series NX-OS software includes the following documents:

Release Notes

- *Cisco Nexus 5000 Series and Cisco Nexus 2000 Series Release Notes*
- *Cisco Nexus 5000 Series Switch Release Notes*

Configuration Guides

- *Cisco Nexus 5000 Series NX-OS Configuration Limits for Cisco NX-OS Release 5.0(2)N1(1)*
- *Cisco Nexus 5000 Series NX-OS Configuration Limits for Cisco NX-OS Release 4.2(1)N1(1) and Release 4.2(1)N2(1)*
- *Cisco Nexus 5000 Series NX-OS Multicast Configuration Guide*
- *Cisco Nexus 5000 Series NX-OS Unicast Configuration Guide*
- *Cisco Nexus 5000 Series NX-OS Fibre Channel over Ethernet Configuration Guide*
- *Cisco Nexus 5000 Series NX-OS Layer 2 Switching Configuration Guide*
- *Cisco Nexus 5000 Series NX-OS Quality of Service Configuration Guide*

- *Cisco Nexus 5000 Series NX-OS SAN Switching Configuration Guide*
- *Cisco Nexus 5000 Series NX-OS Security Configuration Guide*
- *Cisco Nexus 5000 Series NX-OS System Management Configuration Guide*
- *Cisco Nexus 5000 Series Switch NX-OS Software Configuration Guide*
- *Cisco Nexus 5000 Series Fabric Manager Configuration Guide, Release 3.4(1a)*
- *Cisco Nexus 2000 Series Fabric Extender NX-OS Release 4.2(1) Configuration Guide*

Maintain and Operate Guide

- *Cisco Nexus 5000 Series Operations Guide*

Installation and Upgrade Guides

- *Cisco Nexus 5000 Series and Cisco Nexus 5500 Platform Hardware Installation Guide*
- *Cisco Nexus 5000 Series NX-OS Software Upgrade and Downgrade Guide, Release 4.2(1)N1(1)*
- *Regulatory Compliance and Safety Information for the Cisco Nexus 5000 Series Switches and Cisco Nexus 2000 Series Fabric Extenders*

Licensing Guide

- *Cisco NX-OS Licensing Guide*

Command References

- *Cisco Nexus 5000 Series Command Reference*

Technical References

- *Cisco Nexus 5000 Series and Cisco Nexus 2000 Series Fabric Extender MIBs Reference*

Error and System Messages

- *Cisco NX-OS System Messages Reference*

Troubleshooting Guide

- *Cisco Nexus 5000 Series Troubleshooting Guide*

Obtaining Documentation and Submitting a Service Request

For information on obtaining documentation, submitting a service request, and gathering additional information, see the monthly *What's New in Cisco Product Documentation*, which also lists all new and revised Cisco technical documentation, at:

http://www.cisco.com/en/US/docs/general/whatsnew/whatsnew.html

Subscribe to the *What's New in Cisco Product Documentation* as a Really Simple Syndication (RSS) feed and set content to be delivered directly to your desktop using a reader application. The RSS feeds are a free service and Cisco currently supports RSS version 2.0.

CHAPTER 1

New and Changed Information

This chapter provides release-specific information for each new and changed feature in the *Cisco Nexus 5000 Series NX-OS Security Configuration Guide*.

New and Changed Information

This chapter provides release-specific information for each new and changed feature in the *Cisco Nexus 5000 Series NX-OS Security Configuration Guide*.

The latest version of this document is available at the following Cisco website:

http://www.cisco.com/en/US/products/ps9670/products_installation_and_configuration_guides_list.html

To check for the latest information about Cisco NX-OS for the Cisco Nexus 5000 Series switch, see the *Cisco Nexus 5000 Series and Nexus 2000 Series NX-OS Release Notes* available at the following Cisco website:

http://www.cisco.com/en/US/products/ps9670/prod_release_notes_list.html

This table summarizes the new and changed features documented in the *Cisco Nexus 5000 Series NX-OS Security Configuration Guide, Release 5.0(3)N1(1)*, and tells you where they are documented.

Table 1: New and Changed Security Features for Cisco NX-OS Release 5.0(3)N1(1)

Feature	Description	Changed in Release	Where Documented
Dynamic ARP Inspection	Added information to configure Dynamic ARP Inspections.	5.0(3)N1(1)	Configuring Dynamic ARP Inspection
IP Source Guard	Added information to configure IP Source Guard.	5.0(3)N1(1)	Configuring IP Source Guard

This table summarizes the new and changed features documented in the *Cisco Nexus 5000 Series NX-OS Security Configuration Guide, Release 5.0(2)N2(1)*, and tells you where they are documented.

Table 2: New and Changed Security Features for Cisco NX-OS Release 5.0(2)N2(1)

Feature	Description	Changed in Release	Where Documented
DHCP Snooping with Option 82	Added information about the support for optimized DHCP snooping in a vPC environment.	5.0(2)N2(1)	Configuring DHCP Snooping

This table summarizes the new and changed features documented in the *Cisco Nexus 5000 Series NX-OS Security Configuration Guide, Release 5.0(2)N1(1)*, and tells you where they are documented.

Table 3: New and Changed Security Features for Cisco NX-OS Release 5.0(2)N1(1)

Feature	Description	Changed in Release	Where Documented
Command Authorization Support for TACACS+ Servers	Allows you to verify authorized commands for authenticated users using TACACS+	5.0(2)N1(1)	Configuring TACACS+
ACLs on VTY lines	Allows you to restrict incoming and outgoing connections between a VTY line (into a Cisco Nexus 5000 Series switch) and the addresses in an access list,	5.0(2)N1(1)	Configuring Access Control Lists

This table summarizes the new and changed features documented in the *Cisco Nexus 5000 Series NX-OS Security Configuration Guide*, and tells you where they are documented.

Table 4: New and Changed Security Features for Cisco NX-OS Release 4.2(1)N1(1)

Feature	Description	Changed in Release	Where Documented
AAA Command Authorization	Allows you to authorize every command that a user can execute.	4.2(1)N1(1)	Configuring AAA

This table summarizes the new and changed features documented in the *Cisco Nexus 5000 Series NX-OS Security Configuration Guide*, and tells you where they are documented.

Table 5: New and Changed Security Features for Cisco NX-OS Release 4.1(3)N2(1)

Feature	Description	Changed in Release	Where Documented
IP ACL to mgmt0	Allows you to apply an IP ACL to the mgmt0 interface.	4.1(3)N2(1)	Configuring Access Control Lists

Feature	Description	Changed in Release	Where Documented
Global source interface for TACACS+	Allows you to configure the global source interface for all TACACS+ server groups that are configured on the device.	4.1(3)N2(1)	Configuring TACACS+
Global source interface for RADIUS	Allows you to configure the global source interface for all RADUS server groups that are configured on the device.	4.1(3)N2(1)	Configuring RADIUS

Documentation Organization

As of Cisco NX-OS Release 4.1(3)N2(1), the Nexus 5000 Series configuration information is available in new feature-specific configuration guides for the following information:

- System Management
- Layer 2 Switching
- SAN Switching
- Fibre Channel over Ethernet
- Security
- Quality of Service

The information in these new guides previously existed in the *Cisco Nexus 5000 Series CLI Configuration Guide* which remains available on Cisco.com and should be used for all software releases prior to Cisco Nexus 5000 NX-OS Software Rel 4.1(3). Each new configuration guide addresses the features that are introduced in or are available in a particular release. Select and view the configuration guide that pertains to the software installed in your switch.

The information in the new *Cisco Nexus 5000 Series NX-OS Security Configuration Guide* previously existed in Part 3: Switch Security Features of the *Cisco Nexus 5000 Series CLI Configuration Guide*.

For a complete list of Nexus 5000 Series document titles, see the list of Related Documentation in the "Preface."

New and Changed Information

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

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, page ?

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, page ?
- Configuring TACACS+, page 43

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, page 71

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, page ?

CHAPTER 3

Configuring Authentication, Authorization, and Accounting

This chapter describes how to configure authentication, authorization, and accounting (AAA) on Cisco Nexus 5000 Series switches. It contains the following sections:

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 managing Cisco Nexus 5000 Series switches. The Cisco Nexus 5000 Series switches support Remote Access Dial-In User Service (RADIUS) or Terminal Access Controller Access Control device Plus (TACACS+) protocols.

Based on the user ID and password combination that you provide, the Cisco Nexus 5000 Series 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.

  Authentication is the process of verifying the identity of the person or device accessing the Cisco Nexus 5000 Series switches. This process is based on the user ID and password combination provided by the entity trying to access the switch. The Cisco Nexus 5000 Series switches allow you to perform local authentication (using the local lookup database) or remote authentication (using one or more RADIUS or TACACS+ servers).

- Authorization—Provides access control.

  AAA authorization is the process of assembling a set of attributes that describe what the user is authorized to perform. Authorization in Cisco Nexus 5000 Series switches 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.

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

  The accounting feature tracks and maintains a log of every management session used to access the Cisco Nexus 5000 Series switches. You can use this information to generate reports for troubleshooting and auditing purposes. You can store accounting logs locally or send them to remote AAA servers.

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 Cisco Nexus 5000 Series 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 than using the local databases on the switches are easier to manage.

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. The purpose of a server group is to provide for failover servers in case 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, then that server group option is considered a failure. If required, you can specify multiple server groups. If a Cisco Nexus 5000 Series 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 5000 Series switches, 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 6: 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 user name.

Note If the method is for all RADIUS servers, instead of a specific server group, the Nexus 5000 Series switches 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 Nexus 5000 Series switches.

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

Table 7: 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 5000 Series switches 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 Login

The figure below shows a flowchart of the authentication and authorization process for user login. The following process occurs:

- When you log in to the required Cisco Nexus 5000 Series switch, 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 5000 Series switch 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, then the servers in the next server group are tried.

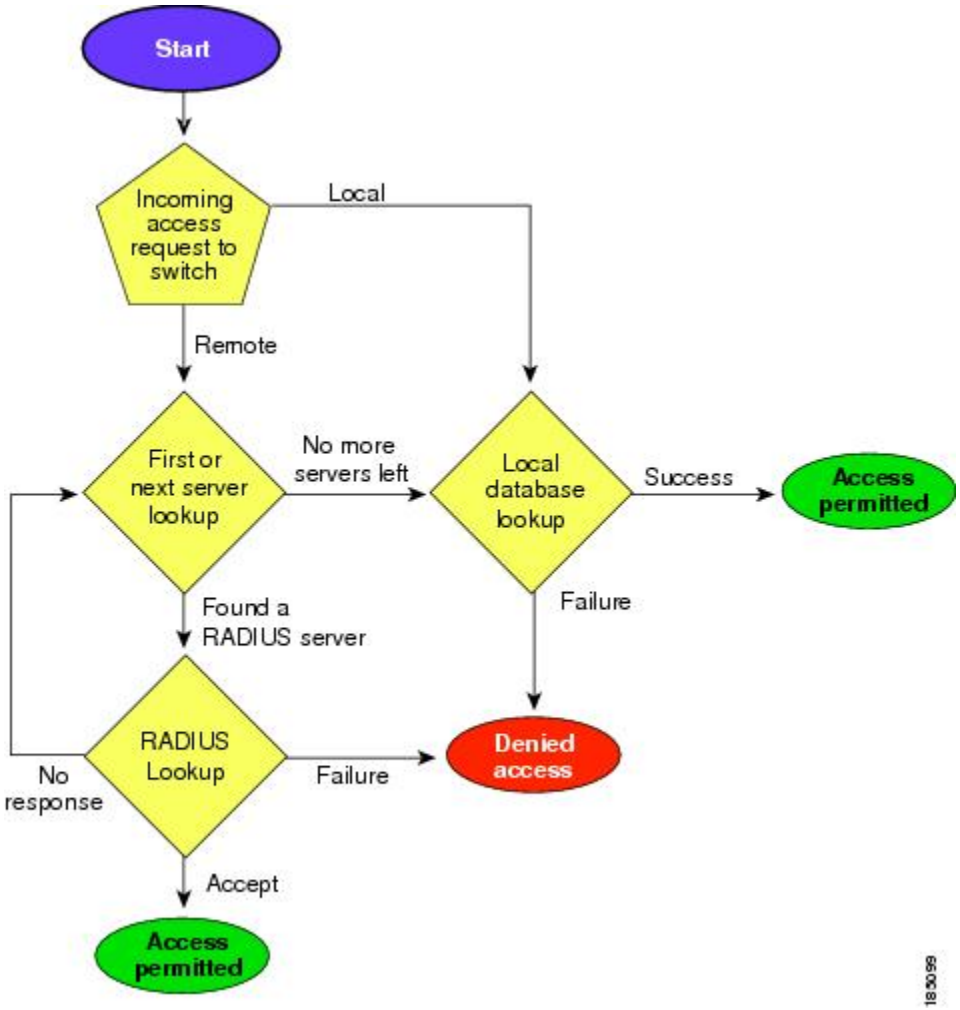
  If all configured methods fail, then the local database is used for authentication.
- If the Cisco Nexus 5000 Series switches successfully authenticate you through a remote AAA server, then the following possibilities apply:

  If the AAA server protocol is RADIUS, then user roles specified in the cisco-av-pair attribute are downloaded with an authentication response.

  If the AAA server protocol is TACACS+, then 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 5000 Series switch logs you in and assigns you the roles configured in the local database.

Figure 1: Authorization and Authentication Flow for User Login



Note "No more server groups left" means that there is no response from any server in all server groups.

"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 5000 Series switch is configured as a client of the AAA servers.

- The preshared secret key is configured on the Cisco Nexus 5000 Series switch and on the remote AAA servers.
- The remote server responds to AAA requests from the Cisco Nexus 5000 Series switch.

Information about AAA Guidelines and Limitations

The Cisco Nexus 5000 Series switches 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 login, the Cisco Nexus 5000 Series switch will still log in the user.

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

Configuring AAA

Configuring Console Login Authentication Methods

This section describes how to configure the authentication methods for the console login.

