Security Configuration Guide, Cisco Catalyst IE9300 Rugged Series Switches

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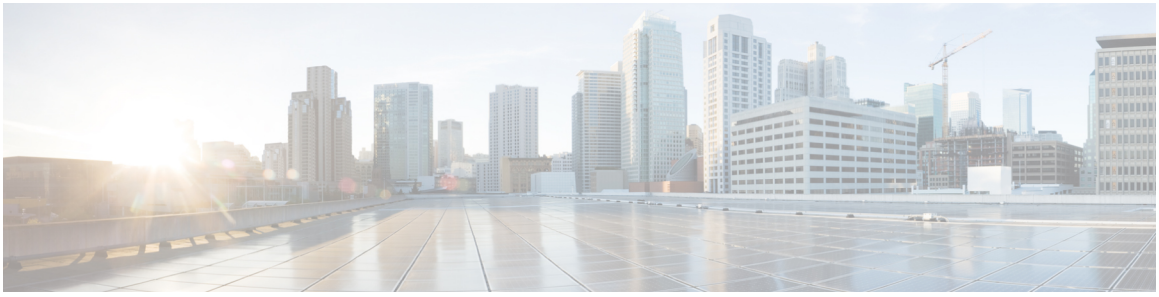

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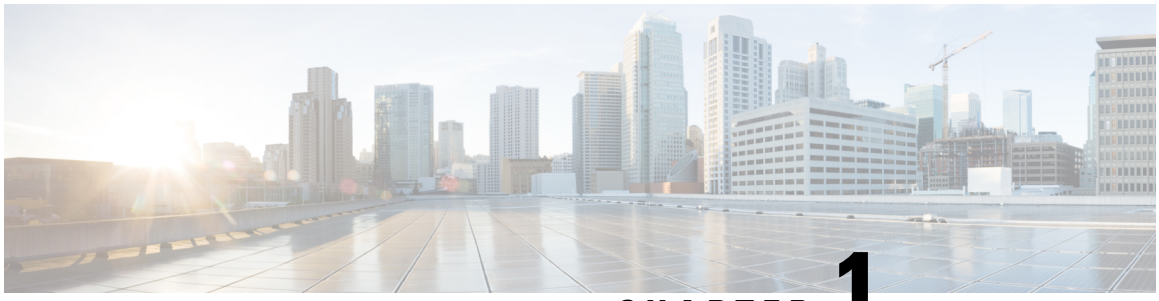


CHAPTER 1

Configuring RADIUS

Prerequisites for Configuring RADIUS

This section lists the prerequisites for controlling device access with RADIUS.

General:

- RADIUS and Authentication, Authorization, and Accounting (AAA) must be enabled to use any of the configuration commands in this chapter.
- RADIUS is facilitated through AAA and can be enabled only through AAA commands.
- Use the **aaa new-model** global configuration command to enable AAA.
- Use the **aaa authentication** global configuration command to define method lists for RADIUS authentication.
- Use **line** and **interface** commands to enable the defined method lists to be used.
- At a minimum, you must identify the host or hosts that run the RADIUS server software and define the method lists for RADIUS authentication. You can optionally define method lists for RADIUS authorization and accounting.
- You should have access to and should configure a RADIUS server before configuring RADIUS features on your device.
- The RADIUS host is normally a multiuser system running RADIUS server software from Cisco (Cisco ISE), Livingston, Merit, Microsoft, or another software provider. For more information, see the RADIUS server documentation.
- To use the Change-of-Authorization (CoA) interface, a session must already exist on the switch. CoA can be used to identify a session and enforce a disconnect request. The update affects only the specified session.

RADIUS operation:

- Users must first successfully complete RADIUS authentication before proceeding to RADIUS authorization, if it is enabled.
- For RADIUS over IPv6 configurations, users must enable IPv6 unicast routing by enabling the **ipv6 unicast-routing** command.

Restrictions for Configuring RADIUS

General:

- To prevent a lapse in security, you cannot configure RADIUS through a network management application.
- Radius and AAA servers can be configured to run only on the standard default ports:
  - 1812 and 1813
  - 1645 and 1646

RADIUS is not suitable in the following network security situations:

- Multiprotocol access environments. RADIUS does not support AppleTalk Remote Access (ARA), NetBIOS Frame Control Protocol (NBFCP), NetWare Asynchronous Services Interface (NASI), or X.25 PAD connections.
- Switch-to-switch or router-to-router situations. RADIUS does not provide two-way authentication. RADIUS can be used to authenticate from one device to a non-Cisco device if the non-Cisco device requires authentication.
- Networks using a variety of services. RADIUS generally binds a user to one service model.

DSCP marking support for RADIUS packets:

- DSCP marking for authentication and accounting is not supported for private servers, fully qualified domain name (FQDN) servers and radsec servers.
- In the case of wired IEEE 802.1x authentication, when source port extension is not enabled, the default ports are in use. The DSCP marking is set to the default ports and all the requests will be marked with the same DSCP value.
- DSCP marking is not supported in the case of wireless IEEE 802.1x authentication, where the source port extension is enabled by default.

Information about RADIUS

RADIUS and Switch Access

This section describes how to enable and configure RADIUS. RADIUS provides detailed accounting information and flexible administrative control over the authentication and authorization processes.

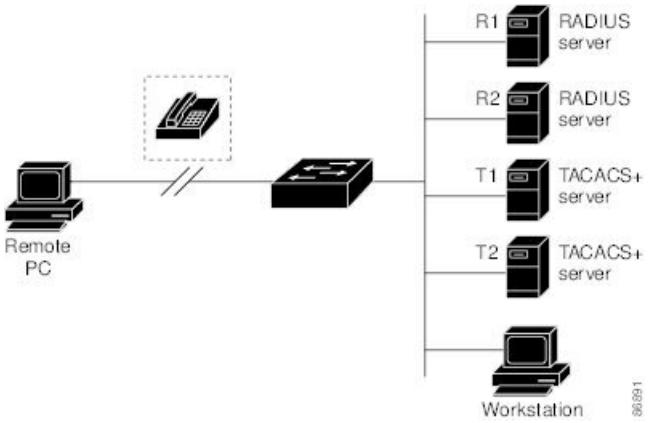
RADIUS Overview

RADIUS is a distributed client/server system that secures networks against unauthorized access. RADIUS clients run on supported Cisco devices. Clients send authentication requests to a central RADIUS server, which contains all user authentication and network service access information.

Use RADIUS in these network environments that require access security:

- Networks with multiple-vendor access servers, each supporting RADIUS. For example, access servers from several vendors use a single RADIUS server-based security database. In an IP-based network with multiple vendors' access servers, dial-in users are authenticated through a RADIUS server that has been customized to work with the Kerberos security system.
- Turnkey network security environments in which applications support the RADIUS protocol, such as in an access environment that uses a *smart card* access control system.
- Networks already using RADIUS. You can add a Cisco device containing a RADIUS client to the network. This might be the first step when you make a transition to a TACACS+ server. See the illustration: Transitioning from RADIUS to TACACS+ Services below.

Figure 1: Transitioning from RADIUS to TACACS+ Services



- Network in which the user must only access a single service. Using RADIUS, you can control user access to a single host, to a single utility such as Telnet, or to the network through a protocol such as IEEE 802.1x. For more information about this protocol, see the chapter *Configuring IEEE 802.1x Port-Based Authentication*.
- Networks that require resource accounting. You can use RADIUS accounting independently of RADIUS authentication or authorization. The RADIUS accounting functions allow data to be sent at the start and end of services, showing the amount of resources (such as time, packets, bytes, and so forth) used during the session. An Internet service provider might use a freeware-based version of RADIUS access control and accounting software to meet special security and billing needs.

RADIUS Operation

When a user attempts to log in and authenticate to a device that is access controlled by a RADIUS server, these events occur:

1. The user is prompted to enter 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 either not authenticated and is prompted to re-enter the username and password, or access is denied.
   - CHALLENGE—A challenge requires additional data from the user.
   - CHALLENGE PASSWORD—A response requests the user to select a new password.

   The ACCEPT or REJECT response is bundled with additional data that is used for privileged EXEC or network authorization. The additional data included with the ACCEPT or REJECT packets includes these items:

   - Telnet, SSH, rlogin, or privileged EXEC services
   - Connection parameters, including the host or client IP address, access list, and user timeouts

RADIUS Change of Authorization

The RADIUS Change of Authorization (CoA) provides a mechanism to change the attributes of an authentication, authorization, and accounting (AAA) session after it is authenticated. When a policy changes for a user or user group in AAA, administrators can send RADIUS CoA packets from the AAA server such as a Cisco Secure Access Control Server (ACS) to reinitialize authentication and apply the new policy. This section provides an overview of the RADIUS interface including available primitives and how they are used during a CoA.

- Change-of-Authorization Requests
- CoA Request Response Code
- CoA Request Commands
- Session Reauthentication
- Stacking Guidelines for Session Termination

A standard RADIUS interface is typically used in a pulled model where the request originates from a network attached device and the response come from the queried servers. Cisco devices support the RADIUS CoA extensions defined in RFC 5176 that are typically used in a pushed model and allow for the dynamic reconfiguring of sessions from external AAA or policy servers.

Cisco devices supports these per-session CoA requests:

- Session reauthentication
- Session termination
- Session termination with port shutdown
- Session termination with port bounce

This feature is integrated with Cisco Secure Access Control Server (ACS) 5.1.

The RADIUS interface is enabled by default on Cisco devices. However, some basic configuration is required for the following attributes:

- Security and Password—refer to the "Preventing Unauthorized Access to Your Switch" section in this guide.
- Accounting—refer to the "Starting RADIUS Accounting" section in the Configuring Switch-Based Authentication chapter in this guide.

Cisco IOS XE software supports the RADIUS CoA extensions defined in RFC 5176 that are typically used in a push model to allow the dynamic reconfiguring of sessions from external AAA or policy servers. Per-session CoA requests are supported for session identification, session termination, host reauthentication, port shutdown, and port bounce. This model comprises one request (CoA-Request) and two possible response codes:

- CoA acknowledgement (ACK) [CoA-ACK]
- CoA nonacknowledgement (NAK) [CoA-NAK]

The request is initiated from a CoA client (typically a AAA or policy server) and directed to the device that acts as a listener.

The table below shows the RADIUS CoA commands and vendor-specific attributes (VSAs) supported by Identity-Based Networking Services. All CoA commands must include the session identifier between the device and the CoA client.

Table 1: RADIUS CoA Commands Supported by Identity-Based Networking Services

CoA Command	Cisco VSA
Activate service	Cisco:Avpair="subscriber:command=activate-service" Cisco:Avpair="subscriber:service-name=<*service-name*>" Cisco:Avpair="subscriber:precedence=<*precedence-number*>" Cisco:Avpair="subscriber:activation-mode=replace-all"
Deactivate service	Cisco:Avpair="subscriber:command=deactivate-service" Cisco:Avpair="subscriber:service-name=<*service-name*>"
Bounce host port	Cisco:Avpair="subscriber:command=bounce-host-port"
Disable host port	Cisco:Avpair="subscriber:command=disable-host-port"
Session query	Cisco:Avpair="subscriber:command=session-query"
Session reauthenticate	Cisco:Avpair="subscriber:command=reauthenticate" Cisco:Avpair="subscriber:reauthenticate-type=last" or Cisco:Avpair="subscriber:reauthenticate-type=rerun"
Session terminate	This is a standard disconnect request and does not require a VSA.
Interface template	Cisco:AVpair="interface-template-name=<*interfacetemplate*>"

Change-of-Authorization Requests

Change of Authorization (CoA) requests, as described in RFC 5176, are used in a push model to allow for session identification, host reauthentication, and session termination. The model is comprised of one request (CoA-Request) and two possible response codes:

- CoA acknowledgment (ACK) [CoA-ACK]
- CoA non-acknowledgment (NAK) [CoA-NAK]

The request is initiated from a CoA client (typically a RADIUS or policy server) and directed to the switch that acts as a listener.

RFC 5176 Compliance

The Disconnect Request message, which is also referred to as Packet of Disconnect (POD), is supported by the switch for session termination.

This table shows the IETF attributes are supported for this feature.

Table 2: Supported IETF Attributes

Attribute Number	Attribute Name
24	State
31	Calling-Station-ID
44	Acct-Session-ID
80	Message-Authenticator
101	Error-Cause

This table shows the possible values for the Error-Cause attribute.

Table 3: Error-Cause Values

Value	Explanation
201	Residual Session Context Removed
202	Invalid EAP Packet (Ignored)
401	Unsupported Attribute
402	Missing Attribute
403	NAS Identification Mismatch
404	Invalid Request
405	Unsupported Service
406	Unsupported Extension

Value	Explanation
407	Invalid Attribute Value
501	Administratively Prohibited
502	Request Not Routable (Proxy)
503	Session Context Not Found
504	Session Context Not Removable
505	Other Proxy Processing Error
506	Resources Unavailable
507	Request Initiated
508	Multiple Session Selection Unsupported

CoA Request Response Code

The CoA Request response code can be used to convey a command to the switch.

The packet format for a CoA Request Response code as defined in RFC 5176 consists of the following fields: Code, Identifier, Length, Authenticator, and Attributes in the Type:Length:Value (TLV) format. The Attributes field is used to carry Cisco vendor-specific attributes (VSAs).

Session Identification

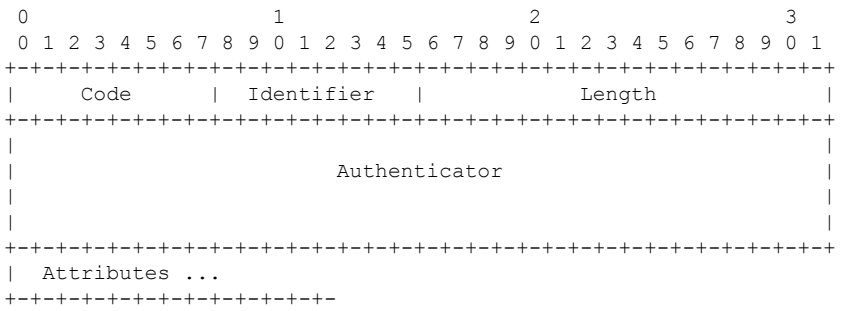
For disconnect and CoA requests targeted at a particular session, the switch locates the session based on one or more of the following attributes:

- Acct-Session-Id (IETF attribute #44)
- Audit-Session-Id (Cisco VSA)
- Calling-Station-Id (IETF attribute #31 which contains the host MAC address)
- IPv6 Attributes, which can be one of the following:
  - Framed-IPv6-Prefix (IETF attribute #97) and Framed-Interface-Id (IETF attribute #96), which together create a full IPv6 address per RFC 3162
  - Framed-IPv6-Address
- Plain IP Address (IETF attribute #8)

Unless all session identification attributes included in the CoA message match the session, the switch returns a Disconnect-NAK or CoA-NAK with the “Invalid Attribute Value” error-code attribute.

If more than one session identification attribute is included in the message, all the attributes must match the session or the switch returns a Disconnect- negative acknowledgment (NAK) or CoA-NAK with the error code “Invalid Attribute Value.”

The packet format for a CoA Request code as defined in RFC 5176 consists of the fields: Code, Identifier, Length, Authenticator, and Attributes in Type:Length:Value (TLV) format.



The attributes field is used to carry Cisco vendor-specific attributes (VSAs).

For CoA requests targeted at a particular enforcement policy, the device returns a CoA-NAK with the error code “Invalid Attribute Value” if any of the above session identification attributes are included in the message.

CoA ACK Response Code

If the authorization state is changed successfully, a positive acknowledgment (ACK) is sent. The attributes returned within CoA ACK will vary based on the CoA Request and are discussed in individual CoA Commands.

CoA NAK Response Code

A negative acknowledgment (NAK) indicates a failure to change the authorization state and can include attributes that indicate the reason for the failure. Use **show** commands to verify a successful CoA.

CoA Request Commands

Table 4: Supported CoA Commands

Command [1]	Cisco VSA
Reauthenticate host	Cisco:Avpair=“subscriber:command=reauthenticate”
Terminate session	This is a standard disconnect request that does not require a VSA.
Bounce host port	Cisco:Avpair=“subscriber:command=bounce-host-port”
Disable host port	Cisco:Avpair=“subscriber:command=disable-host-port”

[1] All CoA commands must include the session identifier between the device and the CoA client.

Session Reauthentication

The AAA server typically generates a session reauthentication request when a host with an unknown identity or posture joins the network and is associated with a restricted access authorization profile (such as a guest VLAN). A reauthentication request allows the host to be placed in the appropriate authorization group when its credentials are known.

To initiate session authentication, the AAA server sends a standard CoA-Request message which contains a Cisco VSA in this form: *Cisco:Avpair=“subscriber:command=reauthenticate”* and one or more session identification attributes.

The current session state determines the switch response to the message. If the session is currently authenticated by IEEE 802.1x, the switch responds by sending an EAPoL (Extensible Authentication Protocol over Lan) -RequestId message to the server.

If the session is currently authenticated by MAC authentication bypass (MAB), the switch sends an access-request to the server, passing the same identity attributes used for the initial successful authentication.

If session authentication is in progress when the switch receives the command, the switch terminates the process, and restarts the authentication sequence, starting with the method configured to be attempted first.

If the session is not yet authorized, or is authorized via guest VLAN, or critical VLAN, or similar policies, the reauthentication message restarts the access control methods, beginning with the method configured to be attempted first. The current authorization of the session is maintained until the reauthentication leads to a different authorization result.

Session Termination

There are three types of CoA requests that can trigger session termination. A CoA Disconnect-Request terminates the session, without disabling the host port. This command causes re-initialization of the authenticator state machine for the specified host, but does not restrict that host access to the network.

To restrict a host's access to the network, use a CoA Request with the Cisco:Avpair="subscriber:command=disable-host-port" VSA. This command is useful when a host is known to be causing problems on the network, and you need to immediately block network access for the host. When you want to restore network access on the port, re-enable it using a non-RADIUS mechanism.

When a device with no supplicant, such as a printer, needs to acquire a new IP address (for example, after a VLAN change), terminate the session on the host port with port-bounce (temporarily disable and then re-enable the port).

CoA Disconnect-Request

This command is a standard Disconnect-Request. If the session cannot be located, the device returns a Disconnect-NAK message with the "Session Context Not Found" error-code attribute. If the session is located, the device terminates the session. After the session has been completely removed, the device returns a Disconnect-ACK.

If the device fails-over to a standby device before returning a Disconnect-ACK to the client, the process is repeated on the new active device when the request is re-sent from the client. If the session is not found following re-sending, a Disconnect-ACK is sent with the "Session Context Not Found" error-code attribute.

CoA Request: Disable Host Port

The RADIUS server CoA disable port command administratively shuts down the authentication port that is hosting a session, resulting in session termination. This command is useful when a host is known to cause problems on the network and network access needs to be immediately blocked for the host. To restore network access on the port, reenable it using a non-RADIUS mechanism. This command is carried in a standard CoA-Request message that has this new vendor-specific attribute (VSA):

Cisco:Avpair="subscriber:command=disable-host-port"

Because this command is session-oriented, it must be accompanied by one or more of the session identification attributes described in the "Session Identification" section. If the session cannot be located, the device returns a CoA-NAK message with the "Session Context Not Found" error-code attribute. If the session is located, the device disables the hosting port and returns a CoA-ACK message.

If the device fails before returning a CoA-ACK to the client, the process is repeated on the new active device when the request is re-sent from the client. If the device fails after returning a CoA-ACK message to the client but before the operation has completed, the operation is restarted on the new active device.

Note A Disconnect-Request failure following command re-sending could be the result of either a successful session termination before change-over (if the Disconnect-ACK was not sent) or a session termination by other means (for example, a link failure) that occurred after the original command was issued and before the standby device became active.

CoA Request: Bounce-Port

A RADIUS server CoA bounce port sent from a RADIUS server can cause a link flap on an authentication port, which triggers DHCP renegotiation from one or more hosts connected to this port. This incident can occur when there is a VLAN change and the endpoint is a device (such as a printer) that does not have a mechanism to detect a change on this authentication port. The CoA bounce port is carried in a standard CoA-Request message that contains the following VSA:

Cisco:Avpair="subscriber:command=bounce-host-port"

Because this command is session-oriented, it must be accompanied by one or more of the session identification attributes. If the session cannot be located, the device returns a CoA-NAK message with the “Session Context Not Found” error-code attribute. If the session is located, the device disables the hosting port for a period of 10 seconds, re-enables it (port-bounce), and returns a CoA-ACK.

If the device fails before returning a CoA-ACK to the client, the process is repeated on the new active device when the request is re-sent from the client. If the device fails after returning a CoA-ACK message to the client but before the operation has completed, the operation is re-started on the new active device.

Default RADIUS Configuration

RADIUS and AAA are disabled by default.

To prevent a lapse in security, you cannot configure RADIUS through a network management application. When enabled, RADIUS can authenticate users accessing the device through the CLI.

RADIUS Server Host

Device-to-RADIUS-server communication involves several components:

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

You identify RADIUS security servers by their hostname or IP address, hostname and specific UDP port numbers, or their IP address and specific UDP port numbers. The combination of the IP address and the UDP

port number creates a unique identifier, allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. This unique identifier enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address.

If two different host entries on the same RADIUS server are configured for the same service—for example, accounting—the second host entry configured acts as a fail-over backup to the first one. Using this example, if the first host entry fails to provide accounting services, the %RADIUS-4-RADIUS_DEAD message appears, and then the device tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order that they are configured.)

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

The timeout, retransmission, and encryption key values can be configured globally for all RADIUS servers, on a per-server basis, or in some combination of global and per-server settings.

RADIUS Login Authentication

To configure AAA authentication, you define a named list of authentication methods and then apply that list to various ports. The method list defines the types of authentication to be performed and the sequence in which they are performed; it must be applied to a specific port before any of the defined authentication methods are performed. The only exception is the default method list. The default method list is automatically applied to all ports except those that have a named method list explicitly defined.

A method list describes the sequence and authentication methods to be queried to authenticate a user. You can designate one or more security protocols to be used for authentication, thus ensuring a backup system for authentication in case the initial method fails. The software uses the first method listed to authenticate users; if that method fails to respond, the software selects the next authentication method in the method list. This process continues until there is successful communication with a listed authentication method or until all defined methods are exhausted. If authentication fails at any point in this cycle—meaning that the security server or local username database responds by denying the user access—the authentication process stops, and no other authentication methods are attempted.

AAA Server Groups

You can configure the device to use AAA server groups to group existing server hosts for authentication. You select a subset of the configured server hosts and use them for a particular service. The server group is used with a global server-host list, which lists the IP addresses of the selected server hosts.

Server groups also can include multiple host entries for the same server if each entry has a unique identifier (the combination of the IP address and UDP port number), allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. This unique identifier enables RADIUS requests to be sent to different UDP ports on a server at the same IP address. If you configure two different host entries on the same RADIUS server for the same service, (for example, accounting), the second configured host entry acts as a fail-over backup to the first one. If the first host entry fails to provide accounting services, the network access server tries the second host entry configured on the same device for accounting services. (The RADIUS host entries are tried in the order in which they are configured.)

AAA Authorization

AAA authorization limits the services available to a user. When AAA authorization is enabled, the device uses information retrieved from the user's profile, which is in the local user database or on the security server, to configure the user's session. The user is granted access to a requested service only if the information in the user profile allows it.

RADIUS Accounting

The AAA accounting feature tracks the services that users are using and the amount of network resources that they are consuming. When you enable AAA accounting, the device reports user activity to the RADIUS security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. You can then analyze the data for network management, client billing, or auditing.

Vendor-Specific RADIUS Attributes

The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating vendor-specific information between the device and the RADIUS server by using the vendor-specific attribute (attribute 26). Vendor-specific attributes (VSAs) allow vendors to support their own extended attributes not suitable for general use. The Cisco RADIUS implementation supports one vendor-specific option by using the format recommended in the specification. Cisco's vendor-ID is 9, and the supported option has vendor-type 1, which is named *cisco-avpair*. The value is a string with this format:

```
protocol : attribute sep value *
```

Protocol is a value of the Cisco protocol attribute for a particular type of authorization. *Attribute* and *value* are an appropriate attributevalue (AV) pair defined in the Cisco TACACS+ specification, and *sep* is = for mandatory attributes and is * for optional attributes. The full set of features available for TACACS+ authorization can then be used for RADIUS.

For example, the following AV pair causes Cisco's "multiple named IP address pools" feature to be activated during IP authorization (during PPP's Internet Protocol Control Protocol (IPCP) address assignment):

```
cisco-avpair= ″ip:addr-pool=first″
```

If you insert an "*", the AV pair "ip:addr-pool=first" becomes optional. Note that any AV pair can be made optional:

```
cisco-avpair= ″ip:addr-pool*first″
```

The following example shows how to cause a user logging in from a network access server to have immediate access to EXEC commands:

```
cisco-avpair= ″shell:priv-lvl=15″
```

Other vendors have their own unique vendor-IDs, options, and associated VSAs. For more information about vendor-IDs and VSAs, see RFC 2138, "Remote Authentication Dial-In User Service (RADIUS)."

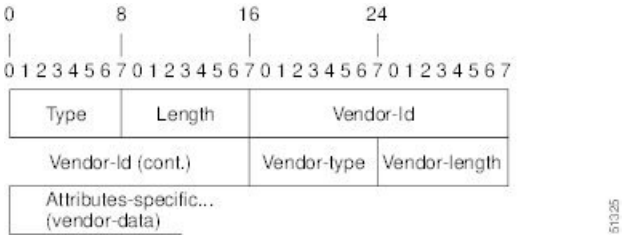
Attribute 26 contains the following three elements:

- Type

- Length
- String (also known as data)
  - Vendor-ID
  - Vendor-Type
  - Vendor-Length
  - Vendor-Data

The figure below shows the packet format for a VSA encapsulated "behind" attribute 26.