The authentication methods include the following:

- Global pool of RADIUS servers
- Named subset of RADIUS or TACACS+ servers
- Local database on the Nexus 5000 Series switch
- 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. To configure console login authentication methods, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **aaa authentication login console** {**group** *group-list* [**none**] | **local** | **none**}
3. switch(config)# **exit**
4. (Optional) switch# **show aaa authentication**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **aaa authentication login console** {**group** *group-list* [**none**] | **local** | **none**}	Configures login authentication methods for the console. The *group-list* argument consists of a space-delimited list of group names. The group names are the following: • **radius** —Uses the global pool of RADIUS servers for authentication. • *named-group* —Uses a named subset of TACACS+ or RADIUS servers for authentication. The **local** method uses the local database for authentication. The **none** method uses the username only. 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.
Step 3	switch(config)# **exit**	Exits configuration mode.
Step 4	switch# **show aaa authentication**	(Optional) Displays the configuration of the console login authentication methods.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following 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 authentication methods include the following:

- Global pool of RADIUS servers
- Named subset of RADIUS or TACACS+ servers
- Local database on the Nexus 5000 Series switch
- Username only

The default method is local.

Before you configure default login authentication methods, configure RADIUS or TACACS+ server groups as needed. To configure default login authentication methods, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **aaa authentication login default** {**group** *group-list* [**none**] | **local** | **none**}
3. switch(config)# **exit**
4. (Optional) switch# **show aaa authentication**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

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

To enable login authentication failure messages, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **aaa authentication login error-enable**
3. switch(config)# **exit**
4. (Optional) switch# **show aaa authentication**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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.
Step 4	switch# **show aaa authentication**	(Optional) Displays the login failure message configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) 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.

SUMMARY STEPS

1. **configure terminal**
2. **aaa authorization** {**commands** | **config-commands**} {**default**} {{[**group** *group-name*] | [**local**]} | {[**group** *group-name*] | [**none**]}}

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**aaa authorization** {**commands**	**config-commands**} {**default**} {{[**group** *group-name*]	[**local**]}	{[**group** *group-name*]	[**none**]}}
					
					Example:
					`switch(config)# aaa authorization config-commands default group tac1`
					
					Example:
					`switch# aaa authorization commands default group tac1`
						Configures authorization parameters.
						Use the**commands** keyword to authorize EXEC mode commandes.
						Use the **config-commands** keyword to authorize configuration mode commands.
						Use the **group**, **local**, or **none** keywords to identify the authorization method.

The following shows EXEC and configuration mode examples.

This example shows how to authorize EXEC mode commands with TACACS+ server group *tac1*

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

This example shows how to authorize configuration mode commands with TACACS+ server group *tac1*

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

This 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
```

This 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
```

This example shows how to authorize EXEC mode commands regardless of the local role

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

This example shows how to authorize EXEC mode commands using the local role for authorization.

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

Table 8: Related Commands

Command	Descriptions
aaa server group	Configures AAA server groups.
feature tacacs+	Enables TACACS+.
tacacs-server host	Configures a TACACS+ server.

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 5000 Series switch through a remote authentication server (RADIUS or TACACS+).

By default, the Cisco Nexus 5000 Series switch uses Password Authentication Protocol (PAP) authentication between the switch and the remote server. If you enable MSCHAP, you need to configure your RADIUS server to recognize the MSCHAP vendor-specific attributes (VSAs).

The following table describes the RADIUS VSAs required for MSCHAP.

Table 9: 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.

To enable MSCHAP authentication, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **aaa authentication login mschap enable**
3. switch(config)# **exit**
4. (Optional) switch# **show aaa authentication login mschap**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch# **show aaa authentication login mschap**	(Optional) Displays the MS-CHAP configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Related Topics

- About VSAs, page 21

Configuring AAA Accounting Default Methods

The Cisco Nexus 5000 Series switch 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 5000 Series switch 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 configure AAA accounting default methods, configure RADIUS or TACACS+ server groups as needed.

To configure AAA accounting default methods, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **aaa accounting default** {**group** *group-list* | **local**}
3. switch(config)# **exit**
4. (Optional) switch# **show aaa accounting**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **aaa accounting default** {**group** *group-list* | **local**}	Configures default accounting method. One or more server group names can be specified in a space separated list. The *group-list* argument consists of a space-delimited list of group names. The group names are of the following: • **radius** —Uses the global pool of RADIUS servers for accounting. • *named-group* —Uses a named subset of TACACS+ or RADIUS servers for accounting. The **local** method uses the local database for accounting. The default method is **local** , which is used when no server groups are configured or when all the configured server group do not respond.
Step 3	switch(config)# **exit**	Exits configuration mode.
Step 4	switch# **show aaa accounting**	(Optional) Displays the configuration AAA accounting default methods.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Using AAA Server VSAs

About VSAs

You can use vendor-specific attributes (VSAs) to specify the Cisco Nexus 5000 Series 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 seperator 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 Nexus 5000 Series switch, the RADIUS protocol directs the RADIUS server to return user attributes, such as authorization information, along with authentication results. This authorization information is specified through VSAs.

VSA Format

The following VSA protocol options are supported by the Cisco Nexus 5000 Series switches:

- 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 5000 Series switches:

- 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 SMNPv3 Parameters on AAA Servers

You can use the VSA cisco-av-pair on AAA servers to specify user role mapping for the Cisco Nexus 5000 Series switch 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.

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 *Cisco Nexus 5000 Series NX-OS System Management Configuration Guide*.

Displaying and Clearing the Local AAA Accounting Log

The Cisco Nexus 5000 Series switch maintains a local log for the AAA accounting activity. To display this log and clear it, perform this task:

SUMMARY STEPS

1. switch# **show accounting log** [*size*] [**start-time** *year month day hh* **:** *mm* **:** *ss*]
2. (Optional) switch# **clear accounting log**

DETAILED STEPS

	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	switch# **clear accounting log**	(Optional) Clears the accounting log contents.

Verifying AAA Configuration

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

SUMMARY STEPS

1. **show aaa accounting**
2. **show aaa authentication** [**login** {**error-enable** | **mschap**}]
3. **show aaa authorization**
4. **show aaa groups**
5. **show running-config aaa** [**all**]
6. **show startup-config aaa**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**show aaa accounting**	Displays AAA accounting configuration.
Step 2	**show aaa authentication** [**login** {**error-enable** | **mschap**}]	Displays AAA authentication information.
Step 3	**show aaa authorization**	Displays AAA authorization information.

	Command or Action	Purpose
Step 4	**show aaa groups**	Displays the AAA server group configuration.
Step 5	**show running-config aaa** [**all**]	Displays the AAA configuration in the running configuration.
Step 6	**show startup-config aaa**	Displays the AAA configuration in the startup configuration.

Example AAA Configuration

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 10: 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:

Configuring RADIUS

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 5000 Series switches 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 Nexus 5000 Series switch with RADIUS to the network. This action might be the first step when you make a transition to a AAA server.

- Networks that require resource accounting.

  You can use RADIUS accounting independent of RADIUS authentication or authorization. The RADIUS accounting functions allow data to be sent at the start and end of services, indicating the amount of resources (such as time, packets, bytes, and so on) used during the session. An Internet service provider (ISP) might use a freeware-based version of 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 Nexus 5000 Series switch to better manage ports using their existing RADIUS solutions and to efficiently manage shared resources to offer different service-level agreements.

RADIUS Operation

When a user attempts to log in and authenticate to a Cisco Nexus 5000 Series switch 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:

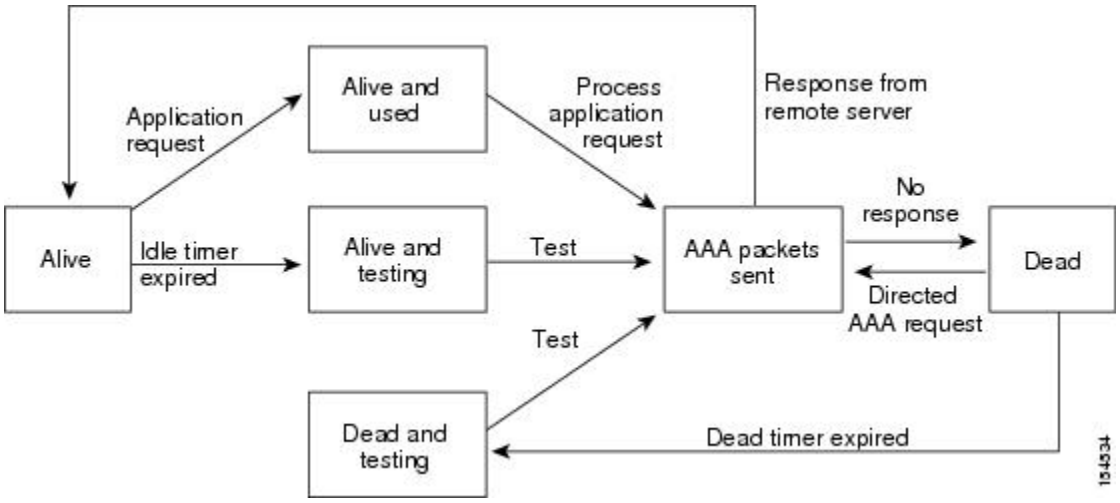
- Services that the user can access, including Telnet, rlogin, or local-area transport (LAT) connections, and Point-to-Point Protocol (PPP), Serial Line Internet Protocol (SLIP), or EXEC services.
- Connection parameters, including the host or client IPv4 or IPv6 address, access list, and user timeouts.

RADIUS Server Monitoring

An unresponsive RADIUS server can cause delay in processing of AAA requests. You can configure the Cisco Nexus 5000 Series switch to periodically monitor a RADIUS server to check whether it is responding (or alive) to save time in processing AAA requests. The Cisco Nexus 5000 Series 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 monitoring process verifies that a RADIUS server is in a working state before real AAA requests are sent its way. Whenever

a RADIUS server changes to the dead or alive state, a Simple Network Management Protocol (SNMP) trap is generated and the Cisco Nexus 5000 Series switch displays an error message that a failure is taking place.

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 5000 Series switch, the RADIUS protocol directs the RADIUS server to return user attributes, such as authorization information, along with authentication results. This authorization information is specified through VSAs.

The following VSA protocol options are supported by the Cisco Nexus 5000 Series switch:

- 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 Nexus 5000 Series switch 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 space.
- 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:

- Obtain IPv4 or IPv6 addresses or host names for the RADIUS servers.
- Obtain preshared keys from the RADIUS servers.
- Ensure that the Cisco Nexus 5000 Series switch is configured as a RADIUS client of the AAA servers.

Guidelines and Limitations for RADIUS

RADIUS has the following guidelines and limitations:

- You can configure a maximum of 64 RADIUS servers on the Cisco Nexus 5000 Series switch.

Configuring RADIUS Servers

To configure RADIUS servers, perform this task:

SUMMARY STEPS

1. Establish the RADIUS server connections to the Cisco Nexus 5000 Series switch.
2. Configure the preshared secret keys for the RADIUS servers.
3. If needed, configure RADIUS server groups with subsets of the RADIUS servers for AAA authentication methods.
4. If needed, configure any of the following optional parameters:
5. If needed, configure periodic RADIUS server monitoring.

DETAILED STEPS

Step 1 Establish the RADIUS server connections to the Cisco Nexus 5000 Series switch.

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 host name 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.

To configure a RADIUS server host, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config) #**radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*}
3. switch(config)# **exit**
4. (Optional) switch# **show radius-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch# **show radius-server**	(Optional) Displays the RADIUS server configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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

```
switch# configure terminal
switch(config)# radius-server host 10.10.1.1
switch(config)# exit
switch# show radius-server
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 5000 Series switch. A preshared key is a shared secret text string between the switch and the RADIUS server hosts.

To configure global preshared keys, obtain the preshared key values for the remote RADIUS servers and perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **radius-server key** [**0** | **7**] *key-value*
3. switch(config)# **exit**
4. (Optional) switch# **show radius-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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. The maximum length is 63 characters. By default, no preshared key is configured.
Step 3	switch(config)# **exit**	Exits configuration mode.
Step 4	switch# **show radius-server**	(Optional) 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	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following example shows how to configure the preshared key values for a remote RADIUS server:

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

Configuring RADIUS Server Preshared Keys

You can configure preshared keys for a RADIUS server. A preshared key is a shared secret text string between the Cisco Nexus 5000 Series switch and the RADIUS server host.

To configure radius server preshared keys, obtain the preshared key values for the remote RADIUS servers and perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **key** [**0** | **7**] *key-value*
3. switch(config)# **exit**
4. (Optional) switch# **show radius-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **key** [**0** | **7**] *key-value*	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.
Step 3	switch(config)# **exit**	Exits configuration mode.
Step 4	switch# **show radius-server**	(Optional) 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	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following example shows how to configure a preshared keys for a RADIUS server:

```
switch# configure terminal
switch(config)# radius-server host 10.10.1.1 key 0 PlIjUhYg
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.

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

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **aaa group server radius** *group-name*
3. switch(config-radius)# **server** {*ipv4-address* | *ipv6-address* | *server-name*}
4. (Optional) switch(config-radius)# **deadtime** *minutes*
5. (Optional) switch(config-radius)# **source-interface** *interface*
6. switch(config-radius)# **exit**
7. (Optional) switch(config) #**show radius-server group** [*group-name*]
8. (Optional) switch(config)# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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 *group-name* argument is a case-sensitive alphanumeric string with a maximum length of 127 characters.
Step 3	switch(config-radius)# **server** {*ipv4-address* | *ipv6-address* | *server-name*}	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	switch(config-radius)# **deadtime** *minutes*	(Optional) 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. See the example that shows how to configure periodic RADIUS server monitoring.
Step 5	switch(config-radius)# **source-interface** *interface* **Example:** switch(config-radius)# **source-interface mgmt 0**	(Optional) 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	switch(config) #**show radius-server group** [*group-name*]	(Optional) Displays the RADIUS server group configuration.

	Command or Action	Purpose
Step 8	switch(config)# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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
```

Table 11: Related Commands

Command	Description
ip radius source-interface	Configures the global source interface for the RADIUS groups configured on the Cisco NX-OS device.
show radius-server groups	Displays the RADIUS server group configuration.

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. Refer to the Related Commands for additional information.

SUMMARY STEPS

1. **configure terminal**
2. **ip radius source-interface** *interface*
3. **exit**
4. (Optional) **show radius-server**
5. (Optional) **copy running-config startup config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)`
		Enters global configuration mode.

	Command or Action	Purpose
Step 2	**ip radius source-interface** *interface* **Example:** `switch(config)# ip radius source-interface mgmt 0`	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	**exit**
	
	Example:
	`switch(config)# exit`
	`switch#`
		Exits configuration mode.

Step 4	**show radius-server** **Example:** `switch# show radius-server`	(Optional) Displays the RADIUS server configuration information.
Step 5	**copy running-config startup config** **Example:** `switch# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Related Commands

Command	Description
aaa group server radius group-name	Creates a RADIUS server group and enters the RADIUS server group configuration submode for that group. The group-name argument is a case-sensitive alphanumeric string with a maximum length of 127 characters.

Allowing Users to Specify a RADIUS Server at Login

To allow users to specify a RADIUS server at login, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **radius-server directed-request**
3. switch(config)# **exit**
4. (Optional) switch# **show radius-server directed-request**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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.
Step 4	switch# **show radius-server directed-request**	(Optional) Displays the directed request configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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 5000 Series switch waits for responses from RADIUS servers before declaring a timeout failure.

To configure the global RADIUS transmission retry count and timeout interval, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **radius-server retransmit** *count*
3. switch(config)# **radius-server timeout** *seconds*
4. switch(config)# **exit**
5. (Optional) switch# **show radius-server**
6. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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.

	Command or Action	Purpose
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 configuration mode.
Step 5	switch# **show radius-server**	(Optional) Displays the RADIUS server configuration.
Step 6	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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

By default, a Cisco Nexus 5000 Series 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.

To configure RADIUS transmission retry count and timeout interval for a server, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. #switch(config)# **radius-server host** {*ipv4-address* |*ipv6-address* | *host-name*} **retransmit** *count*
3. switch(config)# switch(config)# **radius-server host** {*ipv4-address* |*ipv6-address* | *host-name*} **timeout** *seconds*
4. switch(config)# **exit**
5. (Optional) switch# **show radius-server**
6. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	#switch(config)# **radius-server host** {*ipv4-address* |*ipv6-address*	*host-name*} **retransmit** *count*	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)# switch(config)# **radius-server host** {*ipv4-address* |*ipv6-address*	*host-name*} **timeout** *seconds*	Specifies the transmission timeout interval for a specific server. The default is the global value.

	Command or Action	Purpose
		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 configuration mode.
Step 5	switch# **show radius-server**	(Optional) Displays the RADIUS server configuration.
Step 6	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following example shows how to configure RADIUS transmission retry count and timeout interval for a server:

```
switch# configure terminal
switch(config)# radius-server host server1 retransmit 3
switch(config)# radius-server host server1 timeout 10
switch(config)# exit
switch# show radius-server
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.

To configure the accounting and authentication attributes for RADIUS servers, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. (Optional) switch(config) #**radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **acct-port** *udp-port*
3. (Optional) switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **accounting**
4. (Optional) switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **auth-port** *udp-port*
5. (Optional) switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **authentication**
6. switch(config)# **exit**
7. (Optional) switch(config)# **show radius-server**
8. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

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

	Command or Action	Purpose
Step 2	switch(config) #**radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **acct-port** *udp-port*	(Optional) 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	switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **accounting**	(Optional) Specifies that the specified RADIUS server it to be used only for accounting purposes. The default is both accounting and authentication.
Step 4	switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **auth-port** *udp-port*	(Optional) 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	switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **authentication**	(Optional) 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	switch(config)# **show radius-server**	(Optional) Displays the RADIUS server configuration.
Step 8	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following example shows how to configure the 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(config)# exit
switch# show radius-server
switch# copy running-config startup-config
```

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 Cisco Nexus 5000 Series 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 Cisco Nexus 5000 Series switch sends out a test packet.

Note The default idle timer value is 0 minutes. When the idle time interval is 0 minutes, the Cisco Nexus 5000 Series switch does not perform periodic RADIUS server monitoring.

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **test** {**idle-time** *minutes* | **password** *password* [**idle-time** *minutes*] | **username** *name* [**password** *password* [**idle-time** *minutes*]]}
3. switch(config)# **radius-server deadtime** *minutes*
4. switch(config)# **exit**
5. (Optional) switch# **show radius-server**
6. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **radius-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **test** {**idle-time** *minutes* | **password** *password* [**idle-time** *minutes*] | **username** *name* [**password** *password* [**idle-time** *minutes*]]}	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 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** *minutes*	Specifies the number of minutes before the Cisco Nexus 5000 Series 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	switch# **show radius-server**	(Optional) Displays the RADIUS server configuration.
Step 6	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

To configure periodic RADIUS server monitoring, perform this task:

```
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# show radius-server
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 5000 Series switch 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.

To configure dead time interval, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. #switch(config)# **radius-server deadtime**
3. switch(config)# **exit**
4. (Optional) switch# **show radius-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch# **show radius-server**	(Optional) Displays the RADIUS server configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Manually Monitoring RADIUS Servers or Groups

To manually send a test message to a RADIUS server or to a server group, perform this task:

SUMMARY STEPS

1. switch# **test aaa server radius** {*ipv4-address* | *ipv6-address* | *server-name*} [**vrf** *vrf-name*] *username password*
2. switch# **test aaa group** *group-name username password*

DETAILED STEPS

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

The following example shows how to manually send a test message to a RADIUS server:

```
switch# test aaa server radius 10.10.1.1 user1 Ur2Gd2BH
switch# test aaa group RadGroup user2 As3He3CI
```

Verifying RADIUS Configuration

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

SUMMARY STEPS

1. switch# **show running-config radius** [**all**]
2. switch# **show startup-config radius**
3. switch# **show radius-server** [*server-name* | *ipv4-address* | *ipv6-address*] [**directed-request** | **groups** | **sorted** | **statistics**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **show running-config radius** [**all**]	Displays the RADIUS configuration in the running configuration.
Step 2	switch# **show startup-config radius**	Displays the RADIUS configuration in the startup configuration.
Step 3	switch# **show radius-server** [*server-name* | *ipv4-address* | *ipv6-address*] [**directed-request** | **groups** | **sorted** | **statistics**]	Displays all configured RADIUS server parameters.

For detailed information about the fields in the output from this command, refer to the *Cisco Nexus 5000 Series Command Reference*.

Displaying RADIUS Server Statistics

To display the statistics the Cisco Nexus 5000 Series switch maintains for RADIUS server activity, perform this task:

SUMMARY STEPS

1. switch# **show radius-server statistics** {*hostname* | *ipv4-address* | *ipv6-address*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **show radius-server statistics** {*hostname* | *ipv4-address* | *ipv6-address*}	Displays the RADIUS statistics.

The following example shows how to display statistics:

```
switch# show radius-server statistics 10.10.1.1
```

Example RADIUS Configuration

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 RADIUS Settings

The following table lists the default settings for RADIUS parameters.

Table 12: Default RADIUS Parameters

Parameters	Default
Server roles	Authentication and accounting
Dead timer interval	0 minutes
Retransmission count	1
Retransmission timer interval	5 seconds
Idle timer interval	0 minutes
Periodic server monitoring username	test
Periodic server monitoring password	test

CHAPTER 5

Configuring TACACS+

This chapter describes how to configure the Terminal Access Controller Access Control System Plus (TACACS+) protocol on Cisco NX-OS devices.

About Configuring TACACS+

Information About 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 5000 Series switch. 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 5000 Series switch 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. Cisco Nexus 5000 Series switches provide 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 5000 Series switch 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 5000 Series switch using TACACS+, the following actions occur:

1. When the Cisco Nexus 5000 Series switch 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 5000 Series switch will receive one of the following responses from the TACACS+ daemon:
   - ACCEPT—User authentication succeeds and service begins. If the Cisco Nexus 5000 Series switch 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 5000 Series switch. If the Cisco Nexus 5000 Series switch 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 5000 Series switch. Users must first successfully complete TACACS+ authentication before proceeding to TACACS+ authorization.
3. If TACACS+ authorization is required, the Cisco Nexus 5000 Series switch 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 or IPv6), access list, and user timeouts

Default TACACS+ Server Encryption Type and Preshared Key

You must configure the TACACS+ preshared key to authenticate the switch to the TACACS+ server. A preshared key is a secret text string shared between the Cisco Nexus 5000 Series switch 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 5000 Series switch to use.

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

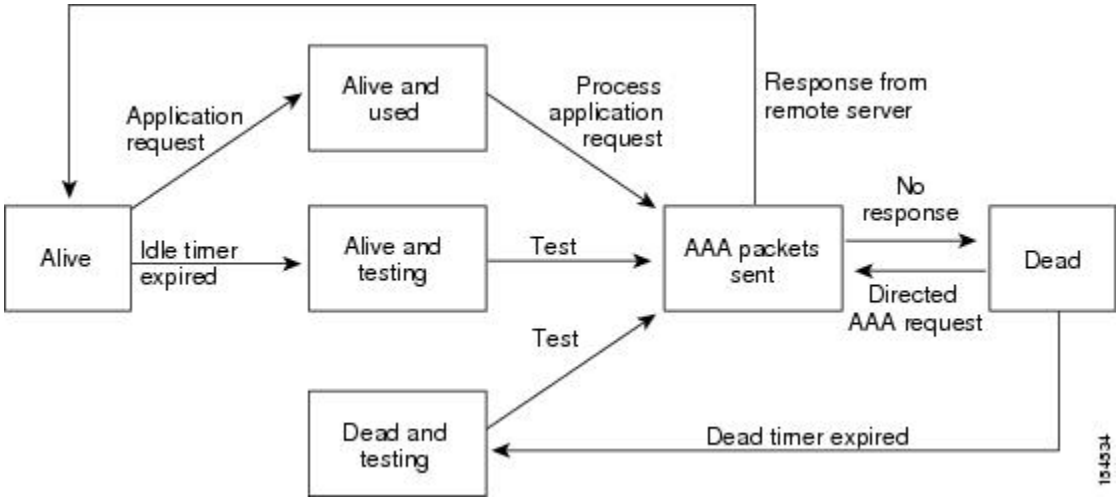
Command Authorization Support for TACACS+ Servers

By default, command authorization is done against a local database in the Cisco NX-OS software when an authenticated user enters a command at the command-line interface (CLI). You can also verify authorized commands for authenticated users using TACACS+.

TACACS+ Server Monitoring

An unresponsive TACACS+ server can delay the processing of AAA requests. A Cisco Nexus 5000 Series switch can periodically monitor an TACACS+ server to check whether it is responding (or alive) to save time in processing AAA requests. The Cisco Nexus 5000 Series switch marks unresponsive TACACS+ servers as dead and does not send AAA requests to any dead TACACS+ servers. A Cisco Nexus 5000 Series switch 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 its way. Whenever an TACACS+ server changes to the dead or alive state, a Simple Network Management Protocol (SNMP) trap is generated and the Cisco Nexus 5000 Series switch displays an error message that a failure is taking place before it can impact performance.

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:

- Obtain the IPv4 or IPv6 addresses or host names for the TACACS+ servers.
- Obtain the preshared keys from the TACACS+ servers, if any.
- Ensure that the Cisco Nexus 5000 Series switch is configured as a TACACS+ client of the AAA servers.

Guidelines and Limitations for TACACS+

TACACS+ has the following guidelines and limitations:

- You can configure a maximum of 64 TACACS+ servers on the Cisco Nexus 5000 Series switch.

Configuring TACACS+

TACACS+ Server Configuration Process

To configure TACACS+ servers, perform this task:

SUMMARY STEPS

1. Enable TACACS+.
2. Establish the TACACS+ server connections to the Cisco Nexus 5000 Series switch.
3. Configure the preshared secret keys for the TACACS+ servers.
4. If needed, configure TACACS+ server groups with subsets of the TACACS+ servers for AAA authentication methods.
5. If needed, configure any of the following optional parameters:
6. If needed, configure periodic TACACS+ server monitoring.

DETAILED STEPS

Step 1 Enable TACACS+.

Step 2 Establish the TACACS+ server connections to the Cisco Nexus 5000 Series switch.

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+

By default, the TACACS+ feature is disabled on the Cisco Nexus 5000 Series switch. To explicitly enable the TACACS+ feature to access the configuration and verification commands for authentication, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **feature tacacs+**
3. switch(config)# **exit**
4. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

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

Configuring TACACS+ Server Hosts

To access a remote TACACS+ server, you must configure the IPv4 or IPv6 address or the hostname for the TACACS+ server on the Cisco Nexus 5000 Series switch. 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 or IPv6 addresses or the hostnames for the remote TACACS+ servers.

To configure TACACS+ server hosts, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*}
3. switch(config)# **exit**
4. (Optional) switch# **show tacacs-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*}	Specifies the IPv4 or IPv6 address or hostname for a TACACS+ server.
Step 3	switch(config)# **exit**	Exits configuration mode.
Step 4	switch# **show tacacs-server**	(Optional) Displays the TACACS+ server configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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 5000 Series switch. A preshared key is a shared secret text string between the Cisco Nexus 5000 Series switch 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.

To configure global preshared keys, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **tacacs-server key** [**0** | **7**] *key-value*
3. switch(config)# **exit**
4. (Optional) switch# **show tacacs-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **tacacs-server key** [**0** | **7**] *key-value*	Specifies a preshared key for all TACACS+ servers. You can specify a clear text (**0**) or encrypted (**7**) preshared key. The default format is clear text. The maximum length is 63 characters. By default, no preshared key is configured.
Step 3	switch(config)# **exit**	Exits configuration mode.
Step 4	switch# **show tacacs-server**	(Optional) 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	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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
```

Related Topics

- Enabling TACACS+ , page 47

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 5000 Series switch and the TACACS+ server host.

To configure the TACACS+ preshared keys, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **key** [**0** | **7**] *key-value*
3. switch(config)# **exit**
4. (Optional) switch# **show tacacs-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **key** [**0** | **7**] *key-value*	Specifies a preshared key for a specific TACACS+ 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.
Step 3	switch(config)# **exit**	Exits configuration mode.
Step 4	switch# **show tacacs-server**	(Optional) 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	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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 PlIjUhYg
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+.

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **aaa group server tacacs+** *group-name*
3. switch(config-tacacs+)# **server** {*ipv4-address* | *ipv6-address* | *host-name*}
4. (Optional) switch(config-tacacs+)# **deadtime** *minutes*
5. (Optional) switch(config-tacacs+)# **source-interface** *interface*
6. switch(config-tacacs+)# **exit**
7. (Optional) switch(config)# **show tacacs-server groups**
8. (Optional) switch(config)# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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.
Step 3	switch(config-tacacs+)# **server** {*ipv4-address* | *ipv6-address* | *host-name*}	Configures the TACACS+ server as a member of the TACACS+ server group. If the specified TACACS+ server is not found, configure it using the **tacacs-server host** command and retry this command.
Step 4	switch(config-tacacs+)# **deadtime** *minutes* **Example:**	(Optional) 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 5	switch(config-tacacs+)# **source-interface** *interface* **Example:** switch(config-tacacs+)# **source-interface mgmt 0**	(Optional) 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 6	switch(config-tacacs+)# **exit**	Exits configuration mode.
Step 7	switch(config)# **show tacacs-server groups**	(Optional) Displays the TACACS+ server group configuration.
Step 8	switch(config)# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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
```

Table 13: Related Commands

Command	Description
feature tacacs+	Enables the TACACS+ feature.
ip tacacs source-interface	Configures the global source interface for the TACACS+ groups configured on the Cisco NX-OS device.
show tacacs-server groups	Displays the TACACS+ server group configuration.