Figure 2: VSA Encapsulated Behind Attribute 26



Note It is up to the vendor to specify the format of their VSA. The Attribute-Specific field (also known as Vendor-Data) is dependent on the vendor's definition of that attribute.

The table below describes significant fields listed in the Vendor-Specific RADIUS IETF Attributes table (second table below), which lists supported vendor-specific RADIUS attributes (IETF attribute 26).

Table 5: Vendor-Specific Attributes Table Field Descriptions

Field	Description
Number	All attributes listed in the following table are extensions of IETF attribute 26.
Vendor-Specific Command Codes	A defined code used to identify a particular vendor. Code 9 defines Cisco VSAs, 311 defines Microsoft VSAs, and 529 defines Ascend VSAs.
Sub-Type Number	The attribute ID number. This number is much like the ID numbers of IETF attributes, except it is a "second layer" ID number encapsulated behind attribute 26.
Attribute	The ASCII string name of the attribute.
Description	Description of the attribute.

Table 6: Vendor-Specific RADIUS IETF Attributes

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
MS-CHAP Attributes				

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	311	1	MSCHAP-Response	Contains the response value provided by a PPP MS-CHAP user in response to the challenge. It is only used in Access-Request packets. This attribute is identical to the PPP CHAP Identifier. (RFC 2548
26	311	11	MSCHAP-Challenge	Contains the challenge sent by a network access server to an MS-CHAP user. It can be used in both Access-Request and Access-Challenge packets. (RFC 2548)
VPDN Attributes				
26	9	1	l2tp-cm-local-window-size	Specifies the maximum receive window size for L2TP control messages. This value is advertised to the peer during tunnel establishment.
26	9	1	l2tp-drop-out-of-order	Respects sequence numbers on data packets by dropping those that are received out of order. This does not ensure that sequence numbers will be sent on data packets, just how to handle them if they are received.
26	9	1	l2tp-hello-interval	Specifies the number of seconds for the hello keepalive interval. Hello packets are sent when no data has been sent on a tunnel for the number of seconds configured here.
26	9	1	l2tp-hidden-avp	When enabled, sensitive AVPs in L2TP control messages are scrambled or hidden.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	l2tp-nosession-timeout	Specifies the number of seconds that a tunnel will stay active with no sessions before timing out and shutting down.
26	9	1	tunnel-tos-reflect	Copies the IP ToS field from the IP header of each payload packet to the IP header of the tunnel packet for packets entering the tunnel at the LNS.
26	9	1	l2tp-tunnel-authen	If this attribute is set, it performs L2TP tunnel authentication.
26	9	1	l2tp-tunnel-password	Shared secret used for L2TP tunnel authentication and AVP hiding.
26	9	1	l2tp-udp-checksum	This is an authorization attribute and defines whether L2TP should perform UDP checksums for data packets. Valid values are “yes” and “no.” The default is no.
Store and Forward Fax Attributes				
26	9	3	Fax-Account-Id-Origin	Indicates the account ID origin as defined by system administrator for the **mmoip aaa receive-id** or the **mmoip aaa send-id** commands.
26	9	4	Fax-Msg-Id=	Indicates a unique fax message identification number assigned by Store and Forward Fax.
26	9	5	Fax-Pages	Indicates the number of pages transmitted or received during this fax session. This page count includes cover pages.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	6	Fax-Coverpage-Flag	Indicates whether or not a cover page was generated by the off-ramp gateway for this fax session. True indicates that a cover page was generated; false means that a cover page was not generated.
26	9	7	Fax-Modem-Time	Indicates the amount of time in seconds the modem sent fax data (x) and the amount of time in seconds of the total fax session (y), which includes both fax-mail and PSTN time, in the form x/y. For example, 10/15 means that the transfer time took 10 seconds, and the total fax session took 15 seconds.
26	9	8	Fax-Connect-Speed	Indicates the modem speed at which this fax-mail was initially transmitted or received. Possible values are 1200, 4800, 9600, and 14400.
26	9	9	Fax-Recipient-Count	Indicates the number of recipients for this fax transmission. Until e-mail servers support Session mode, the number should be 1.
26	9	10	Fax-Process-Abort-Flag	Indicates that the fax session was terminated or successful. True means that the session was terminated; false means that the session was successful.
26	9	11	Fax-Dsn-Address	Indicates the address to which DSNs will be sent.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	12	Fax-Dsn-Flag	Indicates whether or not DSN has been enabled. True indicates that DSN has been enabled; false means that DSN has not been enabled.
26	9	13	Fax-Mdn-Address	Indicates the address to which MDNs will be sent.
26	9	14	Fax-Mdn-Flag	Indicates whether or not message delivery notification (MDN) has been enabled. True indicates that MDN had been enabled; false means that MDN had not been enabled.
26	9	15	Fax-Auth-Status	Indicates whether or not authentication for this fax session was successful. Possible values for this field are success, failed, bypassed, or unknown.
26	9	16	Email-Server-Address	Indicates the IP address of the e-mail server handling the on-ramp fax-mail message.
26	9	17	Email-Server-Ack-Flag	Indicates that the on-ramp gateway has received a positive acknowledgment from the e-mail server accepting the fax-mail message.
26	9	18	Gateway-Id	Indicates the name of the gateway that processed the fax session. The name appears in the following format: hostname.domain-name.
26	9	19	Call-Type	Describes the type of fax activity: fax receive or fax send.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	20	Port-Used	Indicates the slot/port number of the Cisco AS5300 used to either transmit or receive this fax-mail.
26	9	21	Abort-Cause	If the fax session terminates, indicates the system component that signaled the termination. Examples of system components that could trigger an termination are FAP (Fax Application Process), TIFF (the TIFF reader or the TIFF writer), fax-mail client, fax-mail server, ESMTP client, or ESMTP server.
H323 Attributes				
26	9	23	Remote-Gateway-ID (h323-remote-address)	Indicates the IP address of the remote gateway.
26	9	24	Connection-ID (h323-conf-id)	Identifies the conference ID.
26	9	25	Setup-Time (h323-setup-time)	Indicates the setup time for this connection in Coordinated Universal Time (UTC) formerly known as Greenwich Mean Time (GMT) and Zulu time.
26	9	26	Call-Origin (h323-call-origin)	Indicates the origin of the call relative to the gateway. Possible values are originating and terminating (answer).
26	9	27	Call-Type (h323-call-type)	Indicates call leg type. Possible values are **telephony** and **VoIP**.
26	9	28	Connect-Time (h323-connect-time)	Indicates the connection time for this call leg in UTC.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	29	Disconnect-Time (h323-disconnect-time)	Indicates the time this call leg was disconnected in UTC.
26	9	30	Disconnect-Cause (h323-disconnect-cause)	Specifies the reason a connection was taken offline per Q.931 specification.
26	9	31	Voice-Quality (h323-voice-quality)	Specifies the impairment factor (ICPIF) affecting voice quality for a call.
26	9	33	Gateway-ID (h323-gw-id)	Indicates the name of the underlying gateway.
Large Scale Dialout Attributes				
26	9	1	callback-dialstring	Defines a dialing string to be used for callback.
26	9	1	data-service	No description available.
26	9	1	dial-number	Defines the number to dial.
26	9	1	force-56	Determines whether the network access server uses only the 56 K portion of a channel, even when all 64 K appear to be available.
26	9	1	map-class	Allows the user profile to reference information configured in a map class of the same name on the network access server that dials out.
26	9	1	send-auth	Defines the protocol to use (PAP or CHAP) for username-password authentication following CLID authentication.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	send-name	PPP name authentication. To apply for PAP, do not configure the **ppp pap sent-name password** command on the interface. For PAP, “preauth:send-name” and “preauth:send-secret” will be used as the PAP username and PAP password for outbound authentication. For CHAP, “preauth:send-name” will be used not only for outbound authentication, but also for inbound authentication. For a CHAP inbound case, the NAS will use the name defined in “preauth:send-name” in the challenge packet to the caller box. **Note** The send-name attribute has changed over time: Initially, it performed the functions now provided by both the send-name and remote-name attributes. Because the remote-name attribute has been added, the send-name attribute is restricted to its current behavior.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	send-secret	PPP password authentication. The vendor-specific attributes (VSAs) “preauth:send-name” and “preauth:send-secret” will be used as the PAP username and PAP password for outbound authentication. For a CHAP outbound case, both “preauth:send-name” and “preauth:send-secret” will be used in the response packet.
26	9	1	remote-name	Provides the name of the remote host for use in large-scale dial-out. Dialer checks that the large-scale dial-out remote name matches the authenticated name, to protect against accidental user RADIUS misconfiguration. (For example, dialing a valid phone number but connecting to the wrong device.)
Miscellaneous Attributes				

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	2	Cisco-NAS-Port	Specifies additional vendor specific attribute (VSA) information for NAS-Port accounting. To specify additional NAS-Port information in the form an Attribute-Value Pair (AVPair) string, use the **radius-server vsa send** global configuration command. **Note** This VSA is typically used in Accounting, but may also be used in Authentication (Access-Request) packets.
26	9	1	min-links	Sets the minimum number of links for MLP.
26	9	1	proxyacl#<n>	Allows users to configure the downloadable user profiles (dynamic ACLs) by using the authentication proxy feature so that users can have the configured authorization to permit traffic going through the configured interfaces.

Number	Vendor-Specific Company Code	Sub-Type Number	Attribute	Description
26	9	1	spi	Carries the authentication information needed by the home agent to authenticate a mobile node during registration. The information is in the same syntax as the **ip mobile secure host <addr>** configuration command. Basically it contains the rest of the configuration command that follows that string, verbatim. It provides the Security Parameter Index (SPI), key, authentication algorithm, authentication mode, and replay protection timestamp range.

Vendor-Proprietary RADIUS Server Communication

Although an IETF draft standard for RADIUS specifies a method for communicating vendor-proprietary information between the device and the RADIUS server, some vendors have extended the RADIUS attribute set in a unique way. Cisco IOS XE software supports a subset of vendor-proprietary RADIUS attributes.

As mentioned earlier, to configure RADIUS (whether vendor-proprietary or IETF draft-compliant), you must specify the host running the RADIUS server daemon and the secret text string it shares with the device. You specify the RADIUS host and secret text string by using the **radius server** global configuration commands.

DSCP marking for RADIUS packets

Differentiated Services (DiffServ) is a Quality of Service (QoS) model that classifies and manages traffic for preferential handling over other traffic classes. DiffServ uses the 6-bit differentiated services code point (DSCP) setting in IP packets to mark traffic classes with relative priorities. Cisco IOS XE Software supports DSCP marking for RADIUS packets to allow faster authentication and accounting of RADIUS packets.

You can configure DSCP marking on the RADIUS server, RADIUS server group, and in global configuration mode. When DSCP marking is configured for the RADIUS server, server group, and in global configuration mode, the DSCP marking values that are entered on the RADIUS server take precedence.

- If there is no DSCP marking configuration on the RADIUS server, the DSCP marking values that are configured for the server group are applied to the RADIUS packets.
- If there is no DSCP marking configuration for the RADIUS server or RADIUS server group, the DSCP marking values that are configured in global configuration mode are applied to the RADIUS packets.

Configuring RADIUS

Identifying the RADIUS Server Host

To apply these settings globally to all RADIUS servers communicating with the device, use the three unique global configuration commands: **radius-server timeout**, **radius-server retransmit**, and **key** *string*.

You can configure the device to use AAA server groups to group existing server hosts for authentication.

You also need to configure some settings on the RADIUS server. These settings include the IP address of the device and the key string to be shared by both the server and the device.

Follow these steps to configure per-server RADIUS server communication.

Before you begin

If you configure both global and per-server functions (timeout, retransmission, and key commands) on the device, the per-server timer, retransmission, and key value commands override global timer, retransmission, and key value commands.

Note Radius and AAA servers can be configured to run only on the standard default ports:

- 1812 and 1813
- 1645 and 1646

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius server** *server name*
4. **address** {**ipv4 | ipv6**}*ip address*{ **auth-port** *port number* | **acct-port** *port number*}
5. **key** *string*
6. **retransmit** *value*
7. **timeout** *seconds*
8. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**radius server** *server name* **Example:** `Device(config)# radius server rsim`	Specifies the name for the RADIUS server configuration for Protected Access Credential (PAC) provisioning, and enters RADIUS server configuration mode.
Step 4	**address** {**ipv4** | **ipv6**}*ip address*{ **auth-port** *port number* | **acct-port** *port number*} **Example:** `Device(config-radius-server)# address ipv4 124.2.2.12 auth-port 1612`	(Optional) Specifies the RADIUS server parameters. For **auth-port** *port-number*, specify the UDP destination port for authentication requests. The default is 1645. The range is 0 to 65536. For **acct-port** *port-number*, specify the UDP destination port for accounting requests. The default is 1646.
Step 5	**key** *string* **Example:** `Device(config-radius-server)# key rad123`	(Optional) For **key** *string*, specify the authentication and encryption key used between the device and the RADIUS daemon running on the RADIUS server. **Note** The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the **radius server** command. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
Step 6	**retransmit** *value* **Example:** `Device(config-radius-server)# retransmit 10`	(Optional) Specifies the number of times a RADIUS request is resent when the server is not responding or responding slowly. The range is 1 to 100. This setting overrides the **radius-server retransmit** global configuration command setting.
Step 7	**timeout** *seconds* **Example:** `Device(config-radius-server)# timeout 60`	(Optional) Specifies the time interval that the device waits for the RADIUS server to reply before sending a request again. The range is 1 to 1000. This setting overrides the **radius-server timeout** global configuration command setting.
Step 8	**end** **Example:** `Device(config-radius-server)# end`	Exits RADIUS server configuration mode and enters privileged EXEC mode.

Configuring RADIUS Login Authentication

Follow these steps to configure RADIUS login authentication:

Before you begin

To secure the device for HTTP access by using AAA methods, you must configure the **ip http authentication aaa** global configuration command. By default, configuring AAA authentication does not secure the device for HTTP access by using AAA methods.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa authentication login** {**default** | *list-name*} *method1* [*method2...*]
5. **line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*]
6. **login authentication** {**default** | *list-name*}
7. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Device(config)# aaa new-model`	Enables AAA.
Step 4	**aaa authentication login** {**default** | *list-name*} *method1* [*method2...*] **Example:** `Device(config)# aaa authentication login default local`	Creates a login authentication method list. • To create a default list that is used when a named list is *not* specified in the **login authentication** command, use the **default** keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all ports. • For *list-name*, specify a character string to name the list you are creating.

	Command or Action	Purpose
		• For *method1...*, specify the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails. Select one of these methods: • *enable*—Use the enable password for authentication. Before you can use this authentication method, you must define an enable password by using the **enable** *password* global configuration command. • *group radius*—Use RADIUS authentication. Before you can use this authentication method, you must configure the RADIUS server. • *line*—Use the line password for authentication. Before you can use this authentication method, you must define a line password. Use the **password** *password* line configuration command. • *local*—Use the local username database for authentication. You must enter username information in the database. Use the **username** *name* **password** global configuration command. • *local-case*—Use a case-sensitive local username database for authentication. You must enter username information in the database by using the **username** *password* global configuration command. • *none*—Do not use any authentication for login.
Step 5	**line** [**console** | **tty** | **vty**] *line-number* [*ending-line-number*] **Example:** `Device(config)# line 1 4`	Enters line configuration mode, and configure the lines to which you want to apply the authentication list.
Step 6	**login authentication** {**default** | *list-name*} **Example:** `Device(config-line)# login authentication default`	Applies the authentication list to a line or set of lines. • If you specify **default**, use the default list created with the **aaa authentication login** command. • For *list-name*, specify the list created with the **aaa authentication login** command.
Step 7	**end** **Example:** `Device(config-line)# end`	Exits line configuration mode and enters privileged EXEC mode.

Defining AAA Server Groups

You use the **server** group server configuration command to associate a particular server with a defined group server. You can either identify the server by its IP address or identify multiple host instances or entries by using the optional **auth-port** and **acct-port** keywords.

Follow these steps to define AAA server groups:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius server** *name*
4. **address** {**ipv4** | **ipv6**} {*ip-address* | *hostname*} **auth-port** *port-number* **acct-port** *port-number*
5. **key** *string*
6. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**radius server** *name* **Example:** `Device(config)# radius server ISE`	Specifies the name of the RADIUS server configuration for Protected Access Credential (PAC) provisioning and enters RADIUS server configuration mode. The device also supports RADIUS for IPv6.
Step 4	**address** {**ipv4** | **ipv6**} {*ip-address* | *hostname*} **auth-port** *port-number* **acct-port** *port-number* **Example:** `Device(config-radius-server)# address ipv4 10.1.1.1 auth-port 1645 acct-port 1646`	Configures the IPv4 address for the RADIUS server accounting and authentication parameters.
Step 5	**key** *string* **Example:** `Device(config-radius-server)# key cisco123`	Specifies the authentication and encryption key for all RADIUS communications between the device and the RADIUS server.

	Command or Action	Purpose
Step 6	**end** **Example:** `Device(config-radius-server)# end`	Exits RADIUS server configuration mode and returns to privileged EXEC mode.

Configuring RADIUS Authorization for User Privileged Access and Network Services

Note Authorization is bypassed for authenticated users who log in through the CLI even if authorization has been configured.

Follow these steps to configure RADIUS authorization for user priviledged access and network services:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa authorization network** *authorization-list* **radius**
4. **aaa authorization exec** *authorization-list* **radius**
5. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa authorization network** *authorization-list* **radius** **Example:** `Device(config)# aaa authorization network list1 radius`	Configures the device for user RADIUS authorization for all network-related service requests.

	Command or Action	Purpose
Step 4	**aaa authorization exec** *authorization-list* **radius** **Example:** `Device(config)# aaa authorization exec list1 radius`	Configures the device for user RADIUS authorization if the user has privileged EXEC access. The **exec** keyword might return user profile information (such as **autocommand** information).
Step 5	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

What to do next

You can use the **aaa authorization** global configuration command with the **radius** keyword to set parameters that restrict a user's network access to privileged EXEC mode.

The **aaa authorization exec radius local** command sets these authorization parameters:

- Use RADIUS for privileged EXEC access authorization if authentication was performed by using RADIUS.
- Use the local database if authentication was not performed by using RADIUS.

Starting RADIUS Accounting

Follow these steps to start RADIUS accounting:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa accounting network** *accounting-list* **start-stop radius**
4. **aaa accounting exec** *accounting-list* **start-stop radius**
5. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**aaa accounting network** *accounting-list* **start-stop radius** **Example:** `Device(config)# aaa accounting network accounting-list start-stop radius`	Enables RADIUS accounting for all network-related service requests.
Step 4	**aaa accounting exec** *accounting-list* **start-stop radius** **Example:** `Device(config)# aaa accounting exec acc-list start-stop radius`	Enables RADIUS accounting to send a start-record accounting notice at the beginning of a privileged EXEC process and a stop-record at the end.
Step 5	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Configuring Settings for All RADIUS Servers

Beginning in privileged EXEC mode, follow these steps to configure settings for all RADIUS servers:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius server** *server name*
4. **key** *string*
5. **retransmit** *retries*
6. **timeout** *seconds*
7. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**radius server** *server name* **Example:** `Device(config)# radius server rsim`	Specifies the name for the RADIUS server configuration for Protected Access Credential (PAC) provisioning, and enters RADIUS server configuration mode.
Step 4	**key** *string* **Example:** `Device(config-radius-server)# key your_server_key`	Specifies the shared secret text string used between the switch and all RADIUS servers. **Note** The key is a text string that must match the encryption key used on the RADIUS server. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
Step 5	**retransmit** *retries* **Example:** `Device(config-radius-server)# retransmit 5`	Specifies the number of times the switch sends each RADIUS request to the server before giving up. The default is 3; the range 1 to 1000.
Step 6	**timeout** *seconds* **Example:** `Device(config-radius-server)# timeout 3`	Specifies the number of seconds a switch waits for a reply to a RADIUS request before resending the request. The default is 5 seconds; the range is 1 to 1000.
Step 7	**end** **Example:** `Device(config-radius-server)# end`	Exits RADIUS server configuration mode and enters privileged EXEC mode.

Configuring the Device to Use Vendor-Specific RADIUS Attributes

Follow these steps to configure vendor-specific RADIUS attributes:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius-server vsa send** [**accounting** | **authentication**]
4. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**radius-server vsa send** [**accounting** | **authentication**] **Example:** `Device(config)# radius-server vsa send accounting`	Enables the device to recognize and use VSAs as defined by RADIUS IETF attribute 26. • (Optional) Use the **accounting** keyword to limit the set of recognized vendor-specific attributes to only accounting attributes. • (Optional) Use the **authentication** keyword to limit the set of recognized vendor-specific attributes to only authentication attributes. If you enter this command without keywords, both accounting and authentication vendor-specific attributes are used.
Step 4	**end** **Example:** `Device(config)# end`	Exits global configuration mode and enters privileged EXEC mode.

Configuring the Device for Vendor-Proprietary RADIUS Server Communication

Follow these steps to configure vendor-proprietary RADIUS server communication:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius server** *server name*
4. **address** { **ipv4 | ipv6** } *ip address*
5. **non-standard**
6. **key** *string*
7. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**radius server** *server name* **Example:** `Device(config)# radius server rsim`	Specifies the name for the RADIUS server configuration for Protected Access Credential (PAC) provisioning, and enters RADIUS server configuration mode.
Step 4	**address** { **ipv4** | **ipv6** } *ip address* **Example:** `Device(config-radius-server)# address ipv4 172.24.25.10`	(Optional) Specifies the IP address of the RADIUS server.
Step 5	**non-standard** **Example:** `Device(config-radius-server)# non-standard`	Identifies that the RADIUS server using a vendor-proprietary implementation of RADIUS.
Step 6	**key** *string* **Example:** `Device(config-radius-server)# key rad123`	Specifies the shared secret text string used between the device and the vendor-proprietary RADIUS server. The device and the RADIUS server use this text string to encrypt passwords and exchange responses.
Step 7	**end** **Example:** `Device(config-radius-server)# end`	Exits RADIUS server mode and enters privileged EXEC mode.

Configuring DSCP Marking on a RADIUS Server

Follow these steps to configure DSCP marking for authentication and accounting on a radius server:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **radius server** *server_name*
4. **address** { **ipv4 | ipv6** } *ip address* [**auth-port** *auth_port_number* **acct-port** *acct_port_number*]
5. **dscp** {**acct** *dscp_acct_value* | **auth** *dscp_auth_value*}
6. **key** *string*
7. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**radius server** *server_name* **Example:** `Device(config)# radius server rsim`	Specifies the name for the RADIUS server configuration for Protected Access Credential (PAC) provisioning, and enters RADIUS server configuration mode.
Step 4	**address** { **ipv4 | ipv6** } *ip address* [**auth-port** *auth_port_number* **acct-port** *acct_port_number*] **Example:** `Device(config-radius-server)# address ipv4 10.1.1.1 auth-port 1645 acct-port 1646`	(Optional) Specifies the IP address of the RADIUS server. • **auth-port** configures the port value for radius authentication server. The default value is 1812. • **acct-port** configures the port value for radius accounting server. The default value is 1813.
Step 5	**dscp** {**acct** *dscp_acct_value* | **auth** *dscp_auth_value*} **Example:** `Device(config-radius-server)# dscp auth 10 acct 20`	Configures DSCP marking for authentication and accounting on the radius server. • **acct** configures radius DSCP marking value for accounting. The valid range is from 1 to 63. The default value is 0. • **auth** configures radius DSCP marking value for authentication. The valid range is from 1 to 63. The default value is 0.

	Command or Action	Purpose
Step 6	**key** *string* **Example:** `Device(config-radius-server)# key rad123`	Specifies the shared secret text string used between the device and the vendor-proprietary RADIUS server. The device and the RADIUS server use this text string to encrypt passwords and exchange responses.
Step 7	**end** **Example:** `Device(config-radius-server)# end`	Exits RADIUS server mode and enters privileged EXEC mode.

Configuring the Source Interface and DSCP Marking on RADIUS Server Group

Follow these steps to configure the source interface and DSCP marking for authentication and accounting on radius server groups:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa group server radius** *group_name*
4. **server name** *name*
5. {**ip** | **ipv6**} **radius source-interface** *type number*
6. **dscp** {**acct** *dscp_acct_value* | **auth** *dscp_auth_value*}
7. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa group server radius** *group_name* **Example:** `Device(config)# aaa group server radius abc`	Defines the RADIUS server group configuration and enters RADIUS server group configuration mode.

	Command or Action	Purpose
Step 4	**server name** *name* **Example:** `Device(config-sg-radius)# server name serv1`	Associates the RADIUS server to the server group.
Step 5	{**ip** | **ipv6**} **radius source-interface** *type number* **Example:** `Device(config-sg-radius)# ipv6 radius source-interface ethernet 0/0`	Specifies an interface to use for the source address in RADIUS server.
Step 6	**dscp** {**acct** *dscp_acct_value* | **auth** *dscp_auth_value*} **Example:** `Device(config-sg-radius)# dscp auth 10 acct 20`	Configures DSCP marking for authentication and accounting on the radius server group. • **acct** configures radius DSCP marking value for accounting. The valid range is from 1 to 63. The default value is 0. • **auth** configures radius DSCP marking value for authentication. The valid range is from 1 to 63. The default value is 0.
Step 7	**end** **Example:** `Device(config-radius-server)# end`	Exits RADIUS server mode and enters privileged EXEC mode.