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. Refer to Related Commands for additional information.

SUMMARY STEPS

1. **configure terminal**
2. **ip tacacs source-interface** *interface*
3. **exit**
4. (Optional) **show tacacs-server**
5. (Optional) **copy running-config startup config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)`
		Enters global configuration mode.

Step 2	**ip tacacs source-interface** *interface* **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.

	Command or Action	Purpose

Step 3	**exit**
	
	Example:
	`switch(config)# exit`
	`switch#`
		Exits configuration mode.

Step 4	**show tacacs-server** **Example:** `switch# show tacacs-server`	(Optional) Displays the TACACS+ server configuration information.
Step 5	**copy running-config startup config** **Example:** `switch# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Table 14: Related Commands

Command	Description
aaa group server tacacs group-name	Creates a TACACS+ server group and enters the TACACS+ server group configuration submode for that group. The group-name argument is a case-sensitive alphanumeric string with a maximum length of 127 characters.

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 5000 Series switch 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.

To specify a TACACS+ server at login, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **tacacs-server directed-request**
3. switch(config)# **exit**
4. (Optional) switch# **show tacacs-server directed-request**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch# **show tacacs-server directed-request**	(Optional) Displays the TACACS+ directed request configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Configuring AAA Authorization on TACACS+ Servers

You can configure the default AAA authorization method for TACACS+ servers.

Before You Begin

Enable TACACS+.

SUMMARY STEPS

1. **configure terminal**
2. **aaa authorization ssh-certificate default** {**group** *group-list* [**none**] | **local** | **none**}
3. **exit**
4. (Optional) **show aaa authorization** [**all**]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**aaa authorization ssh-certificate default** {**group** *group-list* [**none**]	**local**	**none**}
			
			Example:
			`switch(config)# aaa authorization ssh-certificate`
			`default group TACACSServer1 TACACSServer2`
				Configures the default AAA authorization method for the TACACS+ servers.
				
				The **ssh-certificate** keyword configures TACACS+ or local authorization with certificate authentication. The default authorization is local authorization, which is the list of authorized commands for the user's assigned role.

	Command or Action	Purpose
		The *group-list* argument consists of a space-delimited list of TACACS+ server group names. Servers belonging to this group are contacted for AAA authorization. The **local** method uses the local database for authorization, and the **none** method specifies that no AAA authorization be used.

Step 3	**exit**
	
	Example:
	`switch(config)# exit`
	`switch#`
		Exits global configuration mode.

Step 4	**show aaa authorization** [**all**] **Example:** `switch# show aaa authorization`	(Optional) Displays the AAA authorization configuration. The **all** keyword displays the default values.
Step 5	**copy running-config startup-config** **Example:** `switch# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring Command Authorization on TACACS+ Servers

You can configure authorization for commands on TACACS+ servers. Command authorization disables user role-based authorization control (RBAC), including the default roles.

Note By default, context sensitive help and command tab completion show only the commands that are supported for a user as defined by the assigned roles. When you enable command authorization, the Cisco NX-OS software displays all commands in the context sensitive help and in tab completion, regardless of the role assigned to the user.

Before You Begin

Enable TACACS+.

Configure TACACS host and server groups before configuring AAA command authorization.

SUMMARY STEPS

1. **configure terminal**
2. **aaa authorization** {**commands** | **config-commands**} **default** [**group** *group-list* [**local**] | **local**]
3. **exit**
4. (Optional) **show aaa authorization** [**all**]
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**aaa authorization** {**commands** | **config-commands**} **default** [**group** *group-list* [**local**] | **local**]
	
	Example:
	`switch(config)# aaa authorization commands`
	`default group TacGroup`
		Configures the default authorization method for commands for all roles.
		The **commands** keyword configures authorization sources for all EXEC commands, and the **config-commands** keyword configures authorization sources for all configuration commands. The default authorization for all commands is local authorization, which is the list of authorized commands for the user's assigned role.
		The *group-list* argument consists of a space-delimited list of TACACS+ server group names. Servers that belong to this group are contacted for command authorization. The **local**method uses the local role-based database for authorization..
		The **local** method is used only if all the configured server groups fail to respond and you have configured **local** as the fallback method.
		The default method is **local**.
		If you have not configured a fallback method after the TACACS+ server group method, authorization fails if all server groups fail to respond.

Step 3	**exit**
	
	Example:
	`switch(config)# exit`
	`switch#`
		Exits global configuration mode.

Step 4	**show aaa authorization** [**all**] **Example:** `switch(config)# show aaa authorization`	(Optional) Displays the AAA authorization configuration. The **all** keyword displays the default values.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Testing Command Authorization on TACACS+ Servers

You can test the command authorization for a user on the TACACS+ servers.

Note You must send correct commands for authorization or the results might not be reliable.

Before You Begin

Enable TACACS+.

Ensure that you have configured command authorization for the TACACS+ servers.

SUMMARY STEPS

1. **test aaa authorization command-type** {**commands** | **config-commands**} **user** *username* **command** *command-string*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**test aaa authorization command-type** {**commands** | **config-commands**} **user** *username* **command** *command-string*
	
	Example:
	`switch# test aaa authorization command-type commands`
	`user TestUser command reload`
		Tests a user's authorization for a command on the TACACS+ servers.
		
		The **commands** keyword specifies only EXEC commands and the **config-commands** keyword specifies only configuration commands.
		
		Note Put double quotes (") before and after the *command-string* argument if it contains spaces.

Enabling and Disabling Command Authorization Verification

You can enable and disable command authorization verificaiton on the command-line interface (CLI) for the default user session or for another username.

Note The commands do not execute when you enable authorization verification.

SUMMARY STEPS

1. **terminal verify-only** [**username** *username*]
2. **terminal no verify-only** [**username** *username*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	**terminal verify-only** [**username** *username*] **Example:** `switch# terminal verify-only`	Enables command authorization verification. After you enter this command, the Cisco NX-OS software indicates whether the commands you enter are authorized or not.

	Command or Action	Purpose
Step 2	**terminal no verify-only** [**username** *username*] **Example:** `switch# terminal no verify-only`	Disables command authorization verification.

Configuring Privilege Level Support for Authorization on TACACS+ Servers

You can configure privilege level support for authorization on TACACS+ servers.

Unlike Cisco IOS devices, which use privilege levels to determine authorization, Cisco NX-OS devices use role-based access control (RBAC). To enable both types of devices to be administered by the same TACACS+ servers, you can map the privilege levels configured on TACACS+ servers to user roles configured on Cisco NX-OS devices.

When a user authenticates with a TACACS+ server, the privilege level is obtained and used to form a local user role name of the format "priv-*n*," where *n* is the privilege level. The user assumes the permissions of this local role. Sixteen privilege levels, which map directly to corresponding user roles, are available. The following table shows the user role permissions that correspond to each privilege level.

Privilege Level	User Role Permissions
15	network-admin permissions
14	vdc-admin permissions
13 - 1	• Standalone role permissions, if the **feature privilege** command is disabled. • Same permissions as privilege level 0 with cumulative privileges for roles, if the **feature privilege** command is enabled.
0	Permission to execute **show** commands and **exec** commands (such as **ping**, **trace**, and **ssh**).

Note When the **feature privilege** command is enabled, privilege roles inherit the permissions of lower level privilege roles.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **feature privilege**
3. [**no**] **enable secret** [**0** | **5**] *password* [**priv-lvl** *priv-lvl* | **all**]
4. [**no**] **username** *username* **priv-lvl** *n*
5. (Optional) **show privilege**
6. (Optional) **copy running-config startup-config**
7. **exit**
8. **enable** *level*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **feature privilege** **Example:** `switch(config)# feature privilege`	Enables or disables the cumulative privilege of roles. Users can see the **enable** command only if this feature is enabled. The default is disabled.
Step 3	[**no**] **enable secret** [**0** | **5**] *password* [**priv-lvl** *priv-lvl* | **all**] **Example:** `switch(config)# enable secret 5 def456 priv-lvl 15`	Enables or disables a secret password for a specific privilege level. Users are prompted to enter the correct password upon each privilege level escalation. The default is disabled. You can enter **0** to specify that the password is in clear text or **5** to specify that the password is in encrypted format. The *password* argument can be up to 64 alphanumeric characters. The *priv-lvl* argument is from 1 to 15. **Note** To enable the secret password, you must have enabled the cumulative privilege of roles by entering the **feature privilege** command.
Step 4	[**no**] **username** *username* **priv-lvl** *n* **Example:** `switch(config)# username user2 priv-lvl 15`	Enables or disables a user to use privilege levels for authorization. The default is disabled. The **priv-lvl** keyword specifies the privilege level to which the user is assigned. There is no default privilege level. Privilege levels 0 to 15 (priv-lvl 0 to priv-lvl 15) map to user roles priv-0 to priv-15.
Step 5	**show privilege** **Example:** `switch(config)# show privilege`	(Optional) Displays the username, current privilege level, and status of cumulative privilege support.

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

Step 7	**exit**
	
	Example:
	`switch(config)# exit`
	`switch#`
		Exits global configuration mode.

Step 8	**enable** *level* **Example:** `switch# enable 15`	Enables a user to move to a higher privilege level. This command prompts for the secret password. The *level* argument specifies the privilege level to which the user is granted access. The only available level is 15.

Permitting or Denying Commands for Users of Privilege Roles

As a network administrator, you can modify the privilege roles to permit users to execute specific commands or to prevent users from running those commands.

You must follow these guidelines when changing the rules of privilege roles:

- You cannot modify the priv-14 and priv-15 roles.
- You can add deny rules only to the priv-0 role.
- These commands are always permitted for the priv-0 role: **configure**, **copy**, **dir**, **enable**, **ping**, **show**, **ssh**, **telnet**, **terminal**, **traceroute**, **end**, and **exit**.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **role name priv-***n*
3. **rule** *number* {**deny** | **permit**} **command** *command-string*
4. **exit**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	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**] **role name priv-***n*
	
	Example:
	`switch(config)# role name priv-5`
	`switch(config-role)#`
		Enables or disables a privilege role and enters role configuration mode. The *n* argument specifies the privilege level and is a number between 0 and 13.

Step 3	**rule** *number* {**deny** | **permit**} **command** *command-string* **Example:** `switch(config-role)# rule 2 permit command pwd`	Configures a command rule for users of privilege roles. These rules permit or deny users to execute specific commands. You can configure up to 256 rules for each role. The rule number determines the order in which the rules are applied. Rules are applied in descending order. For example, if a role has three rules, rule 3 is applied before rule 2, which is applied before rule 1. The *command-string* argument can contain spaces. **Note** Repeat this command for 256 rules.

Step 4	**exit**
	
	Example:
	`switch(config-role)# exit`
	`switch(config)#`
		Exits role configuration mode.

Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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 5000 Series switch 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.

To specify a TACACS+ global timeout interval, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **tacacs-server timeout** *seconds*
3. switch(config)# **exit**
4. (Optional) switch# **show tacacs-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch# **show tacacs-server**	(Optional) Displays the TACACS+ server configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) 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 5000 Series switch 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.

To configure the timeout interval for a server, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **timeout** *seconds*
3. switch(config)# **exit**
4. (Optional) switch# **show tacacs-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **timeout** *seconds*	Specifies the timeout interval for a specific server. The default is the global value. **Note** The timeout interval value specified for a TACACS+ server overrides the global timeout interval value specified for all TACACS+ servers.
Step 3	switch(config)# **exit**	Exits configuration mode.

	Command or Action	Purpose
Step 4	switch# **show tacacs-server**	(Optional) Displays the TACACS+ server configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) 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, Cisco Nexus 5000 Series switches use port 49 for all TACACS+ requests.

To configure TCP ports, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **port** *tcp-port*
3. switch(config)# **exit**
4. (Optional) switch# **show tacacs-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **port** *tcp-port*	Specifies the UDP port to use for TACACS+ accounting messages.The default TCP port is 49. The range is from 1 to 65535.
Step 3	switch(config)# **exit**	Exits configuration mode.
Step 4	switch# **show tacacs-server**	(Optional) Displays the TACACS+ server configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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 5000 Series switch 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 user name 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 5000 Series switch 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.

To configure periodic TACACS+ server monitoring, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **test** {**idle-time** *minutes* | **password** *password* [**idle-time** *minutes*] | **username** *name* [**password** *password* [**idle-time** *minutes*]]}
3. switch(config)# **tacacs-server dead-time** *minutes*
4. switch(config)# **exit**
5. (Optional) switch# **show tacacs-server**
6. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **tacacs-server host** {*ipv4-address* | *ipv6-address* | *host-name*} **test** {**idle-time** *minutes* | **password** *password* [**idle-time** *minutes*] | **username** *name* [**password** *password* [**idle-time** *minutes*]]}	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 and the valid range is 0 to 1440 minutes. **Note** For periodic TACACS+ server monitoring, the idle timer value must be greater than 0.
Step 3	switch(config)# **tacacs-server dead-time** *minutes*	Specifies the number minutes before the Cisco Nexus 5000 Series switch checks a TACACS+ server that was previously unresponsive. The default value is 0 minutes and the valid range is 0 to 1440 minutes.

	Command or Action	Purpose
Step 4	switch(config)# **exit**	Exits configuration mode.
Step 5	switch# **show tacacs-server**	(Optional) Displays the TACACS+ server configuration.
Step 6	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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 5000 Series switch 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-timer interval is 0 minutes, TACACS+ servers are not marked as dead even if they are not responding. You can configure the dead-timer per group.

To configure the dead-time interval for all TACACS+ servers, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **tacacs-server deadtime** *minutes*
3. switch(config)# **exit**
4. (Optional) switch# **show tacacs-server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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.

	Command or Action	Purpose
Step 4	switch# **show tacacs-server**	(Optional) Displays the TACACS+ server configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Manually Monitoring TACACS+ Servers or Groups

To manually issue a test message to a TACACS+ server or to a server group, perform this task:

SUMMARY STEPS

1. switch# **test aaa server tacacs+** {*ipv4-address* | *ipv6-address* | *host-name*} [**vrf** *vrf-name*] *username password*
2. switch# **test aaa group** *group-name username password*

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **test aaa server tacacs+** {*ipv4-address* | *ipv6-address* | *host-name*} [**vrf** *vrf-name*] *username password*	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.

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.

To disable TACACS+, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **no feature tacacs+**
3. switch(config)# **exit**
4. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

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

Displaying TACACS+ Statistics

To display the statistics the Cisco Nexus 5000 Series switch maintains for TACACS+ activity, perform this task:

SUMMARY STEPS

1. switch# **show tacacs-server statistics** {*hostname* | *ipv4-address* | *ipv6-address*}

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **show tacacs-server statistics** {*hostname* | *ipv4-address* | *ipv6-address*}	Displays the TACACS+ statistics.

For detailed information about the fields in the output from this command, see the *Cisco Nexus 5000 Series Command Reference*.

Verifying TACACS+ Configuration

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

SUMMARY STEPS

1. switch# **show tacacs+** {**status** | **pending** | **pending-diff**}
2. switch# **show running-config tacacs** [**all**]
3. switch# **show startup-config tacacs**
4. switch# **show tacacs-serve** [*host-name* | *ipv4-address* | *ipv6-address*] [**directed-request** | **groups** | **sorted** | **statistics**]

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **show tacacs+** {**status** | **pending** | **pending-diff**}	Displays the TACACS+ Cisco Fabric Services distribution status and other details.
Step 2	switch# **show running-config tacacs** [**all**]	Displays the TACACS+ configuration in the running configuration.
Step 3	switch# **show startup-config tacacs**	Displays the TACACS+ configuration in the startup configuration.
Step 4	switch# **show tacacs-serve** [*host-name* | *ipv4-address* | *ipv6-address*] [**directed-request** | **groups** | **sorted** | **statistics**]	Displays all configured TACACS+ server parameters.

Configuration Examples for TACACS+

The following 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
```

The following 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# config t
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 TACACS+ Settings

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

Table 15: Default TACACS+ Parameters

Parameters	Default
TACACS+	Disabled
Dead timer interval	0 minutes
Timeout interval	5 seconds

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

CHAPTER 6

Configuring SSH and Telnet

This chapter describes how to configure Secure Shell Protocol (SSH) and Telnet on Cisco NX-OS devices.

Configuring SSH and Telnet

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 5000 Series switch. SSH uses strong encryption for authentication. The SSH server in the Cisco Nexus 5000 Series switch will interoperate 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 Cisco Nexus 5000 Series switch to make a secure, encrypted connection to another Cisco Nexus 5000 Series switch 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 5000 Series switch works with publicly and commercially available SSH servers.

SSH Server Keys

SSH requires server keys for secure communications to the Cisco Nexus 5000 Series switch. 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 Algrorithm (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 5000 Series switch 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.

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 5000 Series switch.

Guidelines and Limitations for SSH

SSH has the following configuration guidelines and limitations:

- The Cisco Nexus 5000 Series switch supports only SSH version 2 (SSHv2).

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 generated using 1024 bits. To generate SSH server keys, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **ssh key** {**dsa** [**force**] | **rsa** [*bits* [**force**]]}
3. switch(config)# **exit**
4. (Optional) switch# **show ssh key**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **ssh key** {**dsa** [**force**] | **rsa** [*bits* [**force**]]}	Generates the SSH server key. The *bits* argument is the number of bits used to generate the key. The range is 768 to 2048 and the default value is 1024. Use the **force** keyword to replace an existing key.
Step 3	switch(config)# **exit**	Exits global configuration mode.
Step 4	switch# **show ssh key**	(Optional) Displays the SSH server keys.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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.

To specify the SSH public keys in open SSH format, generate an SSH public key in open SSH format and perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **username** *username* **sshkey** *ssh-key*
3. switch(config)# **exit**
4. (Optional) switch# **show user-account**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch# **show user-account**	(Optional) Displays the user account configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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

```
switch# configure terminal
switch(config)# username User1 sshkey ssh-rsa
AAAAB3NzaC1yc2EAAAABIwAAAIEAri3mQy4W1AV9Y2t2hrEWgbUEYz
CfTPO5B8LRkedn56BEy2N9ZcdpqE6aqJLZwfZcTFEzaAAZp9AS86dgBAjsKGs7UxnhGySr8ZELv+DQBsDQH6rZt0KR+2Da8hJD4Z
XIeccWk0gS1DQUNZ300xstQsYZUtqnx1bvm5Ninn0McNinn0Mc=
switch(config)# exit
switch# show user-account
switch# copy running-config startup-config
```

Note The **username** command 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.

To specify the SSH public keys in IETF SECSH format, generate an SSH public key in IETF SCHSH format, and perform this task:

SUMMARY STEPS

1. switch# **copy** *server-file* **bootflash:** *filename*
2. switch# **configure terminal**
3. switch(config)# **username** *username* **sshkey file** *filename*
4. switch(config)# **exit**
5. (Optional) switch# **show user-account**
6. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **copy** *server-file* **bootflash:** *filename*	Downloads the file containing 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 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	switch# **show user-account**	(Optional) Displays the user account configuration.
Step 6	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following example shows how to specify the SSH public keys 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.

To specify the SSH public keys in PEM-formatted Public Key Certificate form, generate an SSH public key in PEM-Formatted Public Key Certificate form and perform this task:

SUMMARY STEPS

1. switch# **copy** *server-file* **bootflash:** *filename*
2. switch# **configure terminal**
3. (Optional) switch# **show user-account**
4. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **copy** *server-file* **bootflash:** *filename*	Downloads the file containing the SSH key in PEM-formatted Public Key Certificate form from a server. The server can be FTP, SCP, SFTP, or TFTP

	Command or Action	Purpose
Step 2	switch# **configure terminal**	Enters configuration mode.
Step 3	switch# **show user-account**	(Optional) Displays the user account configuration.
Step 4	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

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
```

Starting SSH Sessions to Remote Devices

To start SSH sessions to connect to remote devices from your Cisco Nexus 5000 Series switch, perform this task:

SUMMARY STEPS

1. switch# **ssh** {*hostname* | *username@hostname*} [**vrf** *vrf-name*]

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **ssh** {*hostname* | *username@hostname*} [**vrf** *vrf-name*]	Creates an SSH session to a remote device. The *hostname* argument can be an IPv4 address, an IPv6 address, or a host name.

Clearing SSH Hosts

When you download a file from a server using SCP or SFTP, you establish a trusted SSH relationship with that server. To clear the list of trusted SSH servers for your user account, perform this task:

SUMMARY STEPS

1. switch# **clear ssh hosts**

DETAILED STEPS

	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 5000 Series switch.

To disable the SSH server to prevent SSH access to the switch, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **no feature ssh**
3. switch(config)# **exit**
4. (Optional) switch# **show ssh server**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

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

To delete the SSH server keys, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **no feature ssh**
3. switch(config)# **no ssh key** [**dsa** | **rsa**]
4. switch(config)# **exit**
5. (Optional) switch# **show ssh key**
6. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch# **show ssh key**	(Optional) Displays the SSH server configuration.
Step 6	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Clearing SSH Sessions

To clear SSH sessions from the Cisco Nexus 5000 Series switch, perform this task:

SUMMARY STEPS

1. switch# **show users**
2. switch# **clear line** *vty-line*

DETAILED STEPS

	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.

SSH Example Configuration

The following example shows how to configure SSH:

SUMMARY STEPS

1. Generate an SSH server key.
2. Enable the SSH server.
3. Display the SSH server key.
4. Specify the SSH public key in Open SSH format.
5. Save the configuration.

DETAILED STEPS

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 as 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 AAAAB3NzaC1yc2EAAAABIwAAAIEAri3mQy4W1AV9Y2t2hrEWgbUEYzCfTPO5B8LRkedn56BEy2N9ZcdpqE6aqJLZwfZ/
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
CfTPO5B8LRkedn56BEy2N9ZcdpqE6aqJLZwfZcTFEzaAAZp9AS86dgBAjsKGs7UxnhGySr8ZELv+DQBsDQH6rZt0KR+2Da8hJD4Z
XIeccWk0gS1DQUNZ300xstQsYZUtqnx1bvm5Ninn0McNinn0Mc=
```

Step 5 Save the configuration.

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

Configuring Telnet

Enabling the Telnet Server

By default, the Telnet server is enabled. You can disable the Telnet server on your Cisco Nexus 5000 Series switch.

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **feature telnet**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **feature telnet**	Disables the Telnet server. The default is enabled.

Reenabling the Telnet Server

If the Telnet server on your Cisco Nexus 5000 Series switch has been disabled, you can reenable it.

SUMMARY STEPS

1. switch(config)# **feature telnet**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch(config)# **feature telnet**	Reenables the Telnet server.

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, the user name on the remote device.
- Enable the Telnet server on the Cisco Nexus 5000 Series switch.
- Enable the Telnet server on the remote device.

To start Telnet sessions to connect to remote devices from your Cisco Nexus 5000 Series switch, perform this task:

SUMMARY STEPS

1. switch# **telnet** *hostname*

DETAILED STEPS

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

The following example shows starting 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

To clear Telnet sessions from the Cisco Nexus 5000 Series switch, perform this task:

SUMMARY STEPS

1. switch# **show users**
2. switch# **clear line** *vty-line*

DETAILED STEPS

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

Verifying the SSH and Telnet Configuration

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

- switch# **show ssh key** [**dsa** | **rsa**]
  Displays SSH server key-pair information.
- 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.

Default SSH Settings

The following table lists the default settings for SSH parameters.

Table 16: 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	Enabled

CHAPTER 7

Configuring Access Control Lists

This chapter contains the following sections:

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 5000 Series switch supports IPv4, IPv6, and MAC ACLs for security traffic filtering. The switch allows you to use IP ACLs as port ACLs and VLAN ACLs, as shown in the following table.

Table 17: 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: • 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 MAC 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 IPv6 ACLs MAC ACLs

Application Order

When the switch processes a packet, it determines the forwarding path of the packet. The path determines which ACLs that the switch applies to the traffic. The switch applies the Port ACLs first.

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

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 number. In IPv4 ACLs, you can specify protocols by the integer that represents the Internet protocol number. For example, you can use 115 to specify Layer 2 Tunneling Protocol (L2TP) traffic.

Implicit Rules

IP 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.

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

IPv6 ACLs support the following additional filtering options:

- Layer 4 protocol
- Authentication Header Protocol
- Encapsulating Security Payload
- Payload Compression Protocol
- Stream Control Transmission Protocol (SCTP)
- SCTP, TCP, and UDP ports
- ICMP types and codes
- IGMP types
- Flow label
- DSCP value
- TCP packets with the ACK, FIN, PSH, RST, SYN, or URG bit set
- Established TCP connections
- Packet length

Sequence Numbers

The switch supports sequence numbers for rules. Every rule that you enter receives a sequence number, either assigned by you or assigned automatically by the switch. 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 switch 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 switch assigns the sequence number 235 to the new rule.

In addition, the Cisco Nexus 5000 Series switch 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 switch stores operator-operand couples in registers called logical operator units (LOUs).

LOU usage for the "eq" operator is never stored in an LOU. The range operation is inclusive of boundary values.

The following guidelines determine when the switch 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.

Configuring IP ACLs

Creating an IP ACL

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

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# {**ip** | **ipv6** } **access-list** *name*
3. switch(config-acl)# [*sequence-number*] {**permit**|**deny**} *protocol source destination*
4. (Optional) switch(config-acl)# **statistics**
5. (Optional) switch# **show** {**ip** | **ipv6**} **access-lists** *name*
6. (Optional) switch# **show ip access-lists** *name*
7. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# {**ip** | **ipv6** } **access-list** *name*	Creates the IP ACL and enters IP ACL configuration mode. The *name* 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 *sequence-number* 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 *Cisco Nexus 5000 Series Command Reference*.
Step 4	switch(config-acl)# **statistics**	(Optional) Specifies that the switch maintains global statistics for packets matching the rules in the ACL.
Step 5	switch# **show** {**ip** | **ipv6**} **access-lists** *name*	(Optional) Displays the IP ACL configuration.
Step 6	switch# **show ip access-lists** *name*	(Optional) Displays the IP ACL configuration.

	Command or Action	Purpose
Step 7	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following 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
```