Configuring CoA on the Device

Follow these steps to configure CoA on a device. This procedure is required.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **aaa server radius dynamic-author**
5. **client** {*ip-address* | *name*} [**vrf** *vrfname*] [**server-key** *string*]
6. **server-key** [**0** | **7**] *string*
7. **port** *port-number*
8. **auth-type** {**any** | **all** | **session-key**}
9. **ignore server-key**
10. **exit**
11. **authentication command bounce-port ignore**

12. **authentication command disable-port ignore**
13. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa new-model** **Example:** `Device(config)# aaa new-model`	Enables AAA.
Step 4	**aaa server radius dynamic-author** **Example:** `Device(config)# aaa server radius dynamic-author`	Configures the device as an authentication, authorization, and accounting (AAA) server to facilitate interaction with an external policy server, and enters dynamic authorization local server configuration mode.
Step 5	**client** {*ip-address* | *name*} [**vrf** *vrfname*] [**server-key** *string*] **Example:** `Device(config-locsvr-da-radius)# client client1 vrf vrf1`	Specifies a RADIUS client from which a device will accept CoA and disconnect requests.
Step 6	**server-key** [**0** | **7**] *string* **Example:** `Device(config-locsvr-da-radius)# server-key your_server_key`	Configures the RADIUS key to be shared between a device and RADIUS clients.
Step 7	**port** *port-number* **Example:** `Device(config-locsvr-da-radius)# port 25`	Specifies the port on which a device listens for RADIUS requests from configured RADIUS clients.

	Command or Action	Purpose
Step 8	**auth-type** {**any** | **all** | **session-key**} **Example:** `Device(config-locsvr-da-radius)# auth-type any`	Specifies the type of authorization the device uses for RADIUS clients. The client must match all the configured attributes for authorization.
Step 9	**ignore server-key** **Example:** `Device(config-locsvr-da-radius)# ignore server-key`	(Optional) Configures the device to ignore the server-key.
Step 10	**exit** **Example:** `Device(config-locsvr-da-radius)# exit`	Exits dynamic authorization local server configuration mode and returns to global configuration mode.
Step 11	**authentication command bounce-port ignore** **Example:** `Device(config)# authentication command bounce-port ignore`	(Optional) Configures the device to ignore a CoA request to temporarily disable the port hosting a session. The purpose of temporarily disabling the port is to trigger a DHCP renegotiation from the host when a VLAN change occurs and there is no supplicant on the endpoint to detect the change.
Step 12	**authentication command disable-port ignore** **Example:** `Device(config)# authentication command disable-port ignore`	(Optional) Configures the device to ignore a nonstandard command requesting that the port hosting a session be administratively shut down. Shutting down the port results in termination of the session. Use standard CLI or SNMP commands to re-enable the port.
Step 13	**end** **Example:** `Device(config)# end`	Exits global configuration mode an returns to privileged EXEC mode.

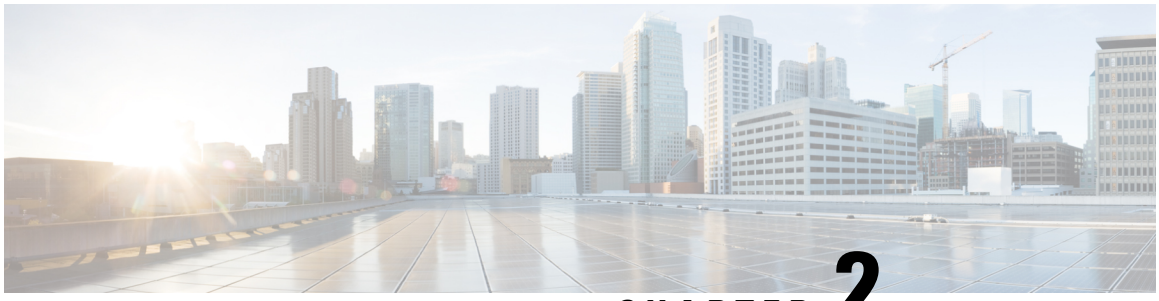
Monitoring CoA Functionality

Table 7: Privileged EXEC show Commands

Command	Purpose
show aaa attributes protocol radius	Displays AAA attributes of RADIUS commands.

Table 8: Global Troubleshooting Commands

Command	Purpose
debug radius	Displays information for troubleshooting RADIUS.
debug aaa coa	Displays information for troubleshooting CoA processing.
debug aaa pod	Displays information for troubleshooting POD packets.
debug aaa subsys	Displays information for troubleshooting POD packets.



CHAPTER 2

MACsec Encryption

MACsec Encryption

MACsec is the IEEE 802.1AE standard for authenticating and encrypting packets between two MACsec-capable devices. Catalyst switches support 802.1AE encryption with MACsec Key Agreement (MKA) on switch-to-host links for encryption between the switch and host device. The switch also supports MACsec encryption for switch-to-switch (inter-network device) security using MKA-based key exchange protocol.

Note When switch-to-switch MACSec is enabled, all traffic is encrypted, except the EAP-over-LAN (EAPOL) packets.

Link layer security can include both packet authentication between switches and MACsec encryption between switches (encryption is optional).

Table 9: MACsec Support on Switch Ports

Connections	MACsec support
Switch-to-host	MACsec MKA encryption
Switch-to-switch	MACsec MKA encryption

Cisco TrustSec is meant only for switch-to-switch links and is not supported on switch ports connected to end hosts, such as PCs or IP phones. MKA is supported on switch-to-host facing links as well as switch-to-switch links. Host-facing links typically use flexible authentication ordering for handling

heterogeneous devices with or without IEEE 802.1x, and can optionally use MKA-based MACsec encryption. Network Edge Access Topology (NEAT) is used for compact switches to extend security outside the wiring closet.

MACsec Key Agreement

MACsec, defined in 802.1AE, provides MAC-layer encryption over wired networks by using out-of-band methods for encryption keying. The MACsec Key Agreement (MKA) Protocol provides the required session keys and manages the required encryption keys. MKA and MACsec are implemented after successful authentication using certificate-based MACsec or Pre Shared Key (PSK) framework.

A switch using MACsec accepts either MACsec or non-MACsec frames, depending on the policy associated with the MKA peer. MACsec frames are encrypted and protected with an integrity check value (ICV). When the switch receives frames from the MKA peer, it decrypts them and calculates the correct ICV by using session keys provided by MKA. The switch compares that ICV to the ICV within the frame. If they are not identical, the frame is dropped. The switch also encrypts and adds an ICV to any frames sent over the secured port (the access point used to provide the secure MAC service to a MKA peer) using the current session key.

The MKA Protocol manages the encryption keys used by the underlying MACsec protocol. The basic requirements of MKA are defined in 802.1x-REV. The MKA Protocol extends 802.1x to allow peer discovery with confirmation of mutual authentication and sharing of MACsec secret keys to protect data exchanged by the peers.

The EAP framework implements MKA as a newly defined EAP-over-LAN (EAPOL) packet. EAP authentication produces a master session key (MSK) shared by both partners in the data exchange. Entering the EAP session ID generates a secure connectivity association key name (CKN). The switch acts as the authenticator for both uplink and downlink; and acts as the key server for downlink. It generates a random secure association key (SAK), which is sent to the client partner. The client is never a key server and can only interact with a single MKA entity, the key server. After key derivation and generation, the switch sends periodic transports to the partner at a default interval of 2 seconds.

The packet body in an EAPOL Protocol Data Unit (PDU) is referred to as a MACsec Key Agreement PDU (MKPDU). MKA sessions and participants are deleted when the MKA lifetime (6 seconds) passes with no MKPDU received from a participant. For example, if a MKA peer disconnects, the participant on the switch continues to operate MKA until 6 seconds have elapsed after the last MKPDU is received from the MKA peer.

Note Integrity check value (ICV) indicator in MKPDU is optional. ICV is not optional when the traffic is encrypted.

EAPoL Announcements indicate the use of the type of keying material. The announcements can be used to announce the capability of the supplicant as well as the authenticator. Based on the capability of each side, the largest common denominator of the keying material could be used.

MKA Policies

To enable MKA on an interface, a defined MKA policy should be applied to the interface. You can configure these options:

- Policy name, not to exceed 16 ASCII characters.

- Confidentiality (encryption) offset of 0, 30, or 50 bytes for each physical interface

Definition of Policy-Map Actions

This section describes the policy-map actions and its definition:

- Activate: Applies a service template to the session.
- Authenticate: Starts authentication of the session.
- Authorize: Explicitly authorizes a session.
- Set-domain: Explicitly sets the domain of a client.
- Terminate: Terminates the method that is running, and deletes all the method details associated with the session.
- Deactivate: Removes the service-template applied to the session. If not applied, no action is taken.
- Set-timer: Starts a timer and gets associated with the session. When the timer expires, any action that needs to be started can be processed.
- Authentication-restart: Restarts authentication.
- Clear-session: Deletes a session.
- Pause: Pauses authentication.

Rest of the actions as self-explanatory and are associated with authentication.

Virtual Ports

Use virtual ports for multiple secured connectivity associations on a single physical port. Each connectivity association (pair) represents a virtual port. In uplink, you can have only one virtual port per physical port. You cannot simultaneously host secured and unsecured sessions in the same VLAN on the same port. Because of this limitation, 802.1x multiple authentication mode is not supported.

The exception to this limitation is in multiple-host mode when the first MACsec supplicant is successfully authenticated and connected to a hub that is connected to the switch. A non-MACsec host connected to the hub can send traffic without authentication because it is in multiple-host mode. We do not recommend using multi-host mode because after the first successful client, authentication is not required for other clients.

Virtual ports represent an arbitrary identifier for a connectivity association and have no meaning outside the MKA Protocol. A virtual port corresponds to a separate logical port ID. Valid port IDs for a virtual port are 0x0002 to 0xFFFF. Each virtual port receives a unique secure channel identifier (SCI) based on the MAC address of the physical interface concatenated with a 16-bit port ID.

MKA Statistics

Some MKA counters are aggregated globally, while others are updated both globally and per session. You can also obtain information about the status of MKA sessions. See Displaying MKA Statistics for further information.

Key Lifetime and Hitless Key Rollover

A MACsec key chain can have multiple pre-shared keys (PSK) each configured with a key id and an optional lifetime. A key lifetime specifies at which time the key expires. In the absence of a lifetime configuration, the default lifetime is unlimited. When a lifetime is configured, MKA rolls over to the next configured pre-shared key in the key chain after the lifetime is expired. Time zone of the key can be local or UTC. Default time zone is UTC.

You can Key rolls over to the next key within the same key chain by configuring a second key in the key chain and configuring a lifetime for the first key. When the lifetime of the first key expires, it automatically rolls over to the next key in the list. If the same key is configured on both sides of the link at the same time, then the key rollover is hitless, that is, key rolls over without traffic interruption.

On all participating devices, the MACsec key chain must be synchronised by using Network Time Protocol (NTP) and the same time zone must be used. If all the participating devices are not synchronized, the connectivity association key (CAK) rekey will not be initiated on all the devices at the same time.

Note The lifetime of the keys need to be overlapped in order to achieve hitless key rollover.

Replay Protection Window Size

Replay protection is a feature provided by MACsec to counter replay attacks. Each encrypted packet is assigned a unique sequence number and the sequence is verified at the remote end. Frames transmitted through a Metro Ethernet service provider network are highly susceptible to reordering due to prioritization and load balancing mechanisms used within the network.

A replay window is necessary to support the use of MACsec over provider networks that reorder frames. Frames within the window can be received out of order, but are not replay protected. The default window size is 0, which enforces strict reception ordering. The replay window size can be configured in the range of 0 to 2^{32}- 1.

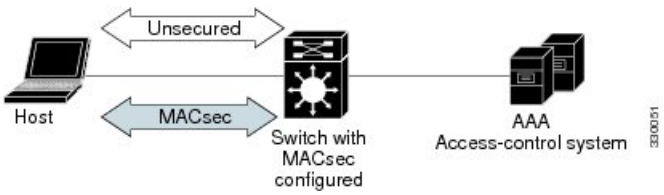
MACsec, MKA and 802.1x Host Modes

You can use MACsec and the MKA Protocol with 802.1x single-host mode, multi-host mode, or Multi Domain Authentication (MDA) mode. Multiple authentication mode is not supported.

Single-Host Mode

The figure shows how a single EAP authenticated session is secured by MACsec by using MKA

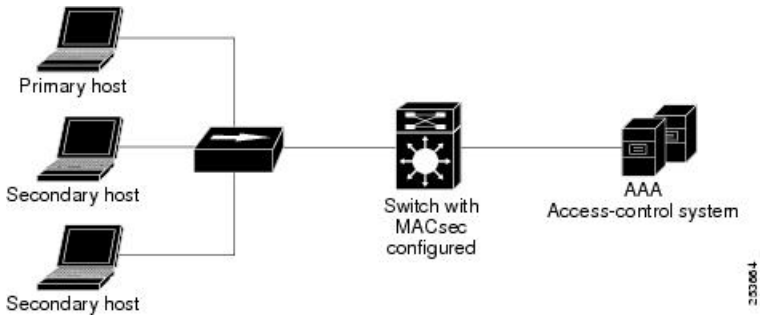
Figure 3: MACsec in Single-Host Mode with a Secured Data Session



Multiple-Host Mode

In standard (not 802.1x REV) 802.1x multiple-host mode, a port is open or closed based on a single authentication. If one user, the primary secured client services client host, is authenticated, the same level of network access is provided to any host connected to the same port. If a secondary host is a MACsec supplicant, it cannot be authenticated and traffic would not flow. A secondary host that is a non-MACsec host can send traffic to the network without authentication because it is in multiple-host mode. The figure shows MACsec in Standard Multiple-Host Unsecure Mode.

Figure 4: MACsec in Multiple-Host Mode - Unsecured



Note Multi-host mode is not recommended because after the first successful client, authentication is not required for other clients, which is not secure.

In standard (not 802.1x REV) 802.1x multiple-domain mode, a port is open or closed based on a single authentication. If the primary user, a PC on data domain, is authenticated, the same level of network access is provided to any domain connected to the same port. If a secondary user is a MACsec supplicant, it cannot be authenticated and traffic would no flow. A secondary user, an IP phone on voice domain, that is a non-MACsec host, can send traffic to the network without authentication because it is in multiple-domain mode.

Multiple-Domain Mode

In standard (not 802.1x REV) 802.1x multiple-domain mode, a port is open or closed based on a single authentication. If the primary user, a PC on data domain, is authenticated, the same level of network access is provided to any domain connected to the same port. If a secondary user is a MACsec supplicant, it cannot be authenticated and traffic would no flow. A secondary user, an IP phone on voice domain, that is a non-MACsec host, can send traffic to the network without authentication because it is in multiple-domain mode.

MACsec MKA using Certificate-based MACsec

MACsec MKA is supported on switch-to-switch links. Using certificate-based MACsec, you can configure MACsec MKA between device uplink ports. Certificate-based MACsec allows mutual authentication and obtains an MSK (master session key) from which the connectivity association key (CAK) is derived for MKA operations. Device certificates are carried, using certificate-based MACsec, for authentication to the AAA server.

Note Certificate-based MACsec is supported for Cisco Catalyst ESS9300 Embedded Series Switch beginning with the Cisco IOS XE 17.13.1 release.

Prerequisites for MACsec MKA Using Certificate-based MACsec

- Ensure that you have a Certificate Authority (CA) server configured for your network.
- Generate a CA certificate.
- Ensure that you have configured Cisco Identity Services Engine (ISE) Release 2.0.
- Ensure that both the participating devices, the CA server, and Cisco Identity Services Engine (ISE) are synchronized using Network Time Protocol (NTP). If time is not synchronized on all your devices, certificates will not be validated.
- Ensure that 802.1x authentication and AAA are configured on your device.

Switch-to-Switch MKA MACsec Must Secure Policy

Must-secure support is enabled on both the ingress and the egress. Must-secure is supported for MKA. With must-secure enabled, only EAPoL traffic will not be encrypted. The rest of the traffic will be encrypted. Unencrypted packets are dropped.

Note Must-secure mode is enabled by default.

MKA/MACsec for Port Channel

MKA/MACsec can be configured on the port members of a port channel. MKA/MACsec is agnostic to the port channel since the MKA session is established between the port members of a port channel.

Note Port channel is supported for PSK-based MACsec but not for certificate-based MACsec.

Note EtherChannel links that are formed as part of the port channel can either be congruent or disparate. That is, the links can either be MACsec-secured or non-MACsec-secured. MKA session between the port members is established even if a port member on one side of the port channel is not configured with MACsec.

We recommend that you enable MKA/MACsec on all the member ports for better security of the port channel.

MACsec Cipher Announcement

Cipher Announcement allows the supplicant and the authenticator to announce their respective MACsec Cipher Suite capabilities to each other. Both the supplicant and the authenticator calculate the largest common supported MACsec Cipher Suite and use the same as the keying material for the MKA session.

Note Only the MACsec Cipher Suite capabilities which are configured in the MKA policy are announced from the authenticator to the supplicant.

There are two types of EAPoL Announcements:

- Unsecured Announcements (EAPoL PDUs) : Unsecured announcements are EAPoL announcements carrying MACsec Cipher Suite capabilities in an unsecured manner. These announcements are used to decide the width of the key used for MKA session prior to authentication.
- Secure Announcements (MKPDUs) : Secure announcements revalidate the MACsec Cipher Suite capabilities which were shared previously through unsecure announcements.

Once the session is authenticated, peer capabilities which were received through EAPoL announcements are revalidated with the secure announcements. If there is a mismatch in the capabilities, the MKA session tears down.

Limitations for MACsec Cipher Announcement

- MACsec Cipher Announcement is supported only on the switch-to-host links.
- The MKA session between the supplicant and the authenticator does not tear down even if the MACsec Cipher Suite capabilities configured on both do not result in a common cipher suite.
- Host to Switch MKA MACsec 256-bit Cipher is not supported on both Network Advantage and Network Essentials.

How to Configure MACsec Encryption

Prerequisites for MACsec Encryption

Prerequisites for MACsec Encryption

- Enable the **ssci-based-on-sci** command while configuring MACsec encryption on the device to allow interoperability with non-Cisco and non-IOS XE devices.
- Ensure that 802.1x authentication and AAA are configured on your device.

Prerequisites for Certificate-Based MACsec

- Ensure that you have a Certificate Authority (CA) server configured for your network.

- Generate a CA certificate.
- Ensure that you have configured Cisco Identity Services Engine (ISE) Release 2.0.
- Ensure that both the participating devices, the CA server, and Cisco Identity Services Engine (ISE) are synchronized using Network Time Protocol (NTP). If time is not synchronized on all your devices, certificates will not be validated.

Restrictions for MACsec Encryption

- MACsec Key Agreement (MKA) is not supported with both stateful and stateless high availability.
- MACsec with MKA is supported only on point-to-point links.
- MACsec configuration is not supported on EtherChannel ports. Instead, MACsec configuration can be applied on the individual member ports of an EtherChannel. To remove MACsec configuration, you must first unbundle the member ports from the EtherChannel, and then remove it from the individual member ports.
- Cisco Catalyst IE9300 Rugged Series Switches support 128-bit MACsec encryption with a Network Essentials license and 256-bit MACsec encryption with a Network Advantage license.
- Certificate-based MACsec is supported only if the access-session is configured as closed or in multiple-host mode. None of the other configuration modes are supported.
- Packet number exhaustion rekey is not supported.
- If the **dot1q tag vlan native** command is configured globally, the dot1x reauthentication will fail on trunk ports.
- MACsec with Precision Time Protocol (PTP) is not supported.
- The **should-secure** access mode is supported on switch-to-switch ports only using PSK authentication.
- PSK fallback key chain is not supported for point-to-multipoint cases.
- PSK fallback key chain is not supported on a high availability setup.
- PSK fallback key chain supports infinite lifetime with one key only.
- The connectivity association key name (CKN) ID used in the fallback key chain must not match any of the CKN IDs used in the primary key chain.
- The following limitations apply only to certificate-based MACsec.
  - The port should be in access mode or trunk mode.
  - MKA is not supported on port channels.
  - Ports with no switch port are not supported.

Recommendations for MACsec Encryption

This section list the recommendations for configuring MACsec encryption:

- Use the confidentiality (encryption) offset as 0 in switch-to-host connections.

- Execute the **shutdown** command, and then the **no shutdown** command on a port, after changing any MKA policy or MACsec configuration for active sessions, so that the changes are applied to active sessions.
- Set the connectivity association key (CAK) rekey overlap timer to 30 seconds or more.

MKA and MACsec Configuration

MACsec is disabled by default. No MKA policies are configured.

Configure an MKA Policy

Beginning in privileged EXEC mode, follow these steps to create an MKA Protocol policy. Note that MKA also requires that you enable 802.1x.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mka policy** *policy-name*
4. **key-server** *priority*
5. **include-icv-indicator**
6. **macsec-cipher-suite** {*gcm-aes-128* | *gcm-aes-256*}
7. **confidentiality-offset** *offset-value*
8. **ssci-based-on-sci**
9. **end**
10. **show mka policy**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mka policy** *policy-name* **Example:** `Device(config)# mka policy mka_policy`	Identifies an MKA policy, and enters MKA policy configuration mode. The maximum policy name length is 16 characters. **Note** The default MACsec cipher suite in the MKA policy will always be "GCM-AES-128". If the device supports both

	Command or Action	Purpose
		"GCM-AES-128" and "GCM-AES-256" ciphers, it is highly recommended to define and use a user defined MKA policy to include both 128 and 256 bits ciphers or only 256 bits cipher, as may be required.
Step 4	**key-server** *priority* **Example:** `Device(config-mka-policy)# key-server priority 200`	Configures MKA key server options and set priority (between 0-255). **Note** When value of key server priority is set to 255, the peer can not become the key server. The key server priority value is valid only for MKA PSK; and not for MKA EAPTLS.
Step 5	**include-icv-indicator** **Example:** `Device(config-mka-policy)# include-icv-indicator`	Enables the ICV indicator in MKPDU. Use the **no** form of this command to disable the ICV indicator.
Step 6	**macsec-cipher-suite** {*gcm-aes-128* | *gcm-aes-256*} **Example:** `Device(config-mka-policy)# macsec-cipher-suite gcm-aes-128`	Configures a cipher suite for deriving SAK with 128-bit or 256-bit encryption.
Step 7	**confidentiality-offset** *offset-value* **Example:** `Device(config-mka-policy)# confidentiality-offset 0`	Set the confidentiality (encryption) offset for each physical interface. **Note** Offset Value can be 0, 30 or 50. If you are using Anyconnect on the client, it is recommended to use Offset 0.
Step 8	**ssci-based-on-sci** **Example:** `Device(config-mka-policy)# ssci-based-on-sci`	(Optional) Computes Short Secure Channel Identifier (SSCI) value based on Secure Channel Identifier (SCI) value. The higher the SCI value, the lower is the SSCI value.
Step 9	**end** **Example:** `Device(config-mka-policy)# end`	Exit enters MKA policy configuration mode and returns to privileged EXEC mode.
Step 10	**show mka policy** **Example:** `Device# show mka policy`	Displays MKA policy configuration information.

Configure Switch-to-host MACsec Encryption

Follow these steps to configure MACsec on an interface with one MACsec session for voice and one for data:

SUMMARY STEPS

1. **enable**
2. **configureterminal**
3. **interface** *type number*
4. **switchport access vlan***vlan-id*
5. **switchport mode access**
6. **macsec**
7. **authentication event linksec fail action authorize vlan** *vlan-id*
8. **authentication host-mode multi-domain**
9. **authentication linksec policy must-secure**
10. **authentication port-control auto**
11. **authentication periodic**
12. **authentication timer reauthenticate**
13. **authentication violation protect**
14. **mka policy** *policy-name*
15. **dot1x pae authenticator**
16. **spanning-tree portfast**
17. **end**
18. **show authentication session interface** *interface-id*
19. **show mka sessions**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device>enable`	Enables privileged EXEC mode. • Enter the password if prompted.
Step 2	**configureterminal** **Example:** `Device>configure terminal`	Enters the global configuration mode.
Step 3	**interface** *type number* **Example:** `Device(config)# interface GigabitEthernet 1/0/1`	Identifies the MACsec interface, and enters interface configuration mode. The interface must be a physical interface.
Step 4	**switchport access vlan***vlan-id* **Example:** `Device(config-if)# switchport access vlan 1`	Configures the access VLAN for the port.
Step 5	**switchport mode access** **Example:**	Configures the interface as an access port.

	Command or Action	Purpose
	`Device(config-if)# switchport mode access`	
Step 6	**macsec** **Example:** `Device(config-if)# macsec`	Enables 802.1ae MACsec on the interface. The macsec command enables MKA MACsec on switch-to-host links only.
Step 7	**authentication event linksec fail action authorize vlan** *vlan-id* **Example:** `Device(config-if)# authentication event linksec fail action authorize vlan 1`	(Optional) Specifies that the switch processes authentication link-security failures resulting from unrecognized user credentials by authorizing a restricted VLAN on the port after a failed authentication attempt.
Step 8	**authentication host-mode multi-domain** **Example:** `Device(config-if)# authentication host-mode multi-domain`	Configures authentication manager mode on the port to allow both a host and a voice device to be authenticated on the 802.1x-authorized port. If not configured, the default host mode is single.
Step 9	**authentication linksec policy must-secure** **Example:** `Device(config-if)# authentication linksec policy must-secure`	Sets the LinkSec security policy to secure the session with MACsec if the peer is available. If not set, the default is *should secure*.
Step 10	**authentication port-control auto** **Example:** `Device(config-if)# authentication port-control auto`	Enables 802.1x authentication on the port. The port changes to the authorized or unauthorized state based on the authentication exchange between the switch and the client.
Step 11	**authentication periodic** **Example:** `Device(config-if)# authentication periodic`	(Optional) Enables or disables re-authentication for this port .
Step 12	**authentication timer reauthenticate** **Example:** `Device(config-if)# authentication timer reauthenticate`	(Optional) Enters a value between 1 and 65535 (in seconds). Obtains re-authentication timeout value from the server. Default re-authentication time is 3600 seconds.
Step 13	**authentication violation protect** **Example:** `Device(config-if)# configure terminal`	Configures the port to drop unexpected incoming MAC addresses when a new device connects to a port or when a device connects to a port after the maximum number of devices are connected to that port. If not configured, the default is to shut down the port.
Step 14	**mka policy** *policy-name* **Example:** `Device(config-if)# mka policy mka_policy`	Applies an existing MKA protocol policy to the interface, and enable MKA on the interface. If no MKA policy was configured (by entering the**mka policy** global configuration command).