The following 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
```

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.

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# {**ip** | **ipv6**} **access-list** *name*
3. switch(config-acl)# [*sequence-number*] {**permit** | **deny**} *protocol source destination*
4. (Optional) switch(config-acl)# **no** {*sequence-number* | {**permit** | **deny**} *protocol source destination*}
5. (Optional) switch(config-acl)# [**no**] **statistics**
6. (Optional) switch#**show ip access-lists** *name*
7. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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-acl)# [*sequence-number*] {**permit** | **deny**} *protocol source destination*	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 *sequence-number* 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 *Cisco Nexus 5000 Series Command Reference*.

	Command or Action	Purpose
Step 4	switch(config-acl)# **no** {*sequence-number* | {**permit** | **deny**} *protocol source destination*}	(Optional) Removes the rule that you specified from the IP ACL. The **permit** and **deny** commands support many ways of identifying traffic. For more information, see the *Cisco Nexus 5000 Series Command Reference*.
Step 5	switch(config-acl)# [**no**] **statistics**	(Optional) Specifies that the switch maintains global statistics for packets matching the rules in the ACL. The **no** option stops the switch from maintaining global statistics for the ACL.
Step 6	switch#**show ip access-lists** *name*	(Optional) Displays the IP ACL configuration.
Step 7	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Related Topics

- Changing Sequence Numbers in an IP ACL, page 90

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.

To remove an IP ACL from the switch, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# no {**ip** | **ipv6**} **access-list** *name*
3. (Optional) switch# **show running-config**
4. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

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

	Command or Action	Purpose
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# **show running-config**	(Optional) Displays ACL configuration. The removed IP ACL should not appear.
Step 4	switch# **copy running-config startup-config**	(Optional) 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. To change sequence numbers, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **resequence** {**ip** | **ipv6**} **access-list** *name starting-sequence-number increment*
3. (Optional) switch# **show** {**ip** | **ipv6**} **access-lists** *name*
4. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **resequence** {**ip** | **ipv6**} **access-list** *name starting-sequence-number increment*	Assigns sequence numbers to the rules contained in the ACL, where the first rule receives the starting sequence number that you specify. Each subsequent rule receives a number larger than the preceding rule. The difference in numbers is determined by the increment that you specify. The *starting-sequence-number* argument and the *increment* argument can be a whole number between 1 and 4294967295.
Step 3	switch# **show** {**ip** | **ipv6**} **access-lists** *name*	(Optional) Displays the IP ACL configuration.
Step 4	switch# **copy running-config startup-config**	(Optional) 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.

SUMMARY STEPS

1. **configure terminal**
2. **interface mgmt** *port*
3. Enter one of the following commands:
   - ip access-group *access-list* {in|out}
   - ipv6 traffic-filter *access-list* {in|out}
4. (Optional) **show running-config aclmgr**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	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	Enter one of the following commands: • ip access-group *access-list* {in|out} • ipv6 traffic-filter *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	**show running-config aclmgr** **Example:** `switch(config-if)# show running-config aclmgr`	(Optional) Displays the ACL configuration.
Step 5	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) 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 or IPv6 ACL to a physical Ethernet interface or a EtherChannel. ACLs applied to these interface types are considered port ACLs.

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

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **interface** {**ethernet** [*chassis*/]*slot*/*port* | **port-channel** *channel-number*}
3. switch(config-if)# {**ip port access-group** | **ipv6 port traffic-filter**} *access-list* **in**
4. (Optional) switch# **show running-config**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch(config-if)# {**ip port access-group** | **ipv6 port traffic-filter**} *access-list* **in**	Applies an IPv4 or IPv6 ACL to the interface or EtherChannel. Only inbound filtering is supported with port ACLs. You can apply one port ACL to an interface.
Step 4	switch# **show running-config**	(Optional) Displays ACL configuration.
Step 5	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Verifying IP ACL Configurations

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

- switch# **show running-config**
  Displays ACL configuration, including IP ACL configuration and interfaces that IP ACLs are applied to.

- switch# **show running-config interface**
  Displays the configuration of an interface to which you have applied an ACL.

For detailed information about the fields in the output from these commands, refer to the *Cisco Nexus 5000 Series Command Reference*.

Displaying 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, refer to the *Cisco Nexus 5000 Series Command Reference*.

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

- 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# **clear** {**ip** | **ipv6**} **access-list counters** [*access-list-name*]
  Clears statistics for all IP ACLs or for a specific IP ACL.

Configuring MAC ACLs

Creating a MAC ACL

To create a MAC ACL and add rules to it, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch# **mac access-list** *name*
3. switch(config-mac-acl)# [*sequence-number*] {**permit** | **deny**} *source destination protocol*
4. (Optional) switch(config-mac-acl)# **statistics**
5. (Optional) switch# **show mac access-lists** *name*
6. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch# **mac access-list** *name*	Creates the MAC ACL and enters ACL configuration mode.

	Command or Action	Purpose
Step 3	switch(config-mac-acl)# [*sequence-number*] {**permit** | **deny**} *source destination protocol*	Creates a rule in the MAC ACL. The **permit** and **deny** options support many ways of identifying traffic. For more information, see the *Cisco Nexus 5000 Series Command Reference*.
Step 4	switch(config-mac-acl)# **statistics**	(Optional) Specifies that the switch maintains global statistics for packets matching the rules in the ACL.
Step 5	switch# **show mac access-lists** *name*	(Optional) Displays the MAC ACL configuration.
Step 6	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following example shows how to create a MAC ACL and add rules to it:

```
switch# configure terminal
switch(config)# mac access-list acl-mac-01
switch(config-mac-acl)# permit 00c0.4f00.0000 0000.00ff.ffff any
switch(config-mac-acl)# statistics
```

Changing a MAC ACL

In an existing MAC ACL, you can add and remove rules. 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.

To change a MAC ACL, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **mac access-list** *name*
3. switch(config-mac-acl)# [*sequence-number*] {**permit** | **deny**} *source destination protocol*
4. (Optional) switch(config-mac-acl)# **no** {*sequence-number* | {**permit**|**deny**} *source destination protocol*}
5. (Optional) switch(config-mac-acl)# [**no**] **statistics**
6. (Optional) switch# **show mac access-lists** *name*
7. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **mac access-list** *name*	Enters ACL configuration mode for the ACL that you specify by name.
Step 3	switch(config-mac-acl)# [*sequence-number*] {**permit** | **deny**} *source destination protocol*	Creates a rule in the MAC 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 **permit** and **deny** commands support many ways of identifying traffic.
Step 4	switch(config-mac-acl)# **no** {*sequence-number* | {**permit**|**deny**} *source destination protocol*}	(Optional) Removes the rule that you specify from the MAC ACL. The **permit** and **deny** commands support many ways of identifying traffic.
Step 5	switch(config-mac-acl)# [**no**] **statistics**	(Optional) Specifies that the switch maintains global statistics for packets matching the rules in the ACL. The **no** option stops the switch from maintaining global statistics for the ACL.
Step 6	switch# **show mac access-lists** *name*	(Optional) Displays the MAC ACL configuration.
Step 7	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

The following example shows how to change a MAC ACL:

```
switch# configure terminal
switch(config)# mac access-list acl-mac-01
switch(config-mac-acl)# 100 permit mac 00c0.4f00.00 0000.00ff.ffff any
switch(config-mac-acl)# statistics
```

Removing a MAC ACL

You can remove a MAC 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 current 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.

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **no mac access-list** *name*
3. (Optional) switch# **show mac access-lists**
4. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **no mac access-list** *name*	Removes the MAC ACL that you specify by name from the running configuration.
Step 3	switch# **show mac access-lists**	(Optional) Displays the MAC ACL configuration.
Step 4	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Changing Sequence Numbers in a MAC ACL

You can change all the sequence numbers assigned to rules in a MAC ACL. Resequencing is useful when you need to insert rules into an ACL and there are not enough available sequence numbers.

To change all the sequence numbers assigned to rules in a MAC ACL, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **resequence mac access-list** *name starting-sequence-number increment*
3. (Optional) switch# **show mac access-lists** *name*
4. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **resequence mac access-list** *name starting-sequence-number increment*	Assigns sequence numbers to the rules contained in the ACL, where the first rule receives the number specified by the starting-sequence number that you specify. Each subsequent rule receives a number larger than the preceding rule. The difference in numbers is determined by the increment number that you specify.

	Command or Action	Purpose
Step 3	switch# **show mac access-lists** *name*	(Optional) Displays the MAC ACL configuration.
Step 4	switch# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Related Topics

- Rules, page 84

Applying a MAC ACL as a Port ACL

You can apply a MAC ACL as a port ACL to any of the following interface types:

- Ethernet interfaces
- EtherChannel interfaces

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

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

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **interface** {**ethernet** [*chassis*/]*slot*/*port* | **port-channel** *channel-number*}
3. switch(config-if)# **mac port access-group** *access-list*
4. (Optional) switch# **show running-config**
5. (Optional) switch# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
Step 2	switch(config)# **interface** {**ethernet** [*chassis*/]*slot*/*port* | **port-channel** *channel-number*}	Enters interface configuration mode for the Ethernet specified interface.
Step 3	switch(config-if)# **mac port access-group** *access-list*	Applies a MAC ACL to the interface.

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

Related Topics

- Creating an IP ACL, page 87

Verifying MAC ACL Configurations

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

- switch# **show mac access-lists**
  Displays the MAC ACL configuration
- switch# **show running-config**
  Displays ACL configuration, including MAC ACLs and the interfaces that ACLs are applied to.
- switch# **show running-config interface**
  Displays the configuration of the interface to which you applied the ACL.

Displaying and Clearing MAC ACL Statistics

Use the **show mac access-lists** command to display statistics about a MAC ACL, including the number of packets that have matched each rule.

- switch# **show mac access-lists**
  Displays MAC ACL configuration. If the MAC ACL includes the **statistics** command, the **show mac access-lists** command output includes the number of packets that have matched each rule.
- switch# **clear mac access-list counters**
  Clears statistics for all MAC ACLs or for a specific MAC ACL.

Example Configuration for MAC ACLs

This example shows how to create a MAC ACL named acl-mac-01 and apply it to Ethernet interface 1/1:

```
switch# configure terminal
switch(config)# mac access-list acl-mac-01
switch(config-mac-acl)# permit 00c0.4f00.0000 0000.00ff.ffff any
switch(config-mac-acl)# exit
switch(config)# interface ethernet 1/1
switch(config-if)# mac access-group acl-mac-01
```

Information About VLAN ACLs

A VLAN ACL (VACL) is one application of a MAC ACL or 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 or a MAC ACL to an action. The switch takes the configured action on packets 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 switch 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 5000 Series switch 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 or MAC ACL with an action to be applied to the matching traffic.

To create or change a VACL, perform this task:

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **vlan access-map** *map-name*
3. switch(config-access-map)# **match ip address** *ip-access-list*
4. switch(config-access-map)# **match mac address** *mac-access-list*
5. switch(config-access-map)# **action** {**drop** | **forward**}
6. (Optional) switch(config-access-map)# [**no**] **statistics**
7. (Optional) switch(config-access-map)# **show running-config**
8. (Optional) switch(config-access-map)# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters configuration mode.
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)# **match mac address** *mac-access-list*	Specifies a MAC ACL for the map.
Step 5	switch(config-access-map)# **action** {**drop** | **forward**}	Specifies the action that the switch applies to traffic that matches the ACL.
Step 6	switch(config-access-map)# [**no**] **statistics**	(Optional) 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 7	switch(config-access-map)# **show running-config**	(Optional) Displays ACL configuration.
Step 8	switch(config-access-map)# **copy running-config startup-config**	(Optional) 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 current 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.

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **no vlan access-map** *map-name*
3. (Optional) switch(config)# **show running-config**
4. (Optional) switch(config)# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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	switch(config)# **show running-config**	(Optional) Displays ACL configuration.
Step 4	switch(config)# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Applying a VACL to a VLAN

You can apply a VACL to a VLAN.

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# [**no**] **vlan filter** *map-name* **vlan-list** *list*
3. (Optional) switch(config)# **show running-config**
4. (Optional) switch(config)# **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose
Step 1	switch# **configure terminal**	Enters 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.

	Command or Action	Purpose
Step 3	switch(config)# **show running-config**	(Optional) Displays ACL configuration.
Step 4	switch(config)# **copy running-config startup-config**	(Optional) Copies the running configuration to the startup configuration.

Verifying VACL Configuration

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

- 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:

- 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.

Example Configuration for VACL

This 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 ACLs on Virtual Terminal Lines

To restrict incoming and outgoing connections 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 as necessary for this application.

SUMMARY STEPS

1. switch# **configure terminal**
2. switch(config)# **line vty**
3. switch(config-line)# **access-class access-list-number {in | out}**
4. switch(config-line)# **no access-class access-list-number {in | out}**
5. switch(config-line)# **exit**
6. switch# **show running-config aclmgr**
7. switch# **copy running-config startup-config**

DETAILED STEPS

	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	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)#`
		(Optional) Removes inbound or outbound access restrictions.

Step 5	switch(config-line)# **exit**
	
	Example:
	`switch(config-line)# exit`
	`switch#`
		Exits line configuration mode.

	Command or Action	Purpose
Step 6	switch# **show running-config aclmgr** **Example:** `switch# show running-config aclmgr`	(Optional) Displays the running configuration of the ACLs on the switch.
Step 7	switch# **copy running-config startup-config** **Example:** `switch# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

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

```
switch# conf t
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 *access-list-name*	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   .         14425 *
admin    pts/0        Aug 27 20:06 00:46       14176 (172.18.217.82) session=ssh
admin    pts/1        Aug 27 20:52   .         14584 (10.55.144.118)
```

This example shows the following:

- Applying the ip access-list ozi command to the in direction of the VTY line allows vty connections to all IPv4 hosts except 172.18.217.82.
- Applying the ip access-list ozi2 command to the out direction of the VTY line, denies vty connections to any IPv4 host except 10.55.144.118, 172.18.217.79, 172.18.217.82, 172.18.217.92.
- Applying the ipv6 access-list ozi7 command to the in direction of the VTY line, denies VTY connections to all IPv6 hosts.

- Applying the ipv6 access-list ozip6 command to the out direction of the VTY line, allows VTY connections to all IPv6 hosts.

```
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
ipv6 access-list ozi7
  10 deny tcp any any
ipv6 access-list ozip6
  10 permit tcp any any

line vty
  access-class ozi in
  access-class ozi2 out
  ipv6 access-class ozi7 in
  ipv6 access-class ozip6 out
```

The following examples shows how to configure the ip access-list by enabling per-entry statistics for the ACL.