	Command or Action	Purpose
Step 15	**dot1x pae authenticator** **Example:** `Device(config-if)# dot1x pae authenticator`	Configures the port as an 802.1x port access entity (PAE) authenticator.
Step 16	**spanning-tree portfast** **Example:** `Device(config-if)# spanning-tree portfast`	Enables spanning tree Port Fast on the interface in all its associated VLANs. When the Port Fast feature is enabled, the interface changes directly from a blocking state to a forwarding state without making the intermediate spanning-tree state changes
Step 17	**end** **Example:** `Device(config)# end`	Exits interface configuration mode and returns to privileged EXEC mode.
Step 18	**show authentication session interface** *interface-id* **Example:** `Device# show authentication session interface GigabitEthernet 1/0/1`	Verifies the authorized session security status.
Step 19	**show mka sessions** **Example:** `Device# show mka sessions`	Verifies the established MKA sessions.

Configure MACsec MKA using PSK

Beginning in privileged EXEC mode, follow these steps to configure MACsec MKA policies using a Pre Shared Key (PSK).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **key chain** *key-chain-name* **macsec**
4. **key** *hex-string*
5. **cryptographic-algorithm** *{aes-128-cmac | aes-256-cmac}*
6. **key-string** *{ [0|6|7] pwd-string | pwd-string}*
7. **lifetime local** [*start timestamp {hh::mm::ss | day | month | year}*] [**duration** *seconds* | *end timestamp {hh::mm::ss | day | month | year}*]
8. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**key chain** *key-chain-name* **macsec** **Example:** `Device(config)# key chain keychain1 macsec`	Configures a key chain and enters the key chain configuration mode.
Step 4	**key** *hex-string* **Example:** `Device(config-key-chain)# key 1000`	Configures a unique identifier for each key in the keychain and enters the keychain's key configuration mode. **Note** For 128-bit encryption, use any value between 1 and 32 hex digit key-string. For 256-bit encryption, use 64 hex digit key-string.
Step 5	**cryptographic-algorithm** *{aes-128-cmac | aes-256-cmac}* **Example:** `Device(config-key-chain)# cryptographic-algorithm aes-128-cmac`	Set cryptographic authentication algorithm with 128-bit or 256-bit encryption.
Step 6	**key-string** *{ [0|6|7] pwd-string | pwd-string}* **Example:** `Device(config-key-chain)# key-string 12345678901234567890123456789012`	Sets the password for a key string. Only hex characters must be entered.
Step 7	**lifetime local** [*start timestamp {hh::mm::ss | day | month | year}*] [**duration** *seconds | end timestamp {hh::mm::ss | day | month | year}*] **Example:** `Device(config-key-chain)# lifetime local 12:12:00 July 28 2016 12:19:00 July 28 2016`	Sets the lifetime of the pre shared key.
Step 8	**end** **Example:** `Device(config-key-chain)# end`	Exits key chain configuration mode and returns to privileged EXEC mode.

Configure MACsec MKA on an Interface using PSK

Beginning in privileged EXEC mode, follow these steps to configure MACsec MKA policies on an interface using a Pre Shared Key (PSK).

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **macsec network-link**
5. **mka policy** *policy-name*
6. **mka pre-shared-key key-chain** *key-chain name* [**fallback key-chain** *key-chain name*]
7. **macsec replay-protection window-size** *frame number*
8. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config-if)# interface GigabitEthernet 0/0/0`	Enters interface configuration mode.
Step 4	**macsec network-link** **Example:** `Device(config-if)# macsec network-link`	Enables MACsec on the interface.
Step 5	**mka policy** *policy-name* **Example:** `Device(config-if)# mka policy mka_policy`	Configures an MKA policy.
Step 6	**mka pre-shared-key key-chain** *key-chain name* [**fallback key-chain** *key-chain name*] **Example:** `Device(config-if)# mka pre-shared-key key-chain key-chain-name`	Configures an MKA pre-shared-key key-chain name.

	Command or Action	Purpose
Step 7	**macsec replay-protection window-size** *frame number* **Example:** `Device(config-if)# macsec replay-protection window-size 10`	Sets the MACsec window size for replay protection.
Step 8	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

What to do next

It is not recommended to change the MKA policy on an interface with MKA PSK configured when the session is running. However, if a change is required, you must reconfigure the policy as follows:

1. Disable the existing session by removing macsec network-link configuration on each of the participating node using the **no macsec network-link** command
2. Configure the MKA policy on the interface on each of the participating node using the **mka policy policy-name** command.
3. Enable the new session on each of the participating node by using the **macsec network-link** command.

Configuring MACsec MKA Using Certificate-based MACsec

To configure MACsec with MKA on point-to-point links, perform these tasks:

- Configure Certificate Enrollment
  - Generate Key Pairs
  - Configure SCEP Enrollment
  - Configure Certificates Manually
- Configure an Authentication Policy
- Configure certificate-based MACsec Profiles and IEEE 802.1x Credentials
- Configure MKA MACsec using certificate-based MACsec on Interfaces

Generate Key Pairs

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto key generate rsa label** *label-name* **general-keys modulus** *size*
4. **end**
5. **show authentication session interface** *interface-id*

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto key generate rsa label** *label-name* **general-keys modulus** *size* **Example:** `Device(config)# crypto key generate rsa label general-keys modulus 2048`	Generates a RSA key pair for signing and encryption. You can also assign a label to each key pair using the label keyword. The label is referenced by the trustpoint that uses the key pair. If you do not assign a label, the key pair is automatically labeled <Default-RSA-Key>. If you do not use additional keywords this command generates one general purpose RSA key pair. If the modulus is not specified, the default key modulus of 1024 is used. You can specify other modulus sizes with the modulus keyword.
Step 4	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.
Step 5	**show authentication session interface** *interface-id* **Example:** `Device# show authentication session interface gigabitethernet 0/1/1`	Verifies the authorized session security status.

Configure Enrollment using SCEP

Simple Certificate Enrollment Protocol (SCEP) is a Cisco-developed enrollment protocol that uses HTTP to communicate with the certificate authority (CA) or registration authority (RA). SCEP is the most commonly used method for sending and receiving requests and certificates.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto pki trustpoint** *server name*
4. **enrollment url** *url name pem*
5. **rsakeypair** *label*
6. **serial-number none**

7. **ip-address none**
8. **revocation-check crl**
9. **auto-enroll** *percent* **regenerate**
10. **exit**
11. **crypto pki authenticate** *name*
12. **end**
13. **show crypto pki certificate** *trustpoint name*

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto pki trustpoint** *server name* **Example:** `Device(config)# crypto pki trustpoint ka`	Declares the trustpoint and a given name and enters ca-trustpoint configuration mode.
Step 4	**enrollment url** *url name pem* **Example:** `Device(ca-trustpoint)# enrollment url http://url:80`	Specifies the URL of the CA on which your device should send certificate requests. An IPv6 address can be added in the URL enclosed in brackets. For example: http:// [2001:DB8:1:1::1]:80. The pem keyword adds privacy-enhanced mail (PEM) boundaries to the certificate request.
Step 5	**rsakeypair** *label* **Example:** `Device(ca-trustpoint)# rsakeypair exampleCAkeys`	Specifies which key pair to associate with the certificate. **Note** The **rsakeypair** name must match the trust-point name.
Step 6	**serial-number none** **Example:** `Device(ca-trustpoint)# serial-number none`	The **none** keyword specifies that a serial number will not be included in the certificate request.
Step 7	**ip-address none** **Example:** `Device(ca-trustpoint)# ip-address none`	The **none** keyword specifies that no IP address should be included in the certificate request.

	Command or Action	Purpose
Step 8	**revocation-check crl** **Example:** `Device(ca-trustpoint)# revocation-check crl`	Specifies CRL as the method to ensure that the certificate of a peer has not been revoked.
Step 9	**auto-enroll** *percent* **regenerate** **Example:** `Device(ca-trustpoint)# auto-enroll 90 regenerate`	Enables auto-enrollment, allowing the client to automatically request a rollover certificate from the CA. If auto-enrollment is not enabled, the client must be manually re-enrolled in your PKI upon certificate expiration. By default, only the Domain Name System (DNS) name of the device is included in the certificate. Use the percent argument to specify that a new certificate will be requested after the percentage of the lifetime of the current certificate is reached. Use the regenerate keyword to generate a new key for the certificate even if a named key already exists. If the key pair being rolled over is exportable, the new key pair will also be exportable. The following comment will appear in the trustpoint configuration to indicate whether the key pair is exportable: "! RSA key pair associated with trustpoint is exportable." It is recommended that a new key pair be generated for security reasons.
Step 10	**exit** **Example:** `Device(ca-trustpoint)# exit`	Exits ca-trustpoint configuration mode and returns to global configuration mode.
Step 11	**crypto pki authenticate** *name* **Example:** `Device(config)# crypto pki authenticate myca`	Retrieves the CA certificate and authenticates it.
Step 12	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.
Step 13	**show crypto pki certificate** *trustpoint name* **Example:** `Device# show crypto pki certificate ka`	Displays information about the certificate for the trust point.

Configure Enrollment Manually

If your CA does not support SCEP or if a network connection between the router and CA is not possible. Perform the following task to set up manual certificate enrollment:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **crypto pki trustpoint** *server name*
4. **enrollment url** *url name pem*
5. **rsakeypair** *label*
6. **serial-number none**
7. **ip-address none**
8. **revocation-check crl**
9. **exit**
10. **crypto pki authenticate** *name*
11. **crypto pki enroll** *name*
12. **crypto pki import** *name* **certificate**
13. **end**
14. **show crypto pki certificate** *trustpoint name*

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**crypto pki trustpoint** *server name* **Example:** `Device# crypto pki trustpoint ka`	Declares the trustpoint and a given name and enters ca-trustpoint configuration mode.
Step 4	**enrollment url** *url name pem* **Example:** `Device(ca-trustpoint)# enrollment url http://url:80`	Specifies the URL of the CA on which your device should send certificate requests. An IPv6 address can be added in the URL enclosed in brackets. For example: http:// [2001:DB8:1:1::1]:80. The pem keyword adds privacy-enhanced mail (PEM) boundaries to the certificate request.
Step 5	**rsakeypair** *label* **Example:** `Device(ca-trustpoint)#  rsakeypair exampleCAkeys`	Specifies which key pair to associate with the certificate.

	Command or Action	Purpose
Step 6	**serial-number none** **Example:** `Device(ca-trustpoint)# serial-number none`	The **none** keyword specifies that a serial number will not be included in the certificate request.
Step 7	**ip-address none** **Example:** `Device(ca-trustpoint)# ip-address none`	The **none** keyword specifies that no IP address should be included in the certificate request.
Step 8	**revocation-check crl** **Example:** `Device(ca-trustpoint)# revocation-check crl`	Specifies CRL as the method to ensure that the certificate of a peer has not been revoked.
Step 9	**exit** **Example:** `Device(ca-trustpoint)# exit`	Exits ca-trustpoint configuration mode and returns to global configuration mode.
Step 10	**crypto pki authenticate** *name* **Example:** `Device(config)# crypto pki authenticate myca`	Retrieves the CA certificate and authenticates it.
Step 11	**crypto pki enroll** *name* **Example:** `Device(config)# crypto pki enroll myca`	Generates certificate request and displays the request for copying and pasting into the certificate server. Enter enrollment information when you are prompted. For example, specify whether to include the device FQDN and IP address in the certificate request. You are also given the choice about displaying the certificate request to the console terminal. The base-64 encoded certificate with or without PEM headers as requested is displayed.
Step 12	**crypto pki import** *name* **certificate** **Example:** `Device(config)# crypto pki import myca certificate`	Imports a certificate via TFTP at the console terminal, which retrieves the granted certificate. The device attempts to retrieve the granted certificate via TFTP using the same filename used to send the request, except the extension is changed from ".req" to ".crt". For usage key certificates, the extensions "-sign.crt" and "-encr.crt" are used. The device parses the received files, verifies the certificates, and inserts the certificates into the internal certificate database on the switch. **Note** Some CAs ignore the usage key information in the certificate request and issue general purpose usage certificates. If your CA ignores the usage key information

	Command or Action	Purpose
		in the certificate request, only import the general purpose certificate. The router will not use one of the two key pairs generated.
Step 13	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.
Step 14	**show crypto pki certificate** *trustpoint name* **Example:** `Device# show crypto pki certificate  ka`	Displays information about the certificate for the trust point.

Enable 802.1x Authentication and Configure AAA

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **aaa new-model**
4. **dot1x system-auth-control**
5. **radius server** *name*
6. **address** *ip_address* **auth-port** *port_number* **acct-port** *port_number*
7. **automate-tester username** *username*
8. **key** *string*
9. **radius-server deadtime** *minutes*
10. **exit**
11. **aaa group server radius** *group_name*
12. **server** *name*
13. **exit**
14. **aaa authentication dot1x default group** *group_name*
15. **aaa authorization network default group** *group_name*

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`device# configure terminal`	
Step 3	**aaa new-model** **Example:** `device(config)# aaa new-model`	Enables AAA.
Step 4	**dot1x system-auth-control** **Example:** `device(config)# dot1x system-auth-control`	Enables 802.1X on your device.
Step 5	**radius server** *name* **Example:** `device(config)# radius server ISE`	Specifies the name of the RADIUS server configuration for Protected Access Credential (PAC) provisioning and enters RADIUS server configuration mode.
Step 6	**address** *ip_address* **auth-port** *port_number* **acct-port** *port_number* **Example:** `device(config-radius-server)# address ipv4 10.64.72.90 auth-port 1645 acct-port 1646`	Configures the IPv4 address for the RADIUS server accounting and authentication parameters.
Step 7	**automate-tester username** *username* **Example:** `device(config-radius-server)# automate-tester username dummy`	Enables the automated testing feature for the RADIUS server. With this practice, the device sends periodic test authentication messages to the RADIUS server. It looks for a Radius response from the server. A success message is not necessary; a failed authentication suffices, because it shows that the server is alive.
Step 8	**key** *string* **Example:** `device(config-radius-server)# key dummy123`	Configures the authentication and encryption key for all RADIUS communications between the device and the RADIUS server.
Step 9	**radius-server deadtime** *minutes* **Example:** `device(config-radius-server)#radius-server deadtime 2`	Improves RADIUS response time when some servers might be unavailable and skips unavailable servers immediately.
Step 10	**exit**	Returns to global configuration mode.
Step 11	**aaa group server radius** *group_name* **Example:** `device(config)# aaa group server radius ISEGRP`	Groups different RADIUS server hosts into distinct lists and distinct methods, and enters server group configuration mode.
Step 12	**server** *name* **Example:** `device(config)#server ise`	

	Command or Action	Purpose
Step 13	**exit** **Example:** `device(config-radius-server)# exit`	Returns to global configuration mode.
Step 14	**aaa authentication dot1x default group** *group_name* **Example:** `device(config)# aaa authentication dot1x default group ISEGRP`	Sets the default authentication server group for IEEE 802.1x.
Step 15	**aaa authorization network default group** *group_name* **Example:** `device(config)# aaa authorization network default group ISEGRP`	Sets the network authorization default group.

Apply the 802.1x MKA MACsec Configuration on the Interfaces

To apply MKA MACsec using EAP-TLS to interfaces, complete the following steps:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface_id*
4. **macsec network-link**
5. **authentication periodic**
6. **authentication timer reauthenticate interval**
7. **access-session host-mode multi-domain**
8. **access-session closed**
9. **access-session port-control auto**
10. **dot1x pae both**
11. **dot1x credentials profile**
12. **dot1x supplicant eap profile** *profile_name*
13. **dot1x authenticator eap profile** *profile_name*
14. **service-policy type control subscriber** *control_policy_name*
15. **exit**
16. **show macsec interface**
17. **copy running-config startup-config**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**configure terminal** **Example:** `device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface_id* **Example:** `device(config)# interface te0/1/2`	Identifies the MACsec interface, and enter interface configuration mode. The interface must be a physical interface.
Step 4	**macsec network-link** **Example:** `device(config)# macsec network-link`	Enables MACsec on the interface.
Step 5	**authentication periodic** **Example:** `device(config)# authentication periodic`	Enables reauthentication for this port.
Step 6	**authentication timer reauthenticate interval** **Example:** `device(config)# authentication timer reauthenticate interval`	Sets the reauthentication interval.
Step 7	**access-session host-mode multi-domain** **Example:** `device(config)# access-session host-mode multi-domain`	Allows hosts to gain access to the interface.
Step 8	**access-session closed** **Example:** `device(config)# access-session closed`	Prevents preauthentication access on the interface.
Step 9	**access-session port-control auto** **Example:** `device(config)# access-session port-control auto`	Sets the authorization state of a port.
Step 10	**dot1x pae both** **Example:** `device(config)# dot1x pae both`	Configures the port as an 802.1X port access entity (PAE) supplicant and authenticator.

	Command or Action	Purpose
Step 11	**dot1x credentials profile** **Example:** `device(config)# dot1x credentials profile`	Assigns a 802.1x credentials profile to the interface.
Step 12	**dot1x supplicant eap profile** *profile_name* **Example:** `device(config)# dot1x supplicant eap profile eap1`	Assigns the EAP-TLS profile to the interface.
Step 13	**dot1x authenticator eap profile** *profile_name* **Example:** `device(config)# dot1x authenticator eap profile eap1`	Assigns the EAP-TLS profile to use during 802.1x authentication.
Step 14	**service-policy type control subscriber** *control_policy_name* **Example:** `device(config)# service-policy type control subscriber controlPolicy2`	Applies a subscriber control policy to the interface.
Step 15	**exit** **Example:** `device(config)# exit`	Returns to privileged EXEC mode.
Step 16	**show macsec interface** **Example:** `device# show macsec interface`	Displays MACsec details for the interface.
Step 17	**copy running-config startup-config** **Example:** `device# copy running-config startup-config`	(Optional) Saves your entries in the configuration file.

Configure MKA/MACsec for Port Channel using PSK

Beginning in privileged EXEC mode, complete the following steps to configure MKA policies on an interface using a pre-shared key (PSK):

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config-if)# interface gigabitethernet 1/0/3`	Enters interface configuration mode.
Step 4	**macsec network-link** **Example:** `Device(config-if)# macsec network-link`	Enables MACsec on the interface. Supports layer 2 and layer 3 port channels.
Step 5	**mka policy** *policy-name* **Example:** `Device(config-if)# mka policy mka_policy`	Configures an MKA policy.
Step 6	**mka pre-shared-key key-chain** *key-chain name* [**fallback key-chain** *key-chain name*] **Example:** `Device(config-if)# mka pre-shared-key key-chain key-chain-name`	Configures an MKA pre-shared-key key-chain name. **Note** The MKA pre-shared key can be configured on either physical interface or subinterfaces and not on both.
Step 7	**macsec replay-protection window-size** *frame number* **Example:** `Device(config-if)# macsec replay-protection window-size 0`	Sets the MACsec window size for replay protection.
Step 8	**channel-group** *channel-group-number* **mode** {**auto** | **desirable**} | {**active** | **passive**} | {**on**} **Example:** `Device(config-if)# channel-group 3 mode auto active on`	Configures the port in a channel group and sets the mode. **Note** You cannot configure ports in a channel group without configuring MACsec on the interface. You must configure the commands in Step 3, 4, 5 and 6 before this step. The channel-number range is from 1 to 4096. The port channel that is associated with this channel group is automatically created if the port channel does not already exist. For mode, select one of the following keywords: • **auto**: Enables PAgP only if a PAgP device is detected. This places the port into a passive negotiating state, in which the port responds to PAgP packets it receives but does not start PAgP packet negotiation. **Note** The **auto** keyword is not supported when EtherChannel members are from different switches in the switch stack.

	Command or Action	Purpose
		• **desirable**: Unconditionally enables PAgP. This places the port into an active negotiating state, in which the port starts negotiations with other ports by sending PAgP packets. **Note** The **desirable** keyword is not supported when EtherChannel members are from different switches in the switch stack. • **on**: Forces the port to channel without PAgP or LACP. In the on mode, an EtherChannel exists only when a port group in the **on** mode is connected to another port group in the **on** mode. • **active**: Enables LACP only if a LACP device is detected. It places the port into an active negotiating state in which the port starts negotiations with other ports by sending LACP packets. • **passive**: Enables LACP on the port and places it into a passive negotiating state in which the port responds to LACP packets that it receives, but does not start LACP packet negotiation.
Step 9	**end** **Example:** `Device(config-if)# cend`	Exits interface configuration mode and returns to privileged EXEC mode.

Configure Port Channel Logical Interfaces for Layer 2 EtherChannels

To create a port channel interface for a Layer 2 EtherChannel, perform this task:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface port-channel** *channel-group-number* **Example:**	Creates the port channel interface. **Note**

	Command or Action	Purpose
	`Device(config)# interface port-channel 1`	Use the **no** form of this command to delete the port channel interface.
Step 4	**switchport** **Example:** `Device(config-if)# switchport`	Switches an interface that is in Layer 3 mode into Layer 2 mode for Layer 2 configuration.
Step 5	**switchport mode** {**access** | **trunk**} **Example:** `Device(config-if)# switchport mode access`	Assigns all ports as static-access ports in the same VLAN, or configure them as trunks.
Step 6	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configure Port Channel Logical Interfaces for Layer 3 EtherChannels

To create a port channel interface for a Layer 3 EtherChannel, perform this task:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet 1/0/2`	Enters interface configuration mode.
Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Switches an interface that is in Layer 2 mode into Layer 3 mode for Layer 3 configuration.
Step 5	**ip address** *ip-address subnet_mask* **Example:** `Device(config-if)# ip address 10.2.2.3 255.255.255.254`	Assigns an IP address and subnet mask to the EtherChannel.

	Command or Action	Purpose
Step 6	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring MACsec Cipher Announcement

Configure an MKA Policy for Secure Announcement

Beginning in privileged EXEC mode, follow these steps to create an MKA Protocol policy to enable secure announcement in MKPDUs. By default, secure announcements are disabled.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mka policy** *policy-name* **Example:** `Device(config)# mka policy mka_policy`	Identifies an MKA policy and enters MKA policy configuration mode. The maximum policy name length is 16 characters. **Note** The default MACsec cipher suite in the MKA policy is GCM-AES-128. If the device supports both "GCM-AES-128" and "GCM-AES-256" ciphers, it is highly recommended to define and use a user defined MKA policy to include both 128 and 256 bits ciphers or only 256 bits cipher, as may be required.
Step 4	**key-server** *priority* **Example:** `Device(config-mka-policy)# key-server priority 200`	Configures MKA key server options and sets priority between 0-255. **Note** When value of key server priority is set to 255, the peer cannot become the key server. The key server priority value is valid only for MKA PSK. This does not apply to MKA EAP-TLS.
Step 5	**send-secure-announcements** **Example:**	Enables sending of secure announcements. Use the **no** form of the command to disable sending of secure

	Command or Action	Purpose
	`Device(config-mka-policy)#` **`send-secure-announcements`**	announcements. By default, secure announcements are disabled.
Step 6	**macsec-cipher-suite** {*gcm-aes-128* | *gcm-aes-256*} **Example:** `Device(config-mka-policy)#` **`macsec-cipher-suite gcm-aes-128`**	Configures cipher suite for deriving SAK with 128-bit or 256-bit encryption.
Step 7	**end** **Example:** `Device(config-mka-policy)#` **`end`**	Exits MKA policy configuration mode and returns to privileged EXEC mode.
Step 8	**show mka policy** **Example:** `Device#` **`show mka policy`**	Displays MKA policies.

Configure Secure Announcement Globally

Beginning in privileged EXEC mode, follow these steps to enable secure announcement globally across all the MKA Policies.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device>` **`enable`**	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device#` **`configure terminal`**	Enters global configuration mode.
Step 3	**mka defaults policy send-secure-announcements** **Example:** `Device(config)#` **`mka defaults policy send-secure-announcements`**	Enables sending of secure announcements in MKPDUs across MKA policies. By default, secure announcements are disabled.
Step 4	**end** **Example:** `Device(config)#` **`end`**	Exits global configuration mode and returns to privileged EXEC mode.

Configure EAPoL Announcements on an Interface

Beginning in privileged EXEC mode, follow these steps to configure EAPoL Announcement on an interface.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet 1/0/1`	Identifies the MACsec interface, and enters interface configuration mode. The interface must be a physical interface.
Step 4	**eapol annoucement** **Example:** `Device(config-if)# eapol announcement`	Enables EAPoL announcements. Use the **no** form of the command to disable EAPoL announcements. By default, EAPoL announcements are disabled.
Step 5	**end** **Example:** `Device(config-if)# configure terminal`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuration Examples for MACsec Encryption

Example: Configuring MKA and MACsec

This example shows how to create an MKA policy:

```
Device> enable
Device# configure terminal
Device(config)# mka policy mka_policy
Device(config-mka-policy)# key-server priority 200
Device(config-mka-policy)# macsec-cipher-suite gcm-aes-128
Device(config-mka-policy)# confidentiality-offset 30
Device(config-mka-policy)# ssci-based-on-sci
Device(config-mka-policy)#end
```

This example shows how to configure MACsec on an interface:

```
Device> enable
Device# configure terminal
Device(config)# interface GigabitEthernet 1/0/1
Device(config-if)# switchport access vlan 1
Device(config-if)# switchport mode access
Device(config-if)# macsec
Device(config-if)#access-session event linksec fail action authorize vlan 1
Device(config-if)# access-session host-mode multi-domain
```

```
Device(config-if)# access-session linksec policy must-secure
Device(config-if)# access-session port-control auto
Device(config-if)#authentication periodic
Device(config-if)# authentication timer reauthenticate
Device(config-if)# authentication violation protect
Device(config-if)#mka policy mka_policy
Device(config-if)# dot1x pae authenticator
Device(config-if)# spanning-tree portfast
Device(config-if)#end
```

Examples: Configuring MACsec MKA Using PSK

This example shows how to configure MACsec MKA using PSK.

```
Device> enable
Device# configure terminal
Device(config)# Key chain keychain1 macsec
Device(config-keychain)# key 1000
Device(config-keychain-key)# cryptographic-algorithm aes-128-cmac
Device(config-keychain-key)# key-string 12345678901234567890123456789012
Device(config-keychain-key)# lifetime local 12:12:00 July 28 2016 12:19:00 July 28 2016
Device(config-keychain-key)# end
```

This example shows how to configure MACsec MKA on an interface using PSK.

```
Device> enable
Device# configure terminal
Device(config)# interface GigabitEthernet 0/0/0
Device(config-if)# mka policy mka_policy
Device(config-if)# mka pre-shared-key key-chain key-chain-name
Device(config-if)# macsec replay-protection window-size 10
Device(config-if)# end
```

MKA-PSK: CKN Behavior Change

Starting Cisco IOS XE Fuji 16.8.1 release, for MKA PSK sessions, the CKN uses exactly the same string as the CKN which is configured as the hex-string for the key, instead of the fixed 32 bytes.

```
Device> enable
Device# configure terminal
Device(config)# key chain abc macsec
Device(config-keychain)# key 11
Device(config-keychain-key)# cryptographic-algorithm aes-128-cmac
Device(config-keychain-key)# key-string 12345678901234567890123456789013
Device(config-keychain-key)# lifetime local 12:21:00 Sep 9 2015 infinite
Device(config-keychain-key)# end
```

The following is sample output of the **show mka session** command for the above configuration:

```
Device# show mka session

Total MKA Sessions....... 1
Secured Sessions... 1
Pending Sessions... 0
=============================================================================================
Interface      Local-TxSCI         Policy-Name      Inherited         Key-Server

Port-ID        Peer-RxSCI          MACsec-Peers     Status            CKN

=============================================================================================
Et0/0          aabb.cc00.6600/0002     icv            NO                NO
```

```
2              aabb.cc00.6500/0002 1                Secured             11    *Note that the
 CKN key-string is exactly the same that has been configured for the key as hex-string.*
```

In case of interoperability between two images, where one having the CKN behavior change, and one without the CKN behavior change, the hex-string for the key must be a 64-character hex-string with zero padded for it to work on a device that has an image with the CKN behavior change. See the examples below:

Configuration without CKN key-string behavior change:

```
Device# configure terminal
Device(config)# key chain abc macsec
Device(config-keychain)# key 11
Device(config-keychain-key)# cryptographic-algorithm aes-128-cmac
Device(config-keychain-key)# key-string 12345678901234567890123456789013
Device(config-keychain-key)# lifetime local 12:21:00 Sep 9 2015 infinite
Device(config-keychain-key)# end
```

Configuration with CKN key-string behavior change:

```
Device# configure terminal
Device(config)# key chain abc macsec
Device(config-keychain)# key 1100000000000000000000000000000000000000000000000000000000000000
Device(config-keychain-key)# cryptographic-algorithm aes-128-cmac
Device(config-keychain-key)# key-string 12345678901234567890123456789013
Device(config-keychain-key)# lifetime local 12:21:00 Sep 9 2015 infinite
Device(config-keychain-key)# end
```

Examples: Configuring MACsec MKA using Certificate-based MACsec

This example shows how to configure MACsec MKA using certificate-based MACsec:

```
Device> enable
Device# configure terminal
Device(config)# interface Gigabitethernet 1/0/1
Device(config-if)# macsec network-link
Device(config-if)# authentication periodic
Device(config-if)# authentication timer reauthenticate interval
Device(config-if)#access-session host-mode multi-domain
Device(config-if)# access-session closed
Device(config-if)# access-session port-control auto
Device(config-if)# dot1x pae both
Device(config-if)#dot1x credentials profile
Device(config-if)# dot1x supplicant eap profile profile_eap_tls
Device(config-if)#service-policy type control subscriber sub1
Device(config-if)# end
```

Examples: Configuring MACsec MKA for Port Channel using PSK

Etherchannel Mode — Static/On

The following is sample configuration on Device 1 and Device 2 with EtherChannel Mode on:

```
Device> enable
Device# configure terminal
Device(config)# key chain KC macsec
Device(config-key-chain)# key 1000
Device(config-key-chain)# cryptographic-algorithm aes-128-cmac
Device(config-key-chain)# key-string FC8F5B10557C192F03F60198413D7D45
Device(config-key-chain)# exit
Device(config)# mka policy POLICY
Device(config-mka-policy)# key-server priority 0
```

```
Device(config-mka-policy)# macsec-cipher-suite gcm-aes-128
Device(config-mka-policy)# confidentiality-offset 0
Device(config-mka-policy)# exit
Device(config)# interface gigabitethernet 1/0/1
Device(config-if)# channel-group 2 mode on
Device(config-if)# macsec network-link
Device(config-if)# mka policy POLICY
Device(config-if)# mka pre-shared-key key-chain KC
Device(config-if)# exit
Device(config)# interface gigabitethernet 1/0/2
Device(config-if)# channel-group 2 mode on
Device(config-if)# macsec network-link
Device(config-if)# mka policy POLICY
Device(config-if)# mka pre-shared-key key-chain KC
Device(config-if)# end
```

Layer 2 EtherChannel Configuration

Device 1

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# switchport
Device(config-if)# switchport mode trunk
Device(config-if)# no shutdown
Device(config-if)# end
```

Device 2

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# switchport
Device(config-if)# switchport mode trunk
Device(config-if)# no shutdown
Device(config-if)# end
```

The following is sample output from the**show etherchannel summary** command:

```
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

        A - formed by Auto LAG


Number of channel-groups in use: 1
Number of aggregators:           1
```

```
 Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------

 2      Po2(RU)           -        Te1/0/1(P)  Te1/0/2(P)
```

Layer 3 EtherChannel Configuration

Device 1

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# no switchport
Device(config-if)# ip address 10.25.25.3 255.255.255.0
Device(config-if)# no shutdown
Device(config-if)# end
```

Device 2

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# no switchport
Device(config-if)# ip address 10.25.25.4 255.255.255.0
Device(config-if)# no shutdown
Device(config-if)# end
```

The following is sample output from the **show etherchannel summary** command:

```
 Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

        A - formed by Auto LAG


 Number of channel-groups in use: 1
 Number of aggregators:           1

 Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------

 2      Po2(RU)           -        Te1/0/1(P)  Te1/0/2(P)
```

Etherchannel Mode — LACP

The following is sample configuration on Device 1 and Device 2 with EtherChannel Mode as LACP.

```
Device> enable
Device# configure terminal
Device(config)# key chain KC macsec
Device(config-key-chain)# key 1000
Device(config-key-chain)# cryptographic-algorithm aes-128-cmac
Device(config-key-chain)# key-string FC8F5B10557C192F03F60198413D7D45
Device(config-key-chain)# exit
Device(config)# mka policy POLICY
Device(config-mka-policy)# key-server priority 0
Device(config-mka-policy)# macsec-cipher-suite gcm-aes-128
Device(config-mka-policy)# confidentiality-offset 0
Device(config-mka-policy)# exit
Device(config)# interface gigabitethernet 1/0/1
Device(config-if)# channel-group 2 mode active
Device(config-if)# macsec network-link
Device(config-if)# mka policy POLICY
Device(config-if)# mka pre-shared-key key-chain KC
Device(config-if)# exit
Device(config)# interface gigabitethernet 1/0/2
Device(config-if)# channel-group 2 mode active
Device(config-if)# macsec network-link
Device(config-if)# mka policy POLICY
Device(config-if)# mka pre-shared-key key-chain KC
Device(config-if)# end
```

Layer 2 EtherChannel Configuration

Device 1

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# switchport
Device(config-if)# switchport mode trunk
Device(config-if)# no shutdown
Device(config-if)# end
```

Device 2

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# switchport
Device(config-if)# switchport mode trunk
Device(config-if)# no shutdown
Device(config-if)# end
```

The following is sample output from the **show etherchannel summary** command:

```
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

        A - formed by Auto LAG
```

```
Number of channel-groups in use: 1
Number of aggregators:           1


------+-------------+-----------+-----------------------------------------------

2      Po2(SU)          LACP      Te1/1/1(P)  Te1/1/2(P)
```

Layer 3 EtherChannel Configuration

Device 1

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# no switchport
Device(config-if)# ip address 10.25.25.3 255.255.255.0
Device(config-if)# no shutdown
Device(config-if)# end
```

Device 2

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# no switchport
Device(config-if)# ip address 10.25.25.4 255.255.255.0
Device(config-if)# no shutdown
Device(config-if)# end
```

The following is sample output from the **show etherchannel summary** command:

```
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

        A - formed by Auto LAG


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports

------+-------------+-----------+-----------------------------------------------

2      Po2(RU)          LACP      Te1/1/1(P)  Te1/1/2(P)
```

Etherchannel Mode — PAgP

The following is sample configuration on Device 1 and Device 2 with EtherChannel Mode as PAgP:

```
Device> enable
Device# configure terminal
Device(config)# key chain KC macsec
Device(config-key-chain)# key 1000
Device(config-key-chain)# cryptographic-algorithm aes-128-cmac
Device(config-key-chain)# key-string FC8F5B10557C192F03F60198413D7D45
Device(config-key-chain)# exit
Device(config)# mka policy POLICY
Device(config-mka-policy)# key-server priority 0
Device(config-mka-policy)# macsec-cipher-suite gcm-aes-128
Device(config-mka-policy)# confidentiality-offset 0
Device(config-mka-policy)# exit
Device(config)# interface gigabitethernet 1/0/1
Device(config-if)# channel-group 2 mode desirable
Device(config-if)# macsec network-link
Device(config-if)# mka policy POLICY
Device(config-if)# mka pre-shared-key key-chain KC
Device(config-if)# exit
Device(config)# interface gigabitethernet 1/0/2
Device(config-if)# channel-group 2 mode desirable
Device(config-if)# macsec network-link
Device(config-if)# mka policy POLICY
Device(config-if)# mka pre-shared-key key-chain KC
Device(config-if)# end
```

Layer 2 EtherChannel Configuration

Device 1

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# switchport
Device(config-if)# switchport mode trunk
Device(config-if)# no shutdown
Device(config-if)# end
```

Device 2

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# switchport
Device(config-if)# switchport mode trunk
Device(config-if)# no shutdown
Device(config-if)# end
```

The following shows a sample output from the **show etherchannel summary** command.

```
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
```

```
        d - default port

        A - formed by Auto LAG


 Number of channel-groups in use: 1
 Number of aggregators:           1


------+-------------+-----------+-----------------------------------------------

 2      Po2(SU)          PAgP      Te1/1/1(P)  Te1/1/2(P)
```

Layer 3 EtherChannel Configuration

Device 1

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# no switchport
Device(config-if)# ip address 10.25.25.3 255.255.255.0
Device(config-if)# no shutdown
Device(config-if)# end
```

Device 2

```
Device> enable
Device# configure terminal
Device(config)# interface port-channel 2
Device(config-if)# no switchport
Device(config-if)# ip address 10.25.25.4 255.255.255.0
Device(config-if)# no shutdown
Device(config-if)# end
```

The following is sample output from the **show etherchannel summary** command:

```
 Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

        A - formed by Auto LAG


 Number of channel-groups in use: 1
 Number of aggregators:           1

 Group  Port-channel  Protocol    Ports

------+-------------+-----------+-----------------------------------------------
```

```
 2       Po2(RU)          PAgP       Te1/1/1(P)   Te1/1/2(P)
```

Displaying Active MKA Sessions

The following shows all the active MKA sessions.

```
Device# show mka sessions interface Te1/0/1

=======================================================================================
Interface      Local-TxSCI          Policy-Name      Inherited
Key-Server
Port-ID        Peer-RxSCI           MACsec-Peers     Status             CKN

=======================================================================================
Te1/0/1        00a3.d144.3364/0025 POLICY           NO                  NO

37             701f.539b.b0c6/0032 1                Secured
1000
```

Examples: Configuring MACsec Cipher Announcement

This example shows how to configure MKA policy for Secure Announcement:

```
Device> enable
Device# configure terminal
Device(config)# mka policy mka_policy
Device(config-mka-policy)# key-server 2
Device(config-mka-policy)# send-secure-announcements
Device(config-mka-policy)#macsec-cipher-suite gcm-aes-128confidentiality-offset 0
Device(config-mka-policy)# end
```

This example shows how to configure Secure Announcement globally:

```
Device> enable
Device# configure terminal
Device(config)# mka defaults policy send-secure-announcements
Device(config)# end
```

This example shows how to configure EAPoL Announcements on an interface:

```
Device> enable
Device# configure terminal
Device(config)# interface GigabitEthernet 1/0/1
Device(config-if)# eapol announcement
Device(config-if)# end
```

The following is sample output from the **show running-config interface** *interface-name* command with EAPoL announcement enabled.

```
Device# show running-config interface GigabitEthernet 1/0/1

switchport mode access
 macsec
 access-session host-mode multi-host
 access-session closed
 access-session port-control auto
 dot1x pae authenticator
 dot1x timeout quiet-period 10
```

```
 dot1x timeout tx-period 5
 dot1x timeout supp-timeout 10
 dot1x supplicant eap profile peap
 eapol announcement
 spanning-tree portfast
 service-policy type control subscriber Dot1X
```

The following is sample output from the **show mka sessions interface** *interface-name* **detail** command with secure announcement disabled.

```
Device# show mka sessions interface GigabitEthernet 1/0/1 detail


MKA Detailed Status for MKA Session
===================================
Status: SECURED - Secured MKA Session with MACsec

Local Tx-SCI............. 204c.9e85.ede4/002b
Interface MAC Address.... 204c.9e85.ede4
MKA Port Identifier...... 43
Interface Name........... GigabitEthernet1/0/1
Audit Session ID.........
CAK Name (CKN)...........
0100000000000000000000000000000000000000000000000000000000000000
Member Identifier (MI)... D46CBEC05D5D67594543CEAE
Message Number (MN)...... 89567
EAP Role................. NA
Key Server............... YES
MKA Cipher Suite......... AES-128-CMAC

Latest SAK Status........ Rx & Tx
Latest SAK AN............ 0
Latest SAK KI (KN)....... D46CBEC05D5D67594543CEAE00000001 (1)
Old SAK Status........... FIRST-SAK
Old SAK AN............... 0
Old SAK KI (KN).......... FIRST-SAK (0)

SAK Transmit Wait Time... 0s (Not waiting for any peers to respond)
SAK Retire Time.......... 0s (No Old SAK to retire)

MKA Policy Name.......... p2
Key Server Priority...... 2
Delay Protection......... NO
Replay Protection........ YES
Replay Window Size....... 0
Confidentiality Offset... 0
Algorithm Agility........ 80C201
Send Secure Announcement.. DISABLED
SAK Cipher Suite......... 0080C20001000001 (GCM-AES-128)
MACsec Capability........ 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired........... YES
```

```
# of MACsec Capable Live Peers..... 1
# of MACsec Capable Live Peers Responded.. 1

Live Peers List:
  MI                       MN          Rx-SCI (Peer)        KS Priority
  -----------------------------------------------------------------------
  38046BA37D7DA77E06D006A9  89555       c800.8459.e764/002a   10

Potential Peers List:
  MI                       MN          Rx-SCI (Peer)        KS Priority
  -----------------------------------------------------------------------

Dormant Peers List:
  MI                       MN          Rx-SCI (Peer)        KS Priority
  -----------------------------------------------------------------------
```

The following is sample output from the **show mka sessions details** command with secure announcement disabled.

```
Device# show mka sessions details

MKA Detailed Status for MKA Session
===================================
Status: SECURED - Secured MKA Session with MACsec

Local Tx-SCI..... 204c.9e85.ede4/002b
Interface MAC Address.... 204c.9e85.ede4
MKA Port Identifier...... 43
Interface Name........... GigabitEthernet1/0/1
Audit Session ID.........
CAK Name (CKN)...........
0100000000000000000000000000000000000000000000000000000000000000
Member Identifier (MI)... D46CBEC05D5D67594543CEAE
Message Number (MN)...... 89572
EAP Role................. NA
Key Server............... YES
MKA Cipher Suite......... AES-128-CMAC

Latest SAK Status........ Rx & Tx
Latest SAK AN............ 0
Latest SAK KI (KN)....... D46CBEC05D5D67594543CEAE00000001 (1)
Old SAK Status........... FIRST-SAK
Old SAK AN............... 0
Old SAK KI (KN).......... FIRST-SAK (0)

SAK Transmit Wait Time... 0s (Not waiting for any peers to respond)
SAK Retire Time.......... 0s (No Old SAK to retire)

MKA Policy Name.......... p2
Key Server Priority...... 2
Delay Protection......... NO
Replay Protection........ YES
Replay Window Size....... 0
```

```
Confidentiality Offset... 0
Algorithm Agility........ 80C201
Send Secure Announcement.. DISABLED
SAK Cipher Suite......... 0080C20001000001 (GCM-AES-128)
MACsec Capability........ 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired........... YES

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

Live Peers List:
  MI                       MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------
  38046BA37D7DA77E06D006A9  89560       c800.8459.e764/002a   10

Potential Peers List:
  MI                       MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------

Dormant Peers List:
  MI                       MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------
```

The following is sample output from the **show mka policy** *policy-name* **detail** command with secure announcement disabled.

```
Device# show mka policy p2 detail

MKA Policy Configuration ("p2")
========================
MKA Policy Name........ p2
Key Server Priority.... 2
Confidentiality Offset. 0
Send Secure Announcement..DISABLED
Cipher Suite(s)........ GCM-AES-128

Applied Interfaces...
  GigabitEthernet1/0/1
```

Examples: Displaying MKA Information

The following is sample output from the **show mka sessions** command.

```
Device# show mka sessions


Total MKA Sessions....... 1
      Secured Sessions... 1
      Pending Sessions... 0

=============================================================================
Interface      Local-TxSCI         Policy-Name      Inherited
Key-Server
Port-ID        Peer-RxSCI          MACsec-Peers     Status           CKN
```

```
==========================================================================
Gi1/0/1         204c.9e85.ede4/002b p2              NO                  YES
43              c800.8459.e764/002a 1                Secured
0100000000000000000000000000000000000000000000000000000000000000
```

The following is sample output from the **show mka sessions interface** *interface-name* command.

```
Device# show mka sessions interface GigabitEthernet 1/0/1

Summary of All Currently Active MKA Sessions on Interface
GigabitEthernet1/0/1...

==========================================================================
Interface       Local-TxSCI          Policy-Name       Inherited
Key-Server
Port-ID         Peer-RxSCI           MACsec-Peers      Status              CKN
==========================================================================
Gi1/0/1         204c.9e85.ede4/002b p2              NO                  YES
43              c800.8459.e764/002a 1                Secured
0100000000000000000000000000000000000000000000000000000000000000
```

The following is sample output from the **show mka sessions interface** *interface-name* **detail**command.

```
Device# show mka sessions interface GigabitEthernet 1/0/1 detail


MKA Detailed Status for MKA Session
===================================
Status: SECURED - Secured MKA Session with MACsec

Local Tx-SCI.............. 204c.9e85.ede4/002b
Interface MAC Address.... 204c.9e85.ede4
MKA Port Identifier...... 43
Interface Name........... GigabitEthernet1/0/1
Audit Session ID.........
CAK Name (CKN)...........
0100000000000000000000000000000000000000000000000000000000000000
Member Identifier (MI)... D46CBEC05D5D67594543CEAE
Message Number (MN)...... 89567
EAP Role................. NA
Key Server............... YES
MKA Cipher Suite......... AES-128-CMAC

Latest SAK Status........ Rx & Tx
Latest SAK AN............ 0
Latest SAK KI (KN)....... D46CBEC05D5D67594543CEAE00000001 (1)
Old SAK Status........... FIRST-SAK
Old SAK AN............... 0
Old SAK KI (KN).......... FIRST-SAK (0)

SAK Transmit Wait Time... 0s (Not waiting for any peers to respond)
SAK Retire Time.......... 0s (No Old SAK to retire)

MKA Policy Name.......... p2
```

```
Key Server Priority...... 2
Delay Protection......... NO
Replay Protection........ YES
Replay Window Size....... 0
Confidentiality Offset... 0
Algorithm Agility........ 80C201
Send Secure Announcement.. DISABLED
SAK Cipher Suite......... 0080C20001000001 (GCM-AES-128)
MACsec Capability........ 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired........... YES

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

Live Peers List:
  MI                        MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------
  38046BA37D7DA77E06D006A9  89555       c800.8459.e764/002a   10

Potential Peers List:
  MI                        MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------

Dormant Peers List:
  MI                        MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------
```

The following is sample output from the **show mka sessions details** command:

```
Device# show mka sessions details

MKA Detailed Status for MKA Session
===================================
Status: SECURED - Secured MKA Session with MACsec

Local Tx-SCI............. 204c.9e85.ede4/002b
Interface MAC Address.... 204c.9e85.ede4
MKA Port Identifier...... 43
Interface Name........... GigabitEthernet1/0/1
Audit Session ID.........
CAK Name (CKN)...........
0100000000000000000000000000000000000000000000000000000000000000
Member Identifier (MI)... D46CBEC05D5D67594543CEAE
Message Number (MN)...... 89572
EAP Role................. NA
Key Server............... YES
MKA Cipher Suite......... AES-128-CMAC

Latest SAK Status........ Rx & Tx
Latest SAK AN............ 0
Latest SAK KI (KN)....... D46CBEC05D5D67594543CEAE00000001 (1)
Old SAK Status........... FIRST-SAK
Old SAK AN............... 0
```

```
Old SAK KI (KN).......... FIRST-SAK (0)

SAK Transmit Wait Time... 0s (Not waiting for any peers to respond)
SAK Retire Time.......... 0s (No Old SAK to retire)

MKA Policy Name.......... p2
Key Server Priority...... 2
Delay Protection......... NO
Replay Protection........ YES
Replay Window Size....... 0
Confidentiality Offset... 0
Algorithm Agility........ 80C201
Send Secure Announcement.. DISABLED
SAK Cipher Suite......... 0080C20001000001 (GCM-AES-128)
MACsec Capability........ 3 (MACsec Integrity, Confidentiality, & Offset)
MACsec Desired........... YES

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

Live Peers List:
  MI                        MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------
  38046BA37D7DA77E06D006A9  89560       c800.8459.e764/002a   10

Potential Peers List:
  MI                        MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------

Dormant Peers List:
  MI                        MN          Rx-SCI (Peer)        KS Priority
  ------------------------------------------------------------------------
```

The following is sample output from the **show mka policy** command:

```
Device# show mka policy


MKA Policy Summary...

Policy            KS       Delay   Replay  Window Conf   Cipher
 Interfaces
Name              Priority Protect Protect Size   Offset Suite(s)
 Applied
================================================================================
*DEFAULT POLICY*  0        FALSE   TRUE    0      0      GCM-AES-128

p1                1        FALSE   TRUE    0      0      GCM-AES-128

p2                2        FALSE   TRUE    0      0      GCM-AES-128
 Gi1/0/1
```

The following is sample output from the **show mka policy** *policy-name* command:

```
Device# show mka policy p2


MKA Policy Summary...