```
switch# conf t
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# conf t
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#
```

Default ACL Settings

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

Table 18: 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 MAC ACLs parameters.

Table 19: Default MAC ACLs Parameters

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

The following table lists the default settings for VACL parameters.

Table 20: Default VACL Parameters

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

CHAPTER 8

Configuring DHCP Snooping

This chapter describes how to configure Dynamic Host Configuration Protocol (DHCP) snooping on a Cisco NX-OS device.

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 and do not disable the DHCP snooping feature.

Global Enablement

After DHCP snooping is feature 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 received and using 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 may 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 switchs 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 the Cisco NX-OS 5000 Series switch, 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 switchs (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, all DHCP servers must be connected 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 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.

DHCP Snooping Option 82 Data Insertion

DHCP can centrally manage the IP address assignments for a large number of subscribers. When you enable Option 82, the device identifies a subscriber device that connects to the network (in addition to its MAC address). Multiple hosts on the subscriber LAN can connect to the same port on the access device and are uniquely identified.

When you enable Option 82 on the Cisco NX-OS device, the following sequence of events occurs:

1. The host (DHCP client) generates a DHCP request and broadcasts it on the network.
2. When the Cisco NX-OS device receives the DHCP request, it adds the Option 82 information in the packet. The Option 82 information contains the device MAC address (the remote ID suboption) and the port identifier, vlan-mod-port, from which the packet is received (the circuit ID suboption). For hosts behind the port channel, the circuit ID is filled with the if_index of the port channel.
3. The device forwards the DHCP request that includes the Option 82 field to the DHCP server.
4. The DHCP server receives the packet. If the server is Option 82 capable, it can use the remote ID, the circuit ID, or both to assign IP addresses and implement policies, such as restricting the number of IP addresses that can be assigned to a single remote ID or circuit ID. The DHCP server echoes the Option 82 field in the DHCP reply.

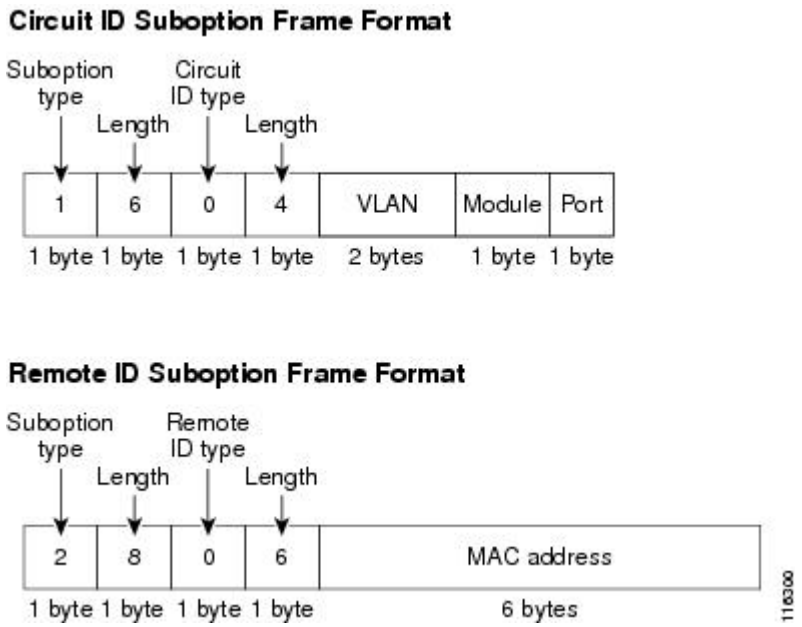
5 The DHCP server sends the reply to the Cisco NX-OS device. The Cisco NX-OS device verifies that it originally inserted the Option 82 data by inspecting the remote ID and possibly the circuit ID fields. The Cisco NX-OS device removes the Option 82 field and forwards the packet to the interface that connects to the DHCP client that sent the DHCP request.

If the previously described sequence of events occurs, the following values do not change:

- Circuit ID suboption fields
  - Suboption type
  - Length of the suboption type
  - Circuit ID type
  - Length of the circuit ID type
- Remote ID suboption fields
  - Suboption type
  - Length of the suboption type
  - Remote ID type
  - Length of the circuit ID type

This figure shows the packet formats for the remote ID suboption and the circuit ID suboption. The Cisco NX-OS device uses the packet formats when you globally enable DHCP snooping and when you enable Option 82 data insertion and removal. For the circuit ID suboption, the module field is the slot number of the module.

Figure 4: Suboption Packet Formats



DHCP Snooping in a vPC Environment

A virtual port channel (vPC) allows two Cisco NX-OS switches to appear as a single logical port channel to a third switch. The third switch can be a switch, server, or any other networking switch that supports port channels.

In a typical vPC environment, DHCP requests can reach one vPC peer switch and the responses can reach the other vPC peer switch, resulting in a partial DHCP (IP-MAC) binding entry in one switch and no binding entry in the other switch. Beginning with Cisco NX-OS Release 5.1, this issue is addressed by using Cisco Fabric Service over Ethernet (CFSoE) distribution to ensure that all DHCP packets (requests and responses) appear on both switches, which helps in creating and maintaining the same binding entry on both switches for all clients behind the vPC link.

CFSoE distribution also allows only one switch to forward the DHCP requests and responses on the vPC link. In non-vPC environments, both switches forward the DHCP packets.

Synchronizing DHCP Snooping Binding Entries

The dynamic DHCP binding entries should be in sync in the following scenarios:

- When the remote vPC is online, all the binding entries for that vPC link should be in sync with the peer.
- When DHCP snooping is enabled on the peer switch, the dynamic binding entries for all vPC links that are up remotely should be in sync with the peer.

Packet Validation

The switch validates DHCP packets received on the untrusted interfaces of VLANs that have DHCP snooping enabled. The switch forwards the DHCP packet unless any of the following conditions occur (in which case, the packet is dropped):

- The switch receives a DHCP response packet (such as a DHCPACK, DHCPNAK, or DHCPOFFER packet) on an untrusted interface.
- The switch receives a packet on an untrusted interface, and the source MAC address and the DHCP client hardware address do not match. This check is performed only if the DHCP snooping MAC address verification option is turned on.
- The switch receives a DHCPRELEASE or DHCPDECLINE message from an untrusted host with an entry in the DHCP snooping binding table, and the interface information in the binding table does not match the interface on which the message was received.

In addition, you can enable strict validation of DHCP packets, which checks the options field of DHCP packets, including the “magic cookie” value in the first four bytes of the options field. By default, strict validation is disabled. When you enable it, by using the **ip dhcp packet strict-validation** command, if DHCP snooping processes a packet that has an invalid options field, it drops the packet.

Information About the DHCP Relay Agent

DHCP Relay Agent

You can configure the device to run a DHCP relay agent, which forwards DHCP packets between clients and servers. This feature is useful when clients and servers are not on the same physical subnet. Relay agent forwarding is distinct from the normal forwarding of an IP router, where IP datagrams are switched between networks somewhat transparently. By contrast, relay agents receive DHCP messages and then generate a new DHCP message to send out on another interface. The relay agent sets the gateway address (giaddr field of the DHCP packet) and, if configured, adds the relay agent information option (Option 82) in the packet and forwards it to the DHCP server. The reply from the server is forwarded back to the client after removing Option 82.

Note When the device relays a DHCP request that already includes Option 82 information, the device forwards the request with the original Option 82 information without altering it.

VRF Support for the DHCP Relay Agent

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

Enabling VRF support for the DHCP relay agent requires that you enable Option 82 for the DHCP relay agent.

If a DHCP request arrives on an interface that you have configured with a DHCP relay address and VRF information and the address of the DCHP server belongs to a network on an interface that is a member of a different VRF, the device inserts Option 82 information in the request and forwards it to the DHCP server in the server VRF. The Option 82 information that the devices adds to a DHCP request relayed to a different VRF includes the following:

VPN identifier	Contains the name of the VRF that the interface that receives the DHCP request is a member of.
Link selection	Contains the subnet address of the interface that receives the DHCP request.
Server identifier override	Contains the IP address of the interface that receives the DHCP request.

Note The DHCP server must support the VPN identifier, link selection, and server identifier override options.

When the device receives the DHCP response message, it strips off the Option 82 information and forwards the response to the DHCP client in the client VRF.

DHCP Relay Binding Database

A relay binding is an entity that associates a DHCP or BOOTP client with a relay agent address and its subnet. Each relay binding stores the client MAC address, active relay agent address, active relay agent address mask, logical and physical interfaces to which the client is connected, giaddr retry count, and total retry count. The giaddr retry count is the number of request packets transmitted with that relay agent address, and the total retry count is the total number of request packets transmitted by the relay agent. One relay binding entry is maintained for each DHCP or BOOTP client.

Guidelines and Limitations for DHCP Snooping

DHCP snooping has the following configuration guidelines and limitations:

- 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 acting as the DHCP server 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.
- Make sure that the DHCP configuration is synchronized across the switches in a vPC link. Otherwise, a run-time error can occur, resulting in dropped packets.

Default Settings for DHCP Snooping

This table lists the default settings for DHCP snooping parameters.

Table 21: Default DHCP Snooping Parameters

Parameters	Default
DHCP snooping feature	Disabled
DHCP snooping globally enabled	No
DHCP snooping VLAN	None
DHCP snooping Option 82 support	Disabled
DHCP snooping trust	Untrusted

Configuring DHCP Snooping

Minimum DHCP Snooping Configuration

Step 1 Enable the DHCP snooping feature.
When the DHCP snooping feature is disabled, you cannot configure DHCP snooping.

Step 2 Enable DHCP snooping globally.

Step 3 Enable DHCP snooping on at least one VLAN.
By default, DHCP snooping is disabled on all VLANs.

Step 4 Ensure that the DHCP server is connected to the switch using a trusted interface.

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.

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.

SUMMARY STEPS

1. **config t**
2. [**no**] **feature dhcp**
3. **show running-config dhcp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`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.

	Command or Action	Purpose
Step 3	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	Shows the DHCP snooping configuration.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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. It preserves DCHP snooping configuration.

Before You Begin

Ensure that you have enabled the DHCP snooping feature.

By default, DHCP snooping is globally disabled.

SUMMARY STEPS

1. **config t**
2. [**no**] **ip dhcp snooping**
3. **show running-config dhcp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`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.
Step 3	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	Shows the DHCP snooping configuration.

	Command or Action	Purpose
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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.

SUMMARY STEPS

1. **config t**
2. [**no**] **ip dhcp snooping vlan** *vlan-list*
3. **show running-config dhcp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **ip dhcp snooping vlan** *vlan-list* **Example:** `switch(config)# ip dhcp snooping vlan 100,200,250-252`	Enables DHCP snooping on the VLANs specified by *vlan-list* . The **no** option disables DHCP snooping on the VLANs specified.
Step 3	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	Shows the DHCP snooping configuration.

	Command or Action	Purpose
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

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.

Before You Begin

By default, the switch does not include Option 82 information in DHCP packets.

Ensure that DHCP snooping is enabled.

SUMMARY STEPS

1. **config t**
2. [**no**] **ip dhcp snooping information option**
3. **show running-config dhcp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`switch(config)#`
		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 from DHCP packets. The **no** option disables the insertion and removal of Option 82 information.
Step 3	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	Shows the DHCP snooping configuration.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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.

SUMMARY STEPS

1. **config t**
2. [**no**] **ip dhcp packet strict-validation**
3. **show running-config dhcp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`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	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	Shows the DHCP snooping configuration.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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.

SUMMARY STEPS

1. **config t**
2. Do one of the following options.
   - **interface ethernet** *slot* / *port*
   - **interface port-channel** *channel-number*
3. [**no**] **ip dhcp snooping trust**
4. **show running-config dhcp**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	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.
	• **interface ethernet** *slot* / *port*
	• **interface port-channel** *channel-number*
	
	Example:
	`switch(config)# interface ethernet 2/1`
	`switch(config-if)#`
		• Enters interface configuration mode, where *slot* / *port* is the Layer 2 Ethernet interface that you want to configure as trusted or untrusted for DHCP snooping.
		• Enters interface configuration mode, where *slot* / *port* 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** **Example:** `switch(config-if)# 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	**show running-config dhcp** **Example:** `switch(config-if)# show running-config dhcp`	Shows the DHCP snooping configuration.
Step 5	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) 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.

SUMMARY STEPS

1. **config t**
2. [**no**] **ip dhcp relay**
3. (Optional) **show ip dhcp relay**
4. (Optional) **show running-config dhcp**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **ip dhcp relay** **Example:** `switch(config)# ip dhcp relay`	Enables the DHCP relay agent. The **no** option disables the DHCP relay agent.
Step 3	**show ip dhcp relay** **Example:** `switch(config)# show ip dhcp relay`	(Optional) Displays the DHCP relay configuration.
Step 4	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	(Optional) Displays the DHCP configuration.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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.

SUMMARY STEPS

1. **config t**
2. [**no**] **ip dhcp relay information option**
3. (Optional) **show ip dhcp relay**
4. (Optional) **show running-config dhcp**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`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 **no** option disables this behavior.
Step 3	**show ip dhcp relay** **Example:** `switch(config)# show ip dhcp relay`	(Optional) Displays the DHCP relay configuration.
Step 4	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	(Optional) Displays the DHCP configuration.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Enabling or Disabling VRF Support for the DHCP Relay Agent

You can configure the device to support the relaying of DHCP requests that arrive on an interface in one VRF to a DHCP server in a different VRF.

Before You Begin

You must enable Option 82 for the DHCP relay agent.

SUMMARY STEPS

1. **config t**
2. [**no**] **ip dhcp relay information option vpn**
3. [**no**] **ip dhcp relay sub-option type cisco**
4. (Optional) **show ip dhcp relay**
5. (Optional) **show running-config dhcp**
6. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **ip dhcp relay information option vpn** **Example:** `switch(config)# ip dhcp relay information option vpn`	Enables VRF support for the DHCP relay agent. The **no** option disables this behavior.
Step 3	[**no**] **ip dhcp relay sub-option type cisco** **Example:** `switch(config)# ip dhcp relay sub-option type cisco`	Enables DHCP to use Cisco proprietary numbers 150, 152, and 151 when filling the link selection, server ID override, and VRF name/VPN ID relay agent Option 82 suboptions. The **no** option causes DHCP to use RFC numbers 5, 11, and 151 for the link selection, server ID override, and VRF name/VPN ID suboptions, respectively.
Step 4	**show ip dhcp relay** **Example:** `switch(config)# show ip dhcp relay`	(Optional) Displays the DHCP relay configuration.
Step 5	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	(Optional) Displays the DHCP configuration.
Step 6	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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.

SUMMARY STEPS

1. **config t**
2. **ip source binding** *IP-address MAC-address* **vlan** *vlan-id* {**interface ethernet** *slot/port* | **port-channel** *channel-no*}
3. (Optional) **show ip dhcp snooping binding**
4. (Optional) **show ip dhcp snooping binding dynamic**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**config t**
	
	Example:
	`switch# config t`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**ip source binding** *IP-address MAC-address* **vlan** *vlan-id* {**interface ethernet** *slot/port*	**port-channel** *channel-no*} **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	**show ip dhcp snooping binding** **Example:** `switch(config)#  ip dhcp snooping binding`	(Optional) Shows the DHCP snooping static and dynamic bindings.
Step 4	**show ip dhcp snooping binding dynamic** **Example:** `switch(config)#  ip dhcp snooping binding dynamic`	(Optional) Shows the DHCP snooping dynamic bindings.
Step 5	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

This 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)#
```

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 *Cisco Nexus 5000 Series NX-OS Security Command Reference*.

Command	Purpose
show running-config dhcp	Displays the DHCP snooping 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 *Cisco Nexus 5000 Series NX-OS Security Command Reference, Release 5.x*.

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.

SUMMARY STEPS

1. (Optional) **clear ip dhcp snooping binding**
2. (Optional) **clear ip dhcp snooping binding interface ethernet** *slot*/*port*[.*subinterface-number*]
3. (Optional) **clear ip dhcp snooping binding interface port-channel** *channel-number*[.*subchannel-number*]
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*] }
5. **show ip dhcp snooping binding**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**clear ip dhcp snooping binding** **Example:** `switch# clear ip dhcp snooping binding`	(Optional) Clears all entries from the DHCP snooping binding database.
Step 2	**clear ip dhcp snooping binding interface ethernet** *slot*/*port*[.*subinterface-number*] **Example:** `switch# clear ip dhcp snooping binding interface ethernet 1/4`	(Optional) Clears entries associated with a specific Ethernet interface from the DHCP snooping binding database.
Step 3	**clear ip dhcp snooping binding interface port-channel** *channel-number*[.*subchannel-number*] **Example:** `switch# clear ip dhcp snooping binding interface port-channel 72`	(Optional) Clears entries associated with a specific port-channel interface from the DHCP snooping binding database.
Step 4	**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`	(Optional) Clears a single, specific entry from the DHCP snooping binding database.
Step 5	**show ip dhcp snooping binding** **Example:** `switch# show ip dhcp snooping binding`	Displays the DHCP snooping binding database.

Configuration Examples for DHCP Snooping

This 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 9

Configuring Dynamic ARP Inspection

This chapter describes how to configure dynamic Address Resolution Protocol (ARP) inspection (DAI) on a Cisco Nexus 5000 Series switch.

This chapter includes the following sections:

Information About DAI

Understanding 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.

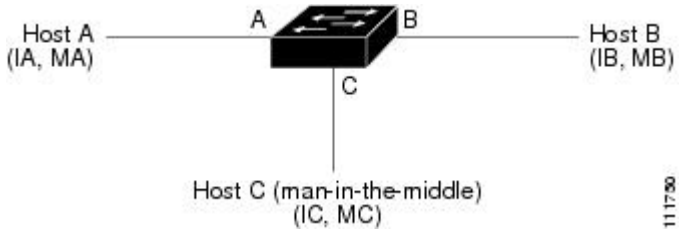
Understanding ARP Spoofing Attacks

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.

This figure shows an example of ARP cache poisoning.

Figure 5: ARP Cache Poisoning



Hosts A, B, and C are connected to the device on interfaces A, B, and C, all of 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.

Understanding 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 NX-OS 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:

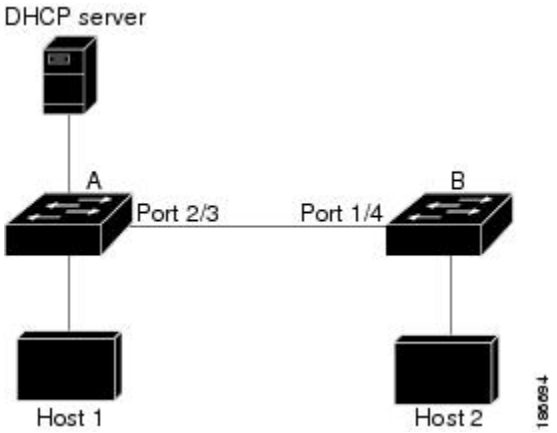
Untrusted	Interfaces that are connected to hosts
Trusted	Interfaces that are connected to devices

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.

In this 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.

Figure 6: ARP Packet Validation on a VLAN Enabled for DAI



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, then the guidelines for configuring the trust state of interfaces on a device running 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 are not running DAI, configure ARP ACLs on the device running 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 NX-OS 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

DAI has the following prerequisite:

- 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, DHCP snooping must configured 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 22: Default DAI Parameters

Parameters	Default
DAI	Disabled on all VLANs.
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.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **ip arp inspection vlan** *list*
3. (Optional) **show ip arp inspection vlan** *list*
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **ip arp inspection vlan** *list* **Example:** `switch(config)# ip arp inspection vlan 13`	Enables DAI for the specified list of VLANs. The **no** option disables DAI for the specified VLANs.
Step 3	**show ip arp inspection vlan** *list* **Example:** `switch(config)# show ip arp inspection vlan 13`	(Optional) Shows the DAI status for the specified list of VLANs.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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, 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.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type slot* / *number*
3. [**no**] **ip arp inspection trust**
4. (Optional) **show ip arp inspection interface** *type slot* / *number*
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**interface** *type slot* / *number*
	
	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	**show ip arp inspection interface** *type slot* / *number* **Example:** `switch(config-if)# show ip arp inspection interface ethernet 2/1`	(Optional) Displays the trust state and the ARP packet rate for the specified interface.
Step 5	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) 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.

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.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **ip arp inspection validate** {[**src-mac**] [**dst-mac**] [**ip**]}
3. (Optional) **show running-config dhcp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

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	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	(Optional) Displays the DHCP snooping configuration, including the DAI configuration.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **ip arp inspection log-buffer entries** *number*
3. (Optional) **show running-config dhcp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	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 0 and 2048 messages.
Step 3	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	(Optional) Displays the DHCP snooping configuration, including the DAI configuration.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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.

SUMMARY STEPS

1. **configure terminal**
2. Enter one of the following commands:
   - **ip arp inspection vlan** *vlan-list* **logging dhcp-bindings all**
   - **ip arp inspection vlan** *vlan-list* **logging dhcp-bindings none**
   - **ip arp inspection vlan** *vlan-list* **logging dhcp-bindingspermit**
   - **no ip arp inspection vlan** *vlan-list* **logging dhcp-bindings** {**all** | **none** | **permit**}
3. (Optional) **show running-config dhcp**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	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: • **ip arp inspection vlan** *vlan-list* **logging dhcp-bindings all** • **ip arp inspection vlan** *vlan-list* **logging dhcp-bindings none** • **ip arp inspection vlan** *vlan-list* **logging dhcp-bindingspermit** • **no ip arp inspection vlan** *vlan-list* **logging dhcp-bindings** {**all**	**none**	**permit**} **Example:** `switch(config)# ip arp inspection vlan 100 dhcp-bindings permit`	Configures DAI log filtering, as follows. The **no** option removes DAI log filtering. • 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	**show running-config dhcp** **Example:** `switch(config)# show running-config dhcp`	(Optional) Displays the DHCP snooping configuration, including the DAI configuration.
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) 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 running-config arp	Displays DAI configuration.
show ip arp inspection	Displays the status of DAI.
show ip arp inspection interface ethernet	Displays the trust state and ARP packet rate for a specific interface.
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

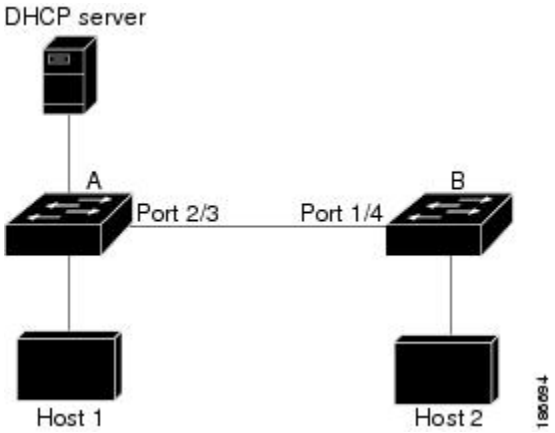
Configuration Examples for DAI

Example 1 Two Devices Support DAI

These procedures show how to configure DAI when two devices support DAI.

This 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.

Figure 7: Two Devices Supporting 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. 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:

Step 1 While logged into device A, verify the connection between device A and device B.

Example:

```
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.

Example:

```
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.

Example:

```
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.

Example:

```
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.

Example:

```
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, 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:

Step 1 While logged into device B, verify the connection between device B and device A.

Example:

```
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.

Example:

```
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.

Example:

```
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.

Example:

```
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.

Example:

```
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#
```

Example 1 Two Devices Support DAI

CHAPTER 10

Configuring IP Source Guard

This chapter describes how to configure IP Source Guard on the Cisco Nexus 5000 Series switch.

This chapter includes the following sections:

Information About IP Source Guard

IP Source Guard is a per-interface traffic filter that permits IP traffic only when the IP address and MAC address of each packet matches one of two sources of IP and MAC address bindings:

- Entries in the Dynamic Host Configuration Protocol (DHCP) snooping binding table.
- Static IP source entries that you configure.

Filtering on trusted IP and MAC address bindings helps prevent spoofing attacks, in which an attacker uses the IP address of a valid host to gain unauthorized network access. To circumvent IP Source Guard, an attacker would have to spoof both the IP address and the MAC address of a valid host.

You can enable IP Source Guard on Layer 2 interfaces that are not trusted by DHCP snooping. IP Source Guard supports interfaces that are configured to operate in access mode and trunk mode. When you initially enable IP Source Guard, all inbound IP traffic on the interface is blocked except for the following:

- DHCP packets, which DHCP snooping inspects and then forwards or drops, depending upon the results of inspecting the packet.

- IP traffic from static IP source entries that you have configured in the Cisco NX-OS device.

The device permits the IP traffic when DHCP snooping adds a binding table entry for the IP address and MAC address of an IP packet or when you have configured a static IP source entry.

The device drops IP packets when the IP address and MAC address of the packet do not have a binding table entry or a static IP source entry. For example, assume that :

```
MacAddress          IpAddress    LeaseSec   Type         VLAN      Interface
----------          ----------   ---------  ------       -------    ---------
00:02:B3:3F:3B:99   10.5.5.2       6943    dhcp-snooping  10      Ethernet2/3
```

If the device receives an IP packet with an IP address of 10.5.5.2, IP Source Guard forwards the packet only if the MAC address of the packet is 00:02:B3:3F:3B:99.

Licensing Requirements for IP Source Guard

This table shows the licensing requirements for IP Source Guard.

Product	License Requirement
Cisco NX-OS	IP Source Guard 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 IP Source Guard

Guidelines and Limitations for IP Source Guard

IP Source Guard has the following configuration guidelines and limitations:

- IP Source Guard limits IP traffic on an interface to only those sources that have an IP-MAC address binding table entry or static IP source entry. When you first enable IP Source Guard on an interface, you may experience disruption in IP traffic until the hosts on the interface receive a new IP address from a DHCP server.
- IP Source Guard is dependent upon DHCP snooping to build and maintain the IP-MAC address binding table or upon manual maintenance of static IP source entries.

Default Settings for IP Source Guard

This table lists the default settings for IP Source Guard parameters.

Table 23: Default IP Source Guard Parameters

Parameters	Default
IP Source Guard	Disabled on each interface.

Parameters	Default
IP source entries	None. No static or default IP source entries exist by default.

Configuring IP Source Guard

Enabling or Disabling IP Source Guard on a Layer 2 Interface

You can enable or disable IP Source Guard on a Layer 2 interface. By default, IP Source Guard is disabled on all interfaces.

Before You Begin

Ensure that the DHCP feature is enabled.

SUMMARY STEPS

1. **configure terminal**
2. **interface ethernet** *slot*/*port*
3. [**no**] **ip verify source dhcp-snooping-vlan**
4. (Optional) **show running-config dhcp**
5. (Optional) **copy running-config startup-config**

DETAILED STEPS

	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)#`
		Enters interface configuration mode for the specified interface.

Step 3	[**no**] **ip verify source dhcp-snooping-vlan** **Example:** `switch(config-if)# ip verify source dhcp-snooping vlan`	Enables IP Source Guard on the interface. The **no** option disables IP Source Guard on the interface.

	Command or Action	Purpose
Step 4	**show running-config dhcp** **Example:** `switch(config-if)# show running-config dhcp`	(Optional) Displays the running configuration for DHCP snooping, including the IP Source Guard configuration.
Step 5	**copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Adding or Removing a Static IP Source Entry

You can add or remove a static IP source entry on a device. By default, there are no static IP source entries on a device.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **ip source binding** *IP-address MAC-address* **vlan** *vlan-ID* **interface ethernet** *slot*/*port*
3. (Optional) **show ip dhcp snooping binding** [**interface ethernet** *slot*/*port*]
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **ip source binding** *IP-address MAC-address* **vlan** *vlan-ID* **interface ethernet** *slot*/*port* **Example:** `switch(config)# ip source binding 10.5.22.17 001f.28bd.0013 vlan 100 interface ethernet 2/3`	Creates a static IP source entry for the current interface, or if you use the **no** option, removes a static IP source entry.
Step 3	**show ip dhcp snooping binding** [**interface ethernet** *slot*/*port*] **Example:** `switch(config)# show ip dhcp snooping binding interface ethernet 2/3`	(Optional) Displays IP-MAC address bindings for the interface specified, including static IP source entries. Static entries appear with the term in the Type column.

	Command or Action	Purpose
Step 4	**copy running-config startup-config** **Example:** `switch(config)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Displaying IP Source Guard Bindings

Use the **show ip verify source** command to display IP-MAC address bindings.

Configuration Example for IP Source Guard

This example shows how to create a static IP source entry and then how to enable IP Source Guard on an interface.

```
ip source binding 10.5.22.17 001f.28bd.0013 vlan 100 interface ethernet 2/3
interface ethernet 2/3
  no shutdown
  ip verify source dhcp-snooping-vlan
```

Additional References for IP Source Guard

Standards

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

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