Policy            KS       Delay   Replay  Window Conf   Cipher
 Interfaces
Name              Priority Protect Protect Size   Offset Suite(s)
 Applied
================================================================================
p2                2        FALSE   TRUE    0      0      GCM-AES-128
 Gi1/0/1
```

The following is sample output from the **show mka policy** *policy-name* **detail** command:

```
Device# show mka policy p2 detail

MKA Policy Configuration ("p2")
========================
MKA Policy Name........ p2
Key Server Priority.... 2
Confidentiality Offset. 0
Send Secure Announcement..DISABLED
Cipher Suite(s)........ GCM-AES-128

Applied Interfaces...
  GigabitEthernet1/0/1
```

The following is sample output from the **show mka statistics interface** *interface-name* command:

```
Device# show mka statistics interface GigabitEthernet 1/0/1


MKA Statistics for Session
==========================
Reauthentication Attempts.. 0

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

SA Statistics
   SAKs Generated......... 1
   SAKs Rekeyed........... 0
   SAKs Received.......... 0
   SAK Responses Received.. 1

MKPDU Statistics
   MKPDUs Validated & Rx... 89585
      "Distributed SAK".. 0
      "Distributed CAK".. 0
   MKPDUs Transmitted...... 89596
```

```
      "Distributed SAK".. 1
      "Distributed CAK".. 0
```

The following is sample output from the **show mka summary** command:

```
Device# show mka summary

Total MKA Sessions....... 1
      Secured Sessions... 1
      Pending Sessions... 0

================================================================================
Interface      Local-TxSCI          Policy-Name      Inherited
Key-Server
Port-ID        Peer-RxSCI           MACsec-Peers     Status             CKN
================================================================================
Gi1/0/1        204c.9e85.ede4/002b p2               NO                 YES
43             c800.8459.e764/002a 1                Secured
0100000000000000000000000000000000000000000000000000000000000000



MKA Global Statistics
=====================
MKA Session Totals
   Secured..................... 1
   Reauthentication Attempts.. 0

   Deleted (Secured).......... 0
   Keepalive Timeouts......... 0

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

SA Statistics
   SAKs Generated............. 1
   SAKs Rekeyed............... 0
   SAKs Received.............. 0
   SAK Responses Received..... 1

MKPDU Statistics
   MKPDUs Validated & Rx...... 89589
      "Distributed SAK"..... 0
      "Distributed CAK"..... 0
   MKPDUs Transmitted......... 89600
      "Distributed SAK"..... 1
      "Distributed CAK"..... 0

MKA Error Counter Totals
```

```
========================
Session Failures
   Bring-up Failures.............. 0
   Reauthentication Failures........ 0
   Duplicate Auth-Mgr Handle........ 0

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

CA Failures
   Group CAK Generation............. 0
   Group CAK Encryption/Wrap........ 0
   Group CAK Decryption/Unwrap...... 0
   Pairwise CAK Derivation.......... 0
   CKN Derivation................... 0
   ICK Derivation................... 0
   KEK Derivation................... 0
   Invalid Peer MACsec Capability... 0
MACsec Failures
   Rx SC Creation................... 0
   Tx SC Creation................... 0
   Rx SA Installation............... 0
   Tx SA Installation............... 0

MKPDU Failures
   MKPDU Tx......................... 0
   MKPDU Rx Validation.............. 0
   MKPDU Rx Bad Peer MN............. 0
   MKPDU Rx Non-recent Peerlist MN.. 0
```

Additional References for MACsec Encryption

Standards and RFCs

Standard/RFC	Title
IEEE 802.1AE-2006	*Media Access Control (MAC) Security*
IEEE 802.1X-2010	*Port-Based Network Access Control*
IEEE 802.1AEbw-2013	*Media Access Control (MAC) Security (Amendment to IEEE 802.1AE-2006)—Extended Packet Numbering (XPN)*

Standard/RFC	Title
IEEE 802.1Xbx-2014	*Port-Based Network Access Control (Amendment to IEEE 802.1X-2010)*
RFC 4493	*The AES-CMAC Algorithm*

Technical Assistance

Description	Link
The Cisco Support website provides extensive online resources, including documentation and tools for troubleshooting and resolving technical issues with Cisco products and technologies. To receive security and technical information about your products, you can subscribe to various services, such as the Product Alert Tool (accessed from Field Notices), the Cisco Technical Services Newsletter, and Really Simple Syndication (RSS) Feeds. Access to most tools on the Cisco Support website requires a Cisco.com user ID and password.	Support & Downloads page on Cisco.com

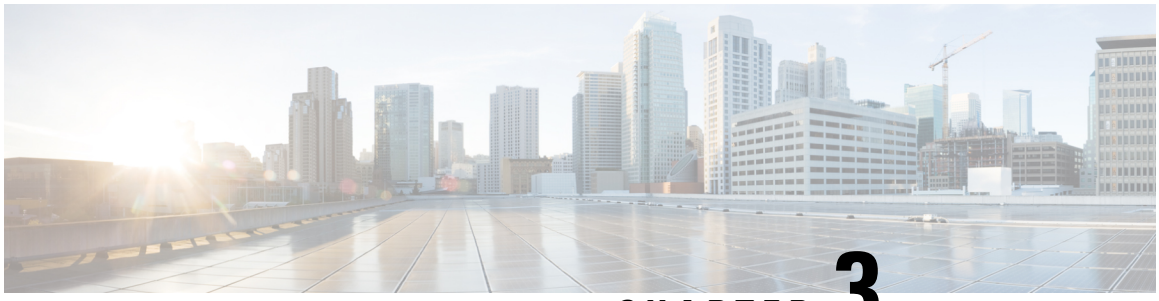
Feature History for MACsec Encryption

This table provides release and related information for the features explained in this module.

These features are available in all the releases subsequent to the one they were introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE 17.13.1	Certificate-based MACsec encryption	Support for this feature was introduced for the Cisco Catalyst ESS9300 Embedded Series Switch in this release.
Cisco IOS XE Cupertino 17.8.x	MACsec encryption	MACsec is the IEEE 802.1AE standard for authenticating and encrypting packets between two MACsec-capable devices. Support for this feature was introduced for Cisco Catalyst IE9300 Rugged Series Switches in this release.

Use the Cisco Feature Navigator to find information about platform and software image support. To access Cisco Feature Navigator, go to http://www.cisco.com/go/cfn.



CHAPTER 3

Network Edge Access Topology

802.1x Supplicant and Authenticator Switches with Network Edge Access Topology

The 802.1x standard defines a client-server-based access control and authentication protocol that prevents unauthorized clients from connecting to a LAN through publicly accessible ports unless they are properly authenticated. The authentication server authenticates each client connected to a switch port before making available any services offered by the switch or the LAN. For more information about 802.1x, including configuration information, see Configuring IEEE 802.1x Port-Based Authentication.

The Network Edge Access Topology (NEAT) feature extends identity to areas outside the wiring closet. This allows any type of device to authenticate on the port. NEAT uses Client Information Signalling Protocol (CISP) to propagate Client MAC and VLAN information between supplicant and Authenticator. CISP and NEAT are supported only on L2 ports, not on L3 ports. You can configure NEAT on Cisco Catalyst IE9300 Rugged Series Switches.

- 802.1x switch supplicant: You can configure a switch to act as a supplicant to another switch by using the 802.1x supplicant feature. This configuration is helpful in a scenario, where, for example, a switch is outside a wiring closet and is connected to an upstream switch through a trunk port. A switch configured with the 802.1x switch supplicant feature authenticates with the upstream switch for secure connectivity. Once the supplicant switch authenticates successfully the port mode changes from access to trunk in an authenticator switch. In a supplicant switch you must manually configure the trunk when enabling CISP.
- If the access VLAN is configured on the authenticator switch, it becomes the native VLAN for the trunk port after successful authentication.

In the default state, when you connect a supplicant switch to an authenticator switch that has BPDU guard enabled, the authenticator port could be error-disabled if it receives a Spanning Tree Protocol (STP) bridge protocol data unit (BPDU) packets before the supplicant switch has authenticated. You can control traffic exiting the supplicant port during the authentication period. Entering the **dot1x supplicant controlled transient**

global configuration command temporarily blocks the supplicant port during authentication to ensure that the authenticator port does not shut down before authentication completes. If authentication fails, the supplicant port opens. Entering the **no dot1x supplicant controlled transient** global configuration command opens the supplicant port during the authentication period. This is the default behavior.

We strongly recommend using the **dot1x supplicant controlled transient**command on a supplicant switch when BPDU guard is enabled on the authenticator switch port with the **spanning-tree bpduguard enable** interface configuration command.

Note If you globally enable BPDU guard on the authenticator switch by using the **spanning-tree portfast bpduguard default** global configuration command, entering the **dot1x supplicant controlled transient** command on the Supplicant switch does not prevent the BPDU violation.

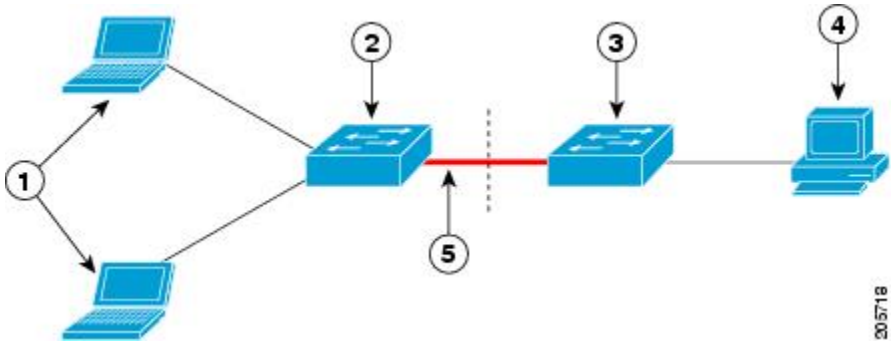
You can enable MDA or multiauth mode on the authenticator switch interface that connects to one more supplicant switches. Multihost mode is not supported on the authenticator switch interface.

When you reboot an authenticator switch with single-host mode enabled on the interface, the interface may move to err-disabled state before authentication. To recover from err-disabled state, flap the authenticator port to activate the interface again and initiate authentication.

Use the **dot1x supplicant force-multicast** global configuration command on the supplicant switch for NEAT to work in all host modes.

- Host Authorization: Ensures that only traffic from authorized hosts (connecting to the switch with supplicant) is allowed on the network. The switches use CISP to send the MAC addresses connecting to the supplicant switch to the authenticator switch.
- Auto enablement: Automatically enables trunk configuration on the authenticator switch, allowing user traffic from multiple VLANs coming from supplicant switches. Configure the cisco-av-pair as *device-traffic-class=switch* at the ISE. (You can configure this under the *group* or the *user* settings.)

Figure 5: Authenticator and Supplicant Switch Using CISP



1	Workstations (clients)
2	Supplicant switch (outside wiring closet)
3	Authenticator switch
4	Cisco ISE

5	Trunk port

Note The **switchport nonegotiate** command is not supported on supplicant and authenticator switches with NEAT. This command should not be configured at the supplicant side of the topology. If configured on the authenticator side, the internal macros will automatically remove this command from the port.

Guidelines and Limitations

The following are guidelines and limitations for configuring and using NEAT.

- A Radius server such as Cisco's Identity Server Engine (ISE) is required.
- CISP and NEAT are supported only on L2 ports, not on L3 ports.
- NEAT and 802.1x are not supported on EtherChannel ports.
- NEAT is not supported on dynamic ports.
- MACsec is supported with NEAT.
- NEAT can operate with PTP.
- MAB and NEAT are mutually exclusive. You cannot enable MAB when NEAT is enabled on an interface, and you should not enable NEAT when MAB is enabled on an interface.

Configure an Authenticator Switch with NEAT

Configuring this feature requires that one switch outside a wiring closet is configured as a supplicant and is connected to an authenticator switch.

Note
- The *cisco-av-pairs* must be configured as *device-traffic-class=switch* on the ISE, which sets the interface as a trunk after the supplicant is successfully authenticated.

Beginning in privileged EXEC mode, follow these steps to configure a switch as an authenticator:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **cisp enable**
4. **interface** *interface-id*
5. **switchport mode access**
6. **authentication port-control auto**
7. **dot1x pae authenticator**

8. **spanning-tree portfast**
9. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**cisp enable** **Example:** `Device(config)# cisp enable`	Enables CISP.
Step 4	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet 1/0/2`	Specifies the port to be configured, and enters interface configuration mode.
Step 5	**switchport mode access** **Example:** `Device(config-if)# switchport mode access`	Sets the port mode to **access**.
Step 6	**authentication port-control auto** **Example:** `Device(config-if)# authentication port-control auto`	Sets the port-authentication mode to auto.
Step 7	**dot1x pae authenticator** **Example:**	Configures the interface as a port access entity (PAE) authenticator.

	Command or Action	Purpose
	`Device(config-if)# dot1x pae authenticator`	
Step 8	**spanning-tree portfast** **Example:** `Device(config-if)# spanning-tree portfast trunk`	Enables the interface to quickly transition to spanning-tree forwarding state for an interface which is a member of multiple VLANs. Use this command only when you are sure that the switch-to-switch connection is not part of a Layer2 loop.
Step 9	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configure a Supplicant Switch with NEAT

Beginning in privileged EXEC mode, follow these steps to configure a switch as a supplicant:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **cisp enable**
4. **eap profile** *profile-name*
5. **method** *type*
6. **exit**
7. **dot1x credentials** *profile*
8. **username** *suppswitch*
9. **password** *password*
10. **dot1x supplicant force-multicast**
11. **interface** *interface-id*
12. **switchport trunk encapsulation dot1q**
13. **switchport mode trunk**
14. **dot1x pae supplicant**
15. **dot1x credentials** *profile-name*
16. **dot1x supplicant eap profile** *profile-name*
17. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**cisp enable** **Example:** `Device(config)# cisp enable`	Enables CISP.
Step 4	**eap profile** *profile-name* **Example:** `Device(config)# eap profile CISP`	Creates an Extensible Authentication Protocol (EAP) profile and enters EAP profile configuration mode.
Step 5	**method** *type* **Example:** `Device(config-eap-profile)# method md5`	Specifies the EAP authentication method.
Step 6	**exit** **Example:** `Device(config-eap-profile)# exit`	Exits EAP profile configuration mode.
Step 7	**dot1x credentials** *profile* **Example:** `Device(config)# dot1x credentials test`	Creates 802.1x credentials profile. This must be attached to the port that is configured as supplicant.
Step 8	**username** *suppswitch* **Example:** `Device(config)# username suppswitch`	Creates a username.

	Command or Action	Purpose
Step 9	**password** *password* **Example:** `Device(config)# password myswitch`	Creates a password for the new username.
Step 10	**dot1x supplicant force-multicast** **Example:** `Device(config)# dot1x supplicant force-multicast`	Forces the switch to send only multicast EAPOL packets when it receives either unicast or multicast packets. This also allows NEAT to work on the supplicant switch in all host modes.
Step 11	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet1/0/1`	Specifies the port to be configured, and enters interface configuration mode.
Step 12	**switchport trunk encapsulation dot1q** **Example:** `Device(config-if)# switchport trunk encapsulation dot1q`	Sets the port to trunk mode.
Step 13	**switchport mode trunk** **Example:** `Device(config-if)# switchport mode trunk`	Configures the interface as a VLAN trunk port.
Step 14	**dot1x pae supplicant** **Example:** `Device(config-if)# dot1x pae supplicant`	Configures the interface as a port access entity (PAE) supplicant.
Step 15	**dot1x credentials** *profile-name* **Example:** `Device(config-if)# dot1x credentials test`	Attaches the 802.1x credentials profile to the interface.
Step 16	**dot1x supplicant eap profile** *profile-name* **Example:** `Device(config-if)# dot1x supplicant eap profile cisp`	Assigns the EAP-TLS profile to the 802.1X interface.

	Command or Action	Purpose
Step 17	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Verifying Configuration

Use the following show commands to verify information about Client Information Signalling Protocol (CISP) and Network Edge Access Topology (NEAT) configuration:

- show cisp interface <interface name>
- show cisp clients
- show cisp summary
- show cisp registrations

Following is example output for **show cisp** commands. GigabitEthernet 1/0/1 is configured as Authenticator, and GigabitEthernet 1/0/2 is configured as Supplicant.

```
Auth# show cisp interface Gi1/0/2

CISP Status for interface Gi1/0/2
 -------------------------------------
Version: 1
Mode: Supplicant Peer
Mode: Authenticator
Supp State: Idle

Auth# show cisp clients

Authenticator Client Table:
 ------------------------
 MAC Address VLAN Interface
 --------------------------------
 0050.5695.4de8 1 Gi1/0/10
6c03.09e7.3947 1 Gi1/0/10
6c03.09e7.3954 11 Gi1/0/10
6c03.09e7.4485 1 Gi1/0/10
 9077.ee4a.8567 1 Gi1/0/10
e41f.7ba1.bbd4 1 Gi1/0/10

Supplicant Client Table:
------------------------
MAC Address VLAN Interface
--------------------------------
9077.ee4a.856b 11 Vl11
9077.ee4a.8572 1 Ap1/1
e41f.7bc7.2f03 1 Gi1/0/9

Auth# show cisp summary

CISP is running on the following interface(s):
---------------------------------------------
```

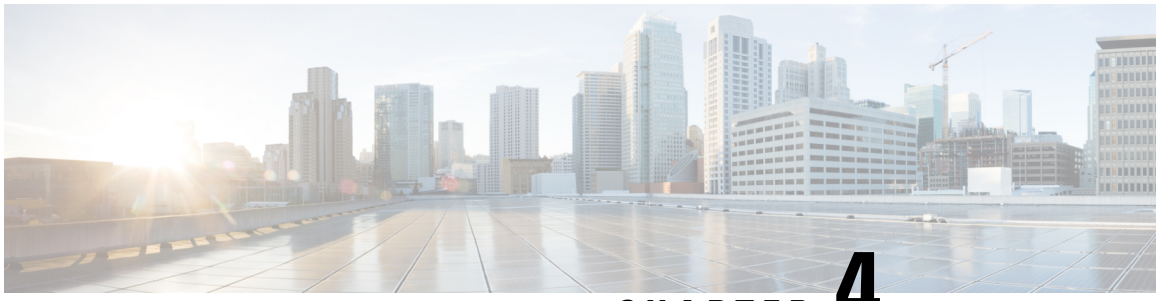
```
Gi1/0/2 (Authenticator)

Supp# show cisp summary

CISP is running on the following interface(s):
---------------------------------------------
Gi1/0/1 (Supplicant)

Auth# show cisp registrations

Interface(s) with CISP registered user(s):
-----------------------------------------
Gi1/0/2
Auth Mgr (Authenticator)

Supp# show cisp registration

Interface(s) with CISP registered user(s):
-----------------------------------------
Gi1/0/1
802.1x Sup (Supplicant)
```

Use the following debug commands to troubleshoot CISP and NEAT:

- debug access-session errors
- debug access-session event
- debug dot1x errors
- debug dot1x packets
- debug dot1x events

Feature History

Feature Name	Release	Feature Information
Network Edge Access Topology (NEAT)	Cisco IOS XE 17.8.1	Initial support on Cisco Catalyst IE9300 Rugged Series Switches



CHAPTER 4

Layer 2 Network Address Translation

Layer 2 Network Address Translation

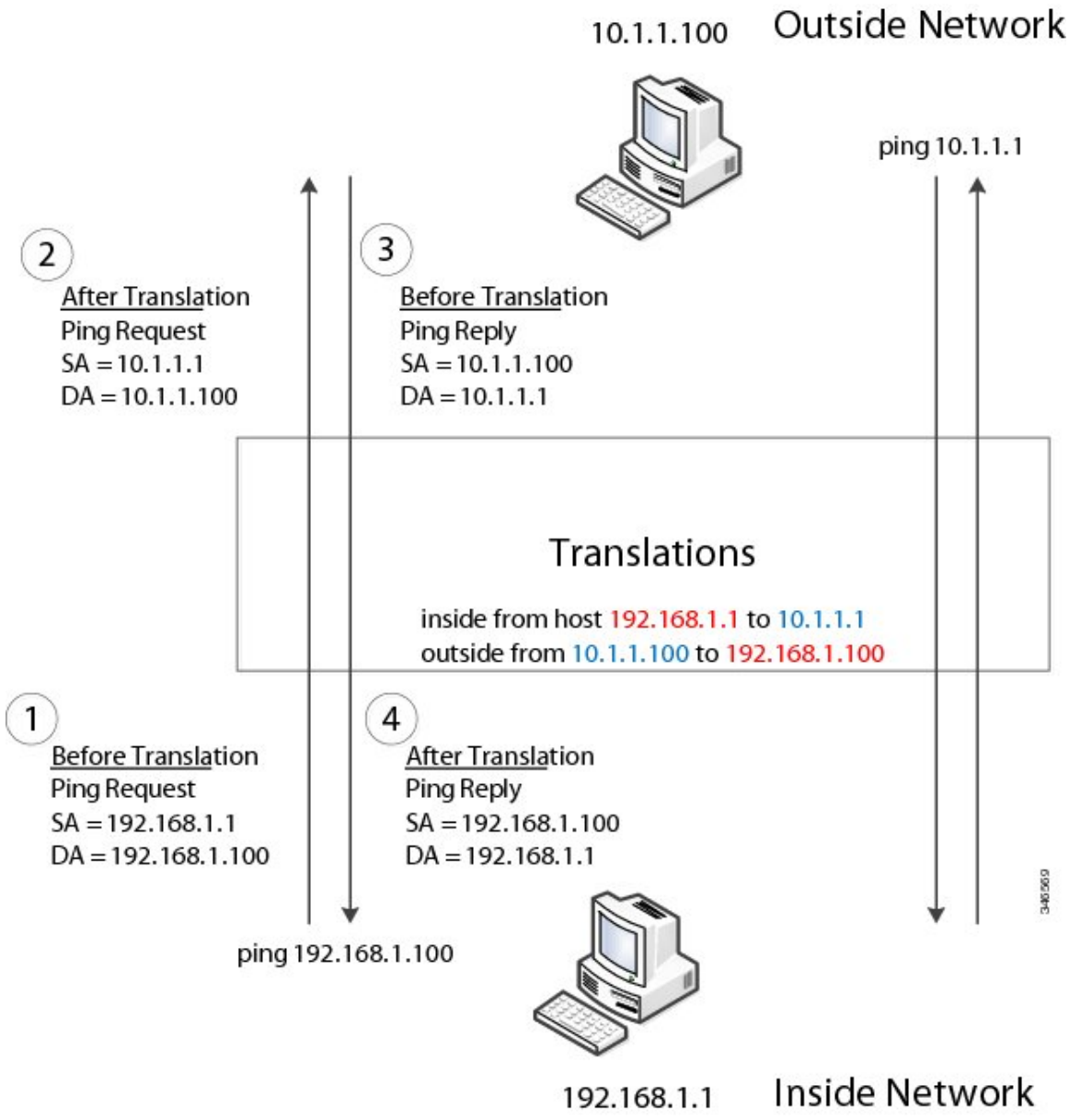
One-to-one Layer 2 NAT (Network Address Translation) is a service that allows the assignment of a unique public IP address to an existing private IP address (end device). The assignment enables the end device to communicate on both the private and public subnets. This service is configured in a NAT-enabled device and is the public “alias” of the IP address that is physically programmed on the end device. This is typically represented by a table in the NAT device.

Layer 2 NAT uses a table to translate IPv4 addresses both public-to-private, and private-to-public at line rate. Layer 2 NAT is a hardware-based implementation that provides the same high level of (bump-on-the-wire) wire-speed performance. This implementation also supports multiple VLANs through the NAT boundary for enhanced network segmentation.

In the following example, Layer 2 NAT translates addresses between sensors on a 192.168.1.x network and a line controller on a 10.1.1.x network.

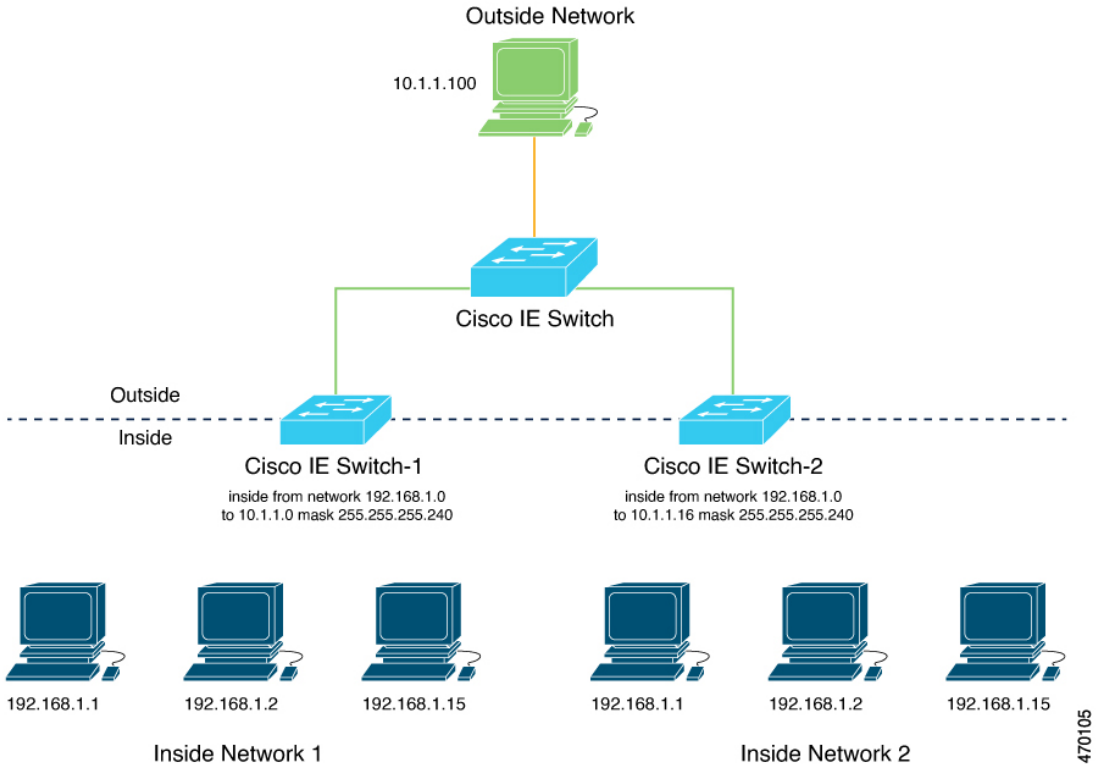
1. The 192.168.1.x network is the inside/internal IP address space and the 10.1.1.x network is the outside or external IP address space.
2. The sensor at 192.168.1.1 sends a ping request to the line controller by using an “inside” address, 192.168.1.100.
3. Before the packet leaves the internal network, Layer 2 NAT translates the source address (SA) to 10.1.1.1 and the destination address (DA) to 10.1.1.100.
4. The line controller sends a ping reply to 10.1.1.1.
5. When the packet is received on the internal network, Layer 2 NAT translates the source address to 192.168.1.100 and the destination address to 192.168.1.1.

Figure 6: Translating Addresses Between Networks



For large numbers of nodes, you can quickly enable translations for all devices in a subnet. In the scenario shown in the following figure, addresses from Inside Network 1 can be translated to outside addresses in the 10.1.1.0/28 subnet, and addresses from Inside Network 2 can be translated to outside addresses in the 10.1.1.16/28 subnet. All addresses in each subnet can be translated with one command. The benefit of using subnet-based translations saves in Layer L2 NAT rules. The switch has limits on the number of Layer 2 NAT rules. A rule with a subnet allows for multiple end devices to be translated with a single rule.

Figure 7: Inside-Outside Address Translation



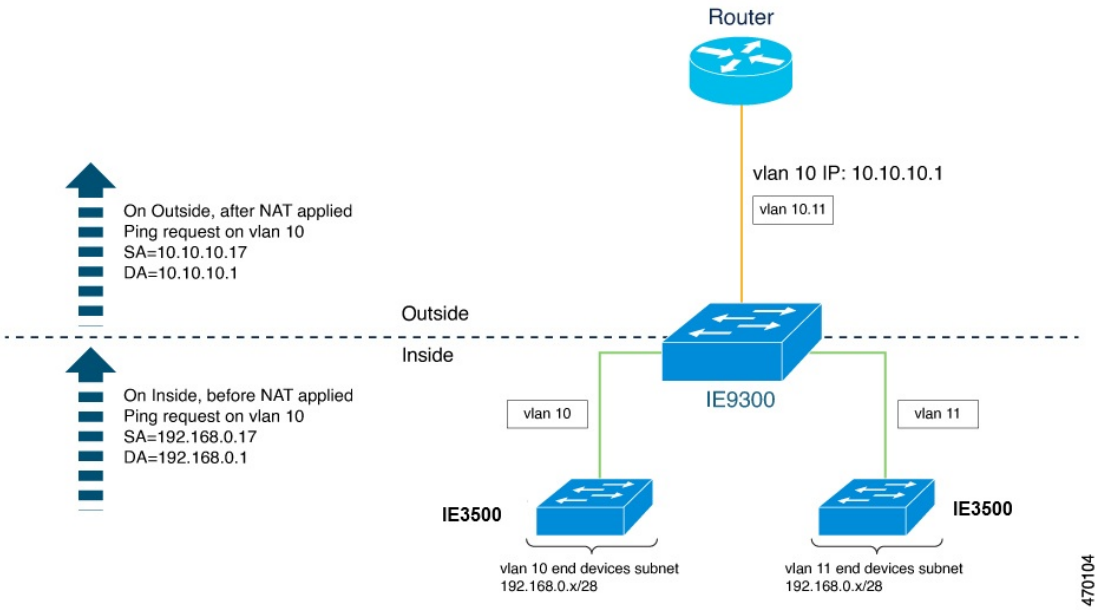
The following figure shows a switch at the aggregation layer forwarding Ethernet packets based on Layer 2 MAC Addresses. In this example, the router is the Layer 3 gateway for all subnets and VLANs.

The L2NAT instance definitions use the **network** command to define a translated row for multiple devices in the same subnet. In this the case, it's a /28 subnet with last byte in the IP address starting with 16 and ending with 31. The gateway for the VLAN is the router with last byte of the IP address ending with .1. An outside host translation is provided for the router. The **network** command in the Layer 2NAT definition translates a subnet's worth of host with a single command, saving on Layer 2 NAT translation records.

The Gi1/1 uplink interface has Layer 2NAT translation instances for vlan10 and vlan 11 subnets. Interfaces can support multiple Layer 2 NAT instance definitions.

The downstream switches are examples of access layer switches which do not perform L2NAT and rely on the upstream aggregation layer switch to do it.

Figure 8: NAT on the Switch



The following example shows the NAT configuration for the preceding diagram:

```
!
l2nat instance Subnet10-NAT
 instance-id 1
 permit all
 fixup all
 outside from host 10.10.10.1 to 192.168.0.1
 inside from network 192.168.0.0 to 10.10.10.16 mask 255.255.255.240
!
l2nat instance Subnet11-NAT
 instance-id 1
 permit all
 fixup all
 outside from host 10.10.11.1 to 192.168.0.1
 inside from network 192.168.0.0 to 10.10.11.16 mask 255.255.255.240
!
interface GigabitEthernet1/1
 switchport mode trunk
 l2nat Subnet10-NAT 10
 l2nat Subnet11-NAT 11
!
Interface vlan 1
  ip address 10.10.1.2
```

Guidelines and Limitations

The following list provides guidelines and limitations for using Layer 2 NAT with the Switch.

Note For scale information, see the section NAT Performance and Scalability, on page 108 in this guide.

- Layer 2 NAT is supported on standalone switches.
- Layer 2 NAT is disabled by default; it becomes enabled when you configure it. See Configure Layer 2 NAT, on page 108 in this guide.
- Layer 2 NAT applies only to unicast traffic. Untranslated unicast traffic, multicast traffic, and IGMP traffic are permitted.
- Layer 2 NAT is supported only on the uplink ports and available in both Network Essentials and Network Advantage licenses.
- Layer 2 NAT supports one-to-one mapping between external and internal IP addresses.
- Layer 2 NAT can be applied to uplink interfaces in access or trunk mode.
- Only IPv4 addresses for Layer 2 traffic can be translated.
- Supported subnet masks on inside network translation are /24, /25, /26, /27, /28, and /32 only.
- Outside translation rule supports only host translations.
- ARP does not work transparently across Layer 2 NAT; however, the switch changes the IP addresses embedded in the payload of IP packets for the protocols to work. Embedded IP addresses are not translated.
- Statistics for debugging include the following statistics: entries for each translation, translated total ingress and egress for each instance, and for each interface. Also included are ARP fixup stats and the number of translations entries allocated in hardware.
- Layer 2 NAT does not support one-to-many and many-to-one IP address mapping.
- Layer 2 NAT cannot save on public IP addresses because public-to-private is a 1:1 translation. It is not 1:N NAT.
- If you configure a translation for a Layer 2 NAT host, do not configure it as a DHCP client.
- When translating an inside address to an outside address using Layer 2 NAT, ensure that the translated IP address is not accessible in the global network.
- The management interface is behind the Layer 2 NAT function. Therefore this interface should not be on the private network VLAN. If it is on the private network VLAN, assign an inside address and configure an inside translation.
- Because Layer 2 NAT is designed to separate outside and inside addresses, we recommend that you do not configure addresses of the same subnet as both outside and inside addresses.
- Layer 2 NAT is only for Layer 2 traffic; do not use it for packets undergoing routing
- Layer 2 NAT does not translate packets destined for CPU and packets coming from CPU. Management traffic should be on a different VLAN from the private network VLAN.
- Layer 2 NAT counters are not based on ports. When the same Layer 2 NAT instance is applied to multiple interfaces, the corresponding Layer 2 NAT counters will be displayed for all those interfaces.

NAT Performance and Scalability

Layer 2 NAT translation and forwarding are performed in the hardware at line rate. The number of Layer 2NAT rules that are supported depends on the number of hardware entries that can be supported in hardware.

Scale depends on the number of inside/outside combinations. The following list provides scale examples.

- An instance with only inside rules can have a total of 128 translation rules.
- Multiple instances with one inside rule can have a total of 128 such instances applied to 128 different VLANs.
- Multiple instances with one inside rule and one outside rule can have a maximum of 64 instances.
- A single instance with one outside rule can have a maximum of 100 inside rules. The number of inside rules that can be supported reduces with increase in the outside rules.

Note We recommended that you use network translation rules to save on the number of rules.

Configure Layer 2 NAT

You must configure Layer 2 NAT instances that specify the address translations. Attach Layer 2 NAT instances to physical Ethernet interfaces, and configure which VLAN or VLANs the instances will be applied to. Layer 2 NAT instances can be configured from management interfaces (CLI/SNMP). You can view detailed statistics about the packets that are sent and received. See the section Verify the Configuration, on page 111 in this guide.

To configure Layer 2 NAT, follow these steps. Refer to the examples in Basic Inside-to-Outside Communications: Example, on page 112 and Duplicate IP Addresses Example, on page 115 in this guide for more details.

Procedure

Step 1 Enter global configuration mode:

configure terminal

Step 2 Create a new Layer 2 NAT instance:

l2nat instance *instance_name* After creating an instance, you use this same command to enter the submode for that instance.

Step 3 Translate an inside address to an outside address:

inside from [*host* | *range* | *network*] *original ip* to *translated ip* [*mask*] *number* | *mask*

You can translate a single host address, a range of host addresses, or all the addresses in a subnet. Translate the source address for outbound traffic and the destination address for inbound traffic.

Step 4 Translate an outside address to an inside address:

outside from [*host* | *range* | *network*] *original ip* to *translated ip* [*mask*] *number* | *mask*

You can translate a single host address, a range of host addresses, or the addresses in a subnet. Translate the destination address for outbound traffic and the source address for inbound traffic.

Step 5 Exit config-l2nat mode:

exit

Step 6 Access interface configuration mode for the specified interface (uplink ports only on the IE 3400):

interface *interface-id*

Step 7 Apply the specified Layer 2 NAT instance to a VLAN or VLAN range. If this parameter is missing, the Layer 2 NAT instance applies to the native VLAN.

l2nat *instance_name* [*vlan* | *vlan_range*]

Step 8 Exit interface configuration mode:

end

Configure Layer 2 NAT support on Port Channel

Note Layer 2 NAT is supported on logical interface of port-channel but not on member interface.

The LACP is defined in IEEE 802.3ad and enables Cisco devices to manage port-channels between devices that conform to the IEEE 802.3ad protocol. LACP facilitates the automatic creation of port-channels by exchanging LACP packets between Ethernet ports.

By using LACP, the switch or switch stack learns the identity of partners capable of supporting LACP and the capabilities of each port. It then dynamically groups similarly configured ports into a single logical link (channel or aggregate port). Similarly configured ports are grouped based on hardware, administrative, and port parameter constraints. For example, LACP groups the ports with the same speed, duplex mode, native VLAN, VLAN range, and trunking status and type. After grouping the links into an port-channels, LACP adds the group to the spanning tree as a single device port.

LACP modes specify whether a port can send LACP packets or only receive LACP packets.

Active mode: Places a port into an active negotiating state in which the port starts negotiations with other ports by sending LACP packets.

Passive mode: Places a port into a passive negotiating state in which the port responds to LACP packets that it receives, but does not start LACP packet negotiation. This setting minimizes the transmission of LACP packets.

Both the active and passive LACP modes enable ports to negotiate with partner ports to a port-channel based on criteria such as port speed, and for Layer 2 EtherChannels, based on trunk state and VLAN numbers.

When you specify the maximum number of bundled LACP ports allowed in a port channel, the remaining ports in the port channel are designated as hot-standby ports. Beginning in privileged EXEC mode, follow these steps to configure the maximum number of LACP ports in a port-channel. This procedure is optional.

Procedure

Step 1 Enter global configuration mode:

device configure

Step 2 Create a new Layer 2 NAT instance called A-LC:

device # l2nat instance A-LC

Step 3 Translate A1's inside address to an outside address:

Device(config-l2nat)# inside from host 192.168.1.1 to 10.1.1.1

Step 4 Translate A2's inside address to an outside address:

Device(config-l2nat)# inside from host 192.168.1.2 to 10.1.1.2

Step 5 Translate A3's inside address to an outside address:

Device(config-l2nat)# inside from host 192.168.1.3 to 10.1.1.3

Step 6 Translate LC's outside address to an inside address:

Device(config-l2nat)# outside from host 10.1.1.200 to 192.168.1.250

Step 7 Exit config-l2nat mode:

Device(config-l2nat)# exit

Step 8 Access interface configuration mode for the port channel:

Device(config)# interface port-channel

Step 9 Apply this Layer 2 NAT instance to the native VLAN on this interface:

Device(config-if)#l2nat A-LC

Note
For tagged traffic on a trunk, add the VLAN number when attaching the instance to an interface as follows: `l2nat instance vlan`

Step 10 Return to privileged EXEC mode:

Device# end

Verify the Configuration

Procedure

Perform the following commands to verify the Layer 2 NAT configuration.

Command	Purpose
show l2nat instance	Displays the configuration details for a specified Layer 2 NAT instance.
show l2nat interface	Displays the configuration details for Layer 2 NAT instances on one or more interfaces.
show l2nat statistics	Displays the Layer 2 NAT statistics for all interfaces.
show l2nat statistics interface	Displays the Layer 2 NAT statistics for a specified interface.
debug l2nat	Enables showing real-time Layer 2 NAT configuration details when the configuration is applied.
show platform hardware fed switch 1 fwd-asic resource tcam table pbr record 0 format 0 -	Displays the hardware entries.
-show platform hardware fed switch active fwd-asic resource tcam utilization | in PBR	Displays the hardware resource utilization.

The following is an example of output of the **show l2nat instance** and the **show l2nat statistics** commands:

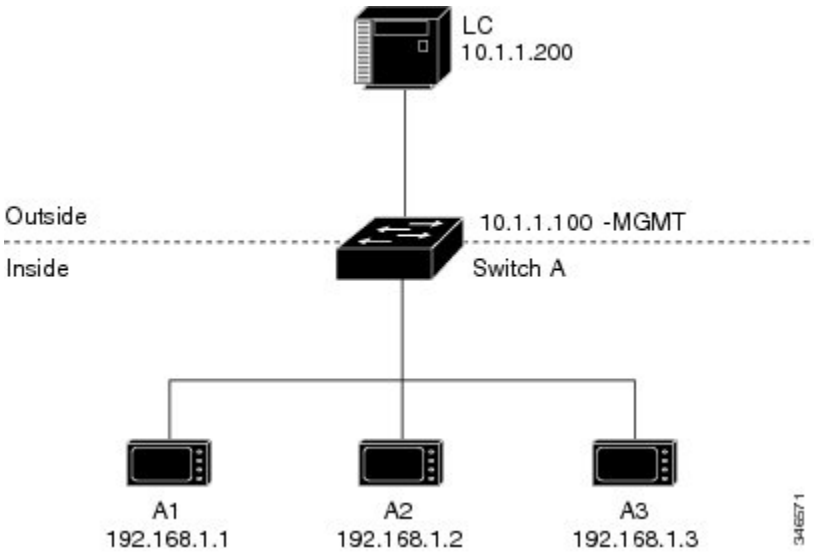
```
switch#show l2nat instance
l2nat instance test
fixup  : all
outside from host    10.10.10.200 to 192.168.1.200
inside  from host    192.168.1.1 to 10.10.10.1
l2nat instance test2
fixup  : all
inside  from host    1.1.1.1 to 2.2.2.2
outside from host    2.2.2.200 to 1.1.1.200

Switch#show l2nat interface
FOLLOWING INSTANCE(S) AND VLAN(s) ATTACHED TO ALL INTERFACES
================================================================
l2nat Gi1/1 test
================================================================

Switch#show l2nat statistics

STATS FOR INSTANCE: test (IN PACKETS)

TRANSLATED STATS (IN PACKETS)
================================================================================
```

```
INTERFACE DIRECTION VLAN   TRANSLATED
Gi1/1     EGRESS    50    0
Gi1/1     INGRESS   50    0
-------------------------------------------------------------------------------

PROTOCOL FIXUP STATS (IN PACKETS)
===============================================================================
INTERFACE DIRECTION VLAN    ARP
Gi1/1     REPLY    50    0
Gi1/1     REQUEST   50    0
-------------------------------------------------------------------------------

PER TRANSLATION STATS (IN PACKETS)
===============================================================================
TYPE    DIRECTION SA/DA ORIGINAL IP     TRANSLATED IP   COUNT
OUTSIDE INGRESS   SA    10.10.10.200    192.168.1.200   0
OUTSIDE EGRESS    DA    192.168.1.200   10.10.10.200    0
INSIDE  EGRESS    SA    192.168.1.1     10.10.10.1      0
INSIDE  INGRESS   DA    10.10.10.1      192.168.1.1     0
-------------------------------------------------------------------------------
===============================================================================

TOTAL TRANSLATIONS ENTRIES IN HARDWARE: 4
TOTAL INSTANCES ATTACHED : 1
===============================================================================
GLOBAL NAT STATISTICS
===============================================================================
Total Number of TRANSLATED NAT  Packets   = 0
Total Number of ARP      FIX UP Packets   = 0
===============================================================================
ad
```

Basic Inside-to-Outside Communications: Example

In this example, A1 must communicate with a logic controller (LC) that is directly connected to the uplink port. A Layer 2 NAT instance is configured to provide an address for A1 on the outside network (10.1.1.1) and an address for the LC on the inside network (192.168.1.250).

Figure 9: Basic Inside-to-Outside Communications



Now this communication can occur:

1. A1 sends an ARP request: SA: 192.168.1.1DA: 192.168.1.250.
2. Cisco Switch A fixes up the ARP request:SA:10.1.1.1DA: 10.1.1.200.
3. LC receives the request and learns the MAC Address of 10.1.1.1.
4. LC sends a response:SA: 10.1.1.200DA: 10.1.1.1.
5. Cisco Switch A fixes up the ARP response:SA: 192.168.1.250DA: 192.168.1.1.
6. A1 learns the MAC address for 192.168.1.250, and communication starts.

Note

- The management interface of the switch must be on a different VLAN from the inside network 192.168.1.x.
- See the section Basic Inside-to-Outside Communications: Configuration, on page 113 for the tasks to configure the example in this section.

Basic Inside-to-Outside Communications: Configuration

This section contains the steps to configure inside-to-outside communications as described in the preceding section. You create the Layer 2 NAT instance, add two translation entries, and then apply the instance to the interface. ARP fixups are enabled by default.

Before you begin

Read and understand the content in the section Basic Inside-to-Outside Communications: Example, on page 112.

Procedure

Step 1 Enter configuration mode.

Example:

```
switch# configure
```

Step 2 Create a new Layer 2 NAT instance called A-LC.

Example:

```
switch(config)# l2nat instance A-LC
```

Step 3 Translate A1's inside address to an outside address.

Example:

```
switch(config-l2nat)# inside from host 192.168.1.1 to 10.1.1.1
```

Step 4 Translate A2's inside address to an outside address.

Example:

```
switch(config-l2nat)# inside from host 192.168.1.2 to 10.1.1.2
```

Step 5 Translate A3's inside address to an outside address.

Example:

```
switch(config-l2nat)# inside from host 192.168.1.3 to 10.1.1.3
```

Step 6 Translate the LC outside address to an inside address.

Example:

```
switch(config-l2nat)# outside from host 10.1.1.200 to 192.168.1.250
```

Step 7 Exit config-l2nat mode.

Example:

```
switch(config-l2nat)# exit
```

Step 8 Access interface configuration mode for the uplink port.

Example:

```
witch(config)# interface Gi1/1
```

Step 9 Apply this Layer 2 NAT instance to the native VLAN on this interface.

Example:

```
switch(config-if)# l2nat A-LC
```

Note
For tagged traffic on a trunk, add the VLAN number when attaching the instance to an interface as follows:

l2nat *instance vlan*

Step 10 Return to privileged EXEC mode.

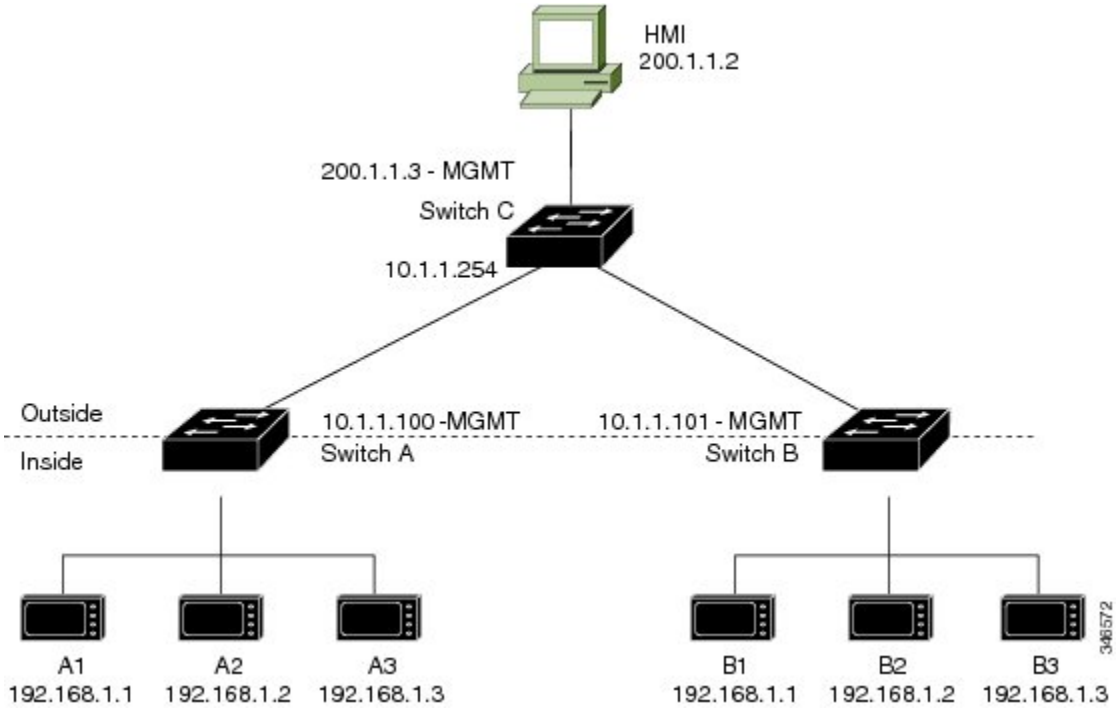
Example:

```
switch# end
```

Duplicate IP Addresses Example

In this scenario, two machine nodes are preconfigured with addresses in the 192.168.1.x space. Layer 2 NAT translates these addresses to unique addresses on separate subnets of the outside network. In addition, for machine-to-machine communications, the Node A machines need unique addresses on the Node B space and the Node B machines need unique addresses in the Node A space.

Figure 10: Duplicate IP Addresses



- Switch C needs an address in the 192.168.1.x space. When packets come into Node A or Node B, the 10.1.1.254 address of Switch C is translated to 192.168.1.254. When packets leave Node A or Node B, the 192.168.1.254 address of Switch C is translated to 10.1.1.254.
- Node A and Node B machines need unique addresses in the 10.1.1.x space. For quick configuration and ease of use, the 10.1.1.x space is divided into subnets: 10.1.1.0, 10.1.1.16, 10.1.1.32, and so on. Each subnet can then be used for a different node. In this example, 10.1.1.16 is used for Node A, and 10.1.1.32 is used for Node B.
- Node A and Node B machines need unique addresses to exchange data. The available addresses are divided into subnets. For convenience, the 10.1.1.16 subnet addresses for the Node A machines are translated to 192.168.1.16 subnet addresses on Node B. The10.1.1.32 subnet addresses for the Node B machines are translated to 192.168.1.32 addresses on Node A.
- Machines have unique addresses on each network:

Table 10: Translated IP Addresses

Node	Address in Node A	Address in Outside Network	Address in Node B
Switch A network address	192.168.1.0	10.1.1.16	192.168.1.16
A1	192.168.1.1	10.1.1.17	192.168.1.17
A2	192.168.1.2	10.1.1.18	192.168.1.18
A3	192.168.1.3	10.1.1.19	192.168.1.19
Cisco Switch B network address	192.168.1.32	10.1.1.32	192.168.1.0
B1	192.168.1.33	10.1.1.33	192.168.1.1
B2	192.168.1.34	10.1.1.34	192.168.1.2
B3	192.168.1.35	10.1.1.35	192.168.1.3
Switch C	192.168.1.254	10.1.1.254	192.168.1.254

Duplicate IP Addresses Configuration: Switch A

This section provides the steps for configuring Layer 2 NAT to translate the duplicated IP address of one machine node in an inside network to a unique address on a subnet of an outside network. This procedure is for Switch A in the section Duplicate IP Addresses Example, on page 115.

Before you begin

Read and understand the content in the section Duplicate IP Addresses Example, on page 115.

Procedure

Step 1 Enter global configuration mode.

Example:

```
switch# configure
```

Step 2 Create a new Layer 2 NAT instance called A-Subnet.

Example:

```
switch(config)# l2nat instance A-Subnet
```

Step 3 Translate the Node A machines' inside addresses to addresses in the 10.1.1.16 255.255.255.240 subnet.

Example:

```
switch(config-l2nat)# inside from network 192.168.1.0 to 10.1.1.16 mask 255.255.255.240
```

Step 4 Translate the outside address of Switch C to an inside address.

Example:

```
switch(config-l2nat)# outside from host 10.1.1.254 to 192.168.1.254
```

Step 5 Translate the Node B machines' outside addresses to their inside addresses.

Example:

```
switch(config-l2nat)# outside from host 10.1.1.32 to 192.168.1.32
outside from host 10.1.1.33 to 192.168.1.33
outside from host 10.1.1.34 to 192.168.1.34
outside from host 10.1.1.35 to 192.168.1.35
```

Step 6 Exits config-l2nat mode.

Example:

```
switch(config-l2nat)# exit
```

Step 7 Access interface configuration mode for the uplink port.

Example:

```
switch(config)# interface Gi1/1
```

Step 8 Apply this Layer 2 NAT instance to the native VLAN on this interface.

Example:

```
switch(config-if)# l2nat A-Subnet
```

Note
For tagged traffic on a trunk, add the VLAN number when attaching the instance to an interface as follows:

l2nat *instance vlan*

Step 9 Return to privileged EXEC mode.

Example:

```
switch# end
```

What to do next

Configure Layer 2 NAT to translate the duplicated IP address of Switch B in the section Duplicate IP Addresses Example, on page 115. See Duplicate IP Addresses Configuration: Switch B, on page 117.

Duplicate IP Addresses Configuration: Switch B

This section provides the steps for configuring Layer 2 NAT to translate the duplicated IP address of one machine node in an inside network to a unique address on a subnet of an outside network. This procedure is for Switch B in the section Duplicate IP Addresses Example, on page 115.

Before you begin

Read and understand the content in the section Duplicate IP Addresses Example, on page 115.

Procedure

Step 1 Enter global configuration mode.

Example:

```
switch# configure
```

Step 2 Create a new Layer 2 NAT instance called B-Subnet.

Example:

```
switch(config)# l2nat instance B-Subnet
```

Step 3 Translate the Node B machines' inside addresses to addresses in the 10.1.1.32 255.255.255.240 subnet.

Example:

```
switch(config-l2nat)# inside from network 192.168.1.0 to 10.1.1.32 255.255.255.240
```

Step 4 Translate the outside address of Switch C to an inside address.

Example:

```
switch(config-l2nat)# outside from host 10.1.1.254 to
```

Step 5 Translate the Node A machines' outside addresses to their inside addresses.

Example:

```
switch(config-l2nat)# outside from host 10.1.1.16 to 192.168.1.16
outside from host 10.1.1.17 to 192.168.1.17
outside from host 10.1.1.18 to 192.168.1.18
outside from host 10.1.1.19 to 192.168.1.19
```

Step 6 Exit config-l2nat mode.

Example:

```
switch(config-l2nat)# exit
```

Step 7 Access interface configuration mode for the uplink port.

Example:

```
switch(config)# interface Gi1/1
```

Step 8 Apply this Layer 2 NAT instance to the native VLAN on this interface.

Example:

```
switch(config-if)# l2nat name1
```

Note
For tagged traffic on a trunk, add the VLAN number when attaching the instance to an interface as follows:

l2nat *instance vlan*

Step 9 Show the configuration details for the specified Layer 2 NAT instance.

Example:

```
switch# show l2nat instance name1
```

Step 10 Show Layer 2 NAT statistics.

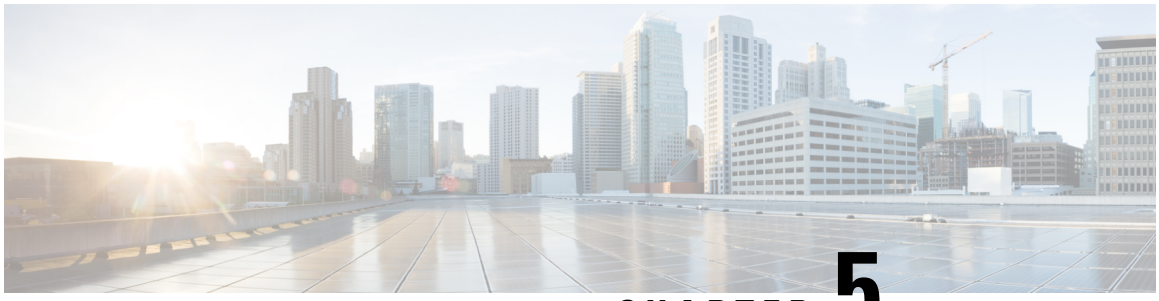
Example:

```
switch# show l2nat statistics
```

Step 11 Return to privileged EXEC mode.

Example:

```
switch# end
```



CHAPTER 5

Configuring Wired Dynamic PVLAN

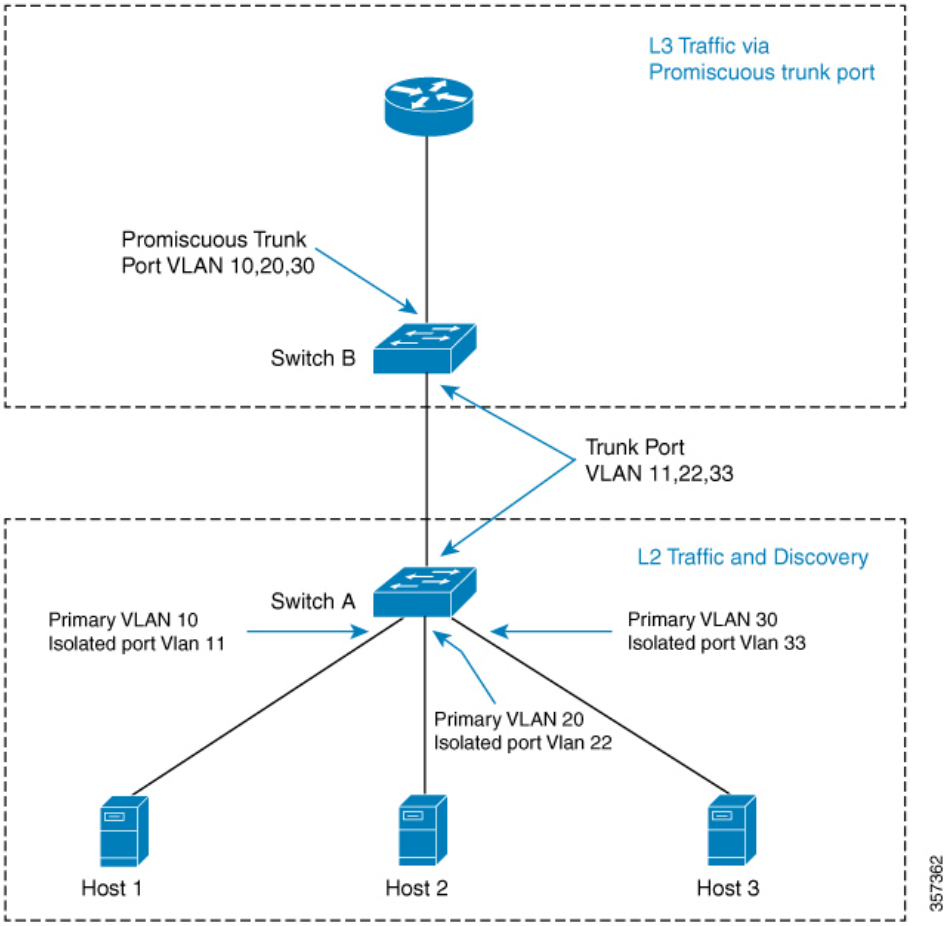
Restrictions for Wired Dynamic PVLAN

- High availability is not supported with Wired Dynamic PVLAN.
- Voice VLAN configuration cannot co-exist with this feature.
- Local Web Authentication (LWA) and Central Web Authentication (CWA) cannot be used with this feature.
- All wired clients using the dynamic PVLAN interface template will be programmed as data clients.
- Only interfaces with existing Access or PVLAN Host switchport mode support PVLAN template.
- Identity Based Networking Services 2.0 (IBNS 2.0) must be used for dynamic template support.

Information About Wired Dynamic PVLAN

Wired Dynamic PVLAN is a feature that uses a private VLAN with AAA authorization to isolate clients and provide Zero-Trust. It is a method to block peer to peer communications within a subnet/VLAN. Here, the client is assigned to a PVLAN which isolates a wired client connected on one port from all other ports on Layer 2 while the Layer 3 communication occurs via the promiscuous port. In this feature, a single wired data client is supported per port interface, to ensure point-to-point blocking.

Note Traffic from multiple clients on the same interface will not be blocked.



In this topology, the hosts are connected to Switch A and they can communicate only with the promiscuous trunk port on the switch. The PVLAN can be extended to span across multiple switches by adding intermediate switches. If there is a switch (Switch C) between Switch A and Switch B in the above topology, then layer 2 trunk ports need to be configured on the intermediate links. If case of a community VLAN, it allows packets to be seen on other hosts within the same community VLAN.

When a host is connected to a switch port with a cable, it is placed into an Isolated PVLAN where it cannot discover any other hosts. The host is then authenticated by the RADIUS server. Another scenario is when the port is placed in closed mode, and if the port is not authenticated, only Extensible Authentication Protocol over LAN (EAPoL) packets are allowed. Once the port is authenticated it is placed into an Isolated VLAN dynamically. As the host first authenticates with the RADIUS server, it sends the name of a dynamic interface template to be applied to the host's port. This interface template contains the configurations to enable the PVLAN Primary and Secondary VLANs on the port. With the template applied to the host, the switchport mode will be changed which will cause the port to flap from access mode to PVLAN mode.

Note The interface template with the same name as referred by AAA Authorization needs to be configured on the switch.

When the interface template is being applied, the port will physically go down for a time period set by the sticky timer and come up again. When the RADIUS server sends the interface template a second time, it is ignored as the conversion has been completed. The port is then assigned to a PVLAN which keeps it isolated. The host completes authorization and comes up to ready state.

Configure the keep time for which the interface template information is retained before it is removed from the port using the **access-session interface-template sticky timer** *time* command.

Configuring Wired Dynamic PVLAN

To configure Wired Dynamic PVLAN, perform these steps on the user device (Switch A in the above topology):

Before you begin

Ensure that the dot1x aaa is configured on the user device.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vlan** *vlan-id*
4. **private-vlan isolated**
5. **exit**
6. **vlan** *vlan-id*
7. **private-vlan primary**
8. **private-vlan association** [**add** | **remove**] *secondary_vlan_list*
9. **exit**
10. **template** *template-name*
11. **switchport mode private-vlan host**
12. **switchport private-vlan host-association** *primary_vlan_id secondary_vlan_id*
13. **exit**
14. **access-session interface-template sticky timer** *time*
15. **interface** *interface-id*
16. **access-session interface-template sticky timer** *time*
17. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**vlan** *vlan-id* **Example:** `Device(config)# vlan 200`	(Optional) Enters VLAN configuration mode and designates or creates a VLAN that will be an isolated VLAN. The VLAN ID range is 2 to 1001 and 1006 to 4094.
Step 4	**private-vlan isolated** **Example:** `Device(config-vlan)# private-vlan isolated`	Designates the VLAN as an isolated VLAN.
Step 5	**exit** **Example:** `Device(config-vlan)# exit`	Returns to global configuration mode.
Step 6	**vlan** *vlan-id* **Example:** `Device(config)# vlan 100`	Enters VLAN configuration mode and designates or creates a VLAN that will be the primary VLAN. The VLAN ID range is 2 to 1001 and 1006 to 4094.
Step 7	**private-vlan primary** **Example:** `Device(config-vlan)# private-vlan primary`	Designates the VLAN as the primary VLAN.
Step 8	**private-vlan association** [**add** | **remove**] *secondary_vlan_list* **Example:** `Device(config-vlan)# private-vlan association 200`	Associates the secondary VLANs with the primary VLAN. It can be a single private-VLAN ID or a hyphenated range of private-VLAN IDs. • The *secondary_vlan_list* parameter cannot contain spaces. It can contain multiple comma-separated items. Each item can be a single private-VLAN ID or a hyphenated range of private-VLAN IDs. • The *secondary_vlan_list* parameter can contain multiple community VLAN IDs but only one isolated VLAN ID.

	Command or Action	Purpose
		• Enter a *secondary_vlan_list*, or use the **add** keyword with a *secondary_vlan_list* to associate secondary VLANs with a primary VLAN. • Use the **remove** keyword with a *secondary_vlan_list* to clear the association between secondary VLANs and a primary VLAN. • The command does not take effect until you exit VLAN configuration mode.
Step 9	**exit** **Example:** `Device(config-vlan)# exit`	Returns to global configuration mode.
Step 10	**template** *template-name* **Example:** `Device(config)# template PVLAN100_200_CFG`	Creates a user template and enters template configuration mode.
Step 11	**switchport mode private-vlan host** **Example:** `Device(config-template)# switchport mode private-vlan host`	Configures a Layer 2 port as a PVLAN host port on the template.
Step 12	**switchport private-vlan host-association** *primary_vlan_id secondary_vlan_id* **Example:** `Device(config-template)# switchport private-vlan host-association 100 200`	Configures the association of a Layer 2 port with a PVLAN on the template.
Step 13	**exit** **Example:** `Device(config-template)# exit`	Returns to global configuration mode.
Step 14	**access-session interface-template sticky timer** *time* **Example:** `Device(config)# access-session interface-template sticky timer 60`	Configures the keep time of the template globally. Once the last client leaves, the template will be removed from the port after the configured keep time. **Note** It is recommended that you set the sticky timer to 60 seconds.

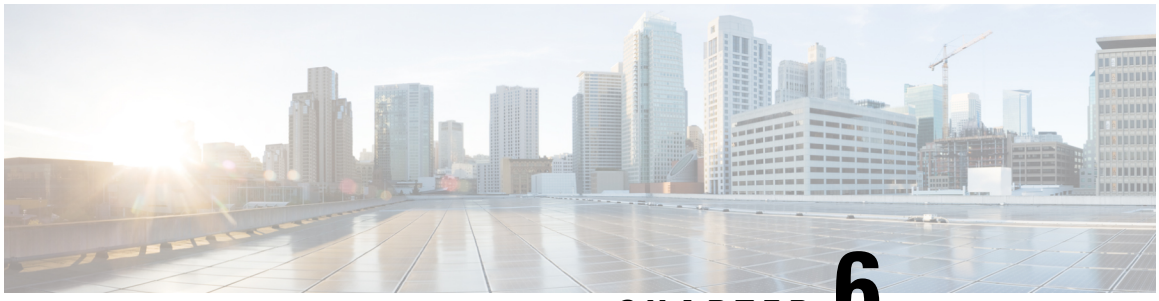
	Command or Action	Purpose
Step 15	**interface** *interface-id* **Example:** `Device(config)# interface GigabitEthernet1/0/1`	Enters interface configuration mode and specifies the interface.
Step 16	**access-session interface-template sticky timer** *time* **Example:** `Device(config-if)# access-session interface-template sticky timer 60`	Configures the keep time of the template on the interface. Once the last client leaves, the template will be removed from the port after the configured keep time. **Note** It is recommended that you set the sticky timer to 60 seconds.
Step 17	**end** **Example:** `Device(config-if)# end`	Returns to privileged EXEC mode.

What to do next

After the above steps, configure the Identity Services Engine (ISE) or any other RADIUS server to assign the template to the client's port interface after the client has been authenticated successfully.

If you are using the ISE, go to the **Policy** > **Policy Elements** > **Authorization** > **Authorization Profile** page. Check the **Interface Template** check box and enter the name of the template to be assigned to the client interface.

If you are using a different RADIUS server, the attribute **Cisco-AVpair="interface:template=name"** must be pushed to the switch after the initial client authentication has been completed.



CHAPTER 6

IPv4 ACLs

Restrictions for IPv4 Access Control Lists

General Network Security

The following are restrictions for configuring network security with ACLs:

- Not all commands that accept a numbered ACL accept a named ACL. ACLs for packet filters and route filters on interfaces can use a name. VLAN maps also accept a name.
- A standard ACL and an extended ACL cannot have the same name.
- Though visible in the command-line help strings, **appletalk** is not supported as a matching condition for the **deny** and **permit** MAC access-list configuration mode commands.
- ACLs cannot be configured on management ports.
- ACL wildcard is not supported in downstream client policy.
- When you apply a scale ACL to an interface that does not program TCAM for a protocol and the ACLs that have been unloaded, it can impact the existing normal movement of traffic for other protocols. The restriction is applicable to .
- Router ACL is enforced on all types of traffic, including CPU generated traffic.
- ACL logging in the egress direction are not supported for packets that are generated from the control plane of the device.
- Time-to-live (TTL) classification is not supported on ACLs.
- If a downloadable ACL contains any type of duplicate entries, the entries are not auto merged. As a result, the 802.1X session authorization fails. Ensure that the downloadable ACL is optimized without any duplicate entries, for example port-based and name-based entries for the same port.
- Egress ACL lookup is not supported for injected traffic that is forwarded by the software.

- ACLs support only Layer 3 interfaces (such as routed interfaces and VLAN interfaces) and sub-interfaces.

IPv4 ACL Network Interfaces

The following restrictions apply to IPv4 ACLs to network interfaces:

- When controlling access to an interface, you can use a named or numbered ACL.
- If you apply an ACL to a Layer 2 interface that is a member of a VLAN, the Layer 2 (port) ACL takes precedence over an input Layer 3 ACL applied to the VLAN interface or a VLAN map applied to the VLAN.
- If you apply an ACL to a Layer 3 interface and routing is not enabled on the switch, the ACL only filters packets that are intended for the CPU, such as SNMP, Telnet, or web traffic.
- If the **preauth_ipv4_acl** ACL is configured to filter packets, the ACL is removed after authentication.
- You do not have to enable routing to apply ACLs to Layer 2 interfaces.

MAC ACLs on a Layer 2 Interface

After you create a MAC ACL, you can apply it to a Layer 2 interface to filter non-IP traffic coming in that interface. When you apply the MAC ACL, consider these guidelines:

- You can apply no more than one IP access list and one MAC access list to the same Layer 2 interface. The IP access list filters only IP packets, and the MAC access list filters non-IP packets.
- A Layer 2 interface can have only one MAC access list. If you apply a MAC access list to a Layer 2 interface that has a MAC ACL configured, the new ACL replaces the previously configured one.

Note The **mac access-group** interface configuration command is only valid when applied to a physical Layer 2 interface. You cannot use the command on EtherChannel port channels.

IP Access List Entry Sequence Numbering

- This feature does not support dynamic, reflexive, or firewall access lists.

Information About IPv4 Access Control Lists

ACL Overview

Packet filtering can help limit network traffic and restrict network use by certain users or devices. ACLs filter traffic as it passes through a device and permit or deny packets crossing specified interfaces. An ACL is a sequential collection of permit and deny conditions that apply to packets. When a packet is received on an interface, the switch compares the fields in the packet against any applied ACLs to verify that the packet has the required permissions to be forwarded, based on the criteria specified in the access lists. One by one, it tests packets against the conditions in an access list. The first match decides whether the switch accepts or rejects the packets. Because the switch stops testing after the first match, the order of conditions in the list is

critical. If no conditions match, the switch rejects the packet. If there are no restrictions, the switch forwards the packet; otherwise, the switch drops the packet. The switch can use ACLs on all packets it forwards.

You configure access lists on a device to provide basic security for your network. If you do not configure ACLs, all packets passing through the switch could be allowed onto all parts of the network. You can use ACLs to control which hosts can access different parts of a network or to decide which types of traffic are forwarded or blocked at device interfaces. For example, you can allow e-mail traffic to be forwarded but not Telnet traffic.

Access Control Entries

An ACL contains an ordered list of access control entries (ACEs). Each ACE specifies *permit* or *deny* and a set of conditions the packet must satisfy in order to match the ACE. The meaning of *permit* or *deny* depends on the context in which the ACL is used.

ACL Supported Types

The device supports IP ACLs and Ethernet (MAC) ACLs:

- IP ACLs filter IPv4 traffic, including TCP, User Datagram Protocol (UDP), Internet Group Management Protocol (IGMP), and Internet Control Message Protocol (ICMP).
- Ethernet ACLs filter non-IP traffic.

This device also supports quality of service (QoS) classification ACLs.

Supported ACLs

The switch supports three types of ACLs to filter the traffic:

- Port ACLs access-control traffic entering a Layer 2 interface. You can apply port ACLs to a Layer 2 interface in each direction to each access list type—IPv4, IPv6, and MAC.
- Router ACLs access-control traffic routed between VLANs and are applied to Layer 3 interfaces in a specific direction (inbound or outbound).

ACL Precedence

When VLAN maps, Port ACLs, and router ACLs are configured on the same switch, the filtering precedence, from greatest to least for ingress traffic is port ACL, VLAN map, and then router ACL. For egress traffic, the filtering precedence is router ACL, VLAN map, and then port ACL.

The following examples describe simple use cases:

- When both an input port ACL and a VLAN map are applied, incoming packets received on ports with a port ACL applied are filtered by the port ACL. Other packets are filtered by the VLAN map
- When an input router ACL and input port ACL exist in a switch virtual interface (SVI), incoming packets received on ports to which a port ACL is applied are filtered by the port ACL. Incoming routed IP packets received on other ports are filtered by the router ACL. Other packets are not filtered.

- When an output router ACL and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are filtered by the port ACL. Outgoing routed IP packets are filtered by the router ACL. Other packets are not filtered.
- When a VLAN map, input router ACL, and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are only filtered by the port ACL. Incoming routed IP packets received on other ports are filtered by both the VLAN map and the router ACL. Other packets are filtered only by the VLAN map.
- When a VLAN map, output router ACL, and input port ACL exist in an SVI, incoming packets received on the ports to which a port ACL is applied are only filtered by the port ACL. Outgoing routed IP packets are filtered by both the VLAN map and the router ACL. Other packets are filtered only by the VLAN map.

Port ACLs

Port ACLs are ACLs that are applied to Layer 2 interfaces on a switch. Port ACLs are supported on physical interfaces and EtherChannel interfaces but not on EtherChannel member interfaces. Port ACLs can be applied to the interface in inbound and outbound direction. The following access lists are supported:

- Standard IP access lists using source addresses
- Extended IP access lists using source and destination addresses and optional protocol type information
- MAC extended access lists using source and destination MAC addresses and optional protocol type information

The switch examines ACLs on an interface and permits or denies packet forwarding based on how the packet matches the entries in the ACL. In this way, ACLs control access to a network or to part of a network.

Figure 11: Using ACLs to Control Traffic in a Network

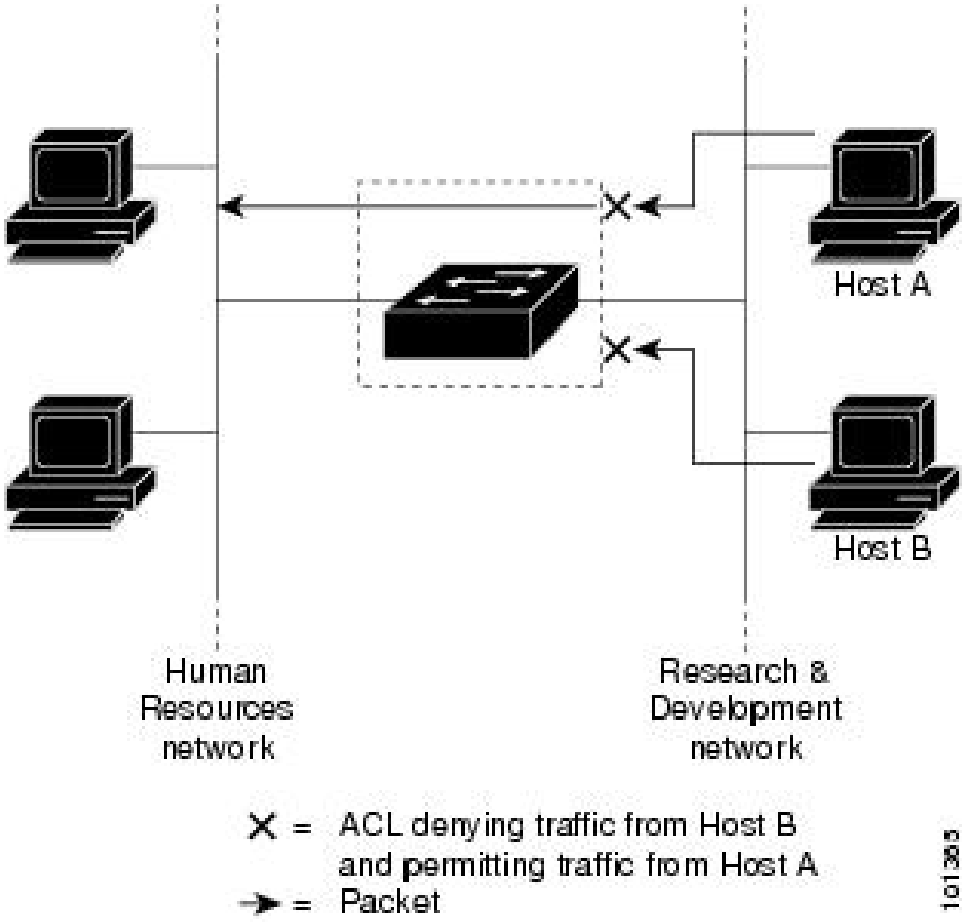


Figure 12: Using ACLs to Control Traffic in a Network

This is an example of using port ACLs to control access to a network when all workstations are in the same VLAN. ACLs applied at the Layer 2 input would allow Host A to access the Human Resources network, but prevent Host B from accessing the same network. Port ACLs can only be applied to Layer 2 interfaces in the inbound direction.

When you apply a port ACL to a trunk port, the ACL filters traffic on all VLANs present on the trunk port. When you apply a port ACL to a port with voice VLAN, the ACL filters traffic on both data and voice VLANs.

With port ACLs, you can filter IP traffic by using IP access lists and non-IP traffic by using MAC addresses. You can filter both IP and non-IP traffic on the same Layer 2 interface by applying both an IP access list and a MAC access list to the interface.

Note You can't apply more than one IP access list and one MAC access list to a Layer 2 interface. If an IP access list or MAC access list is already configured on a Layer 2 interface and you apply a new IP access list or MAC access list to the interface, the new ACL replaces the previously configured one.

Router ACLs

You can apply router ACLs on switch virtual interfaces (SVIs), which are Layer 3 interfaces to VLANs; on physical Layer 3 interfaces; and on Layer 3 EtherChannel interfaces. You apply router ACLs on interfaces for specific directions (inbound or outbound). You can apply one router ACL in each direction on an interface.

The switch supports these access lists for IPv4 traffic:

- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses and optional protocol type information for matching operations.

As with port ACLs, the switch examines ACLs associated with features configured on a given interface. As packets enter the switch on an interface, ACLs associated with all inbound features configured on that interface are examined. After packets are routed and before they are forwarded to the next hop, all ACLs associated with outbound features configured on the egress interface are examined.

ACLs permit or deny packet forwarding based on how the packet matches the entries in the ACL, and can be used to control access to a network or to part of a network.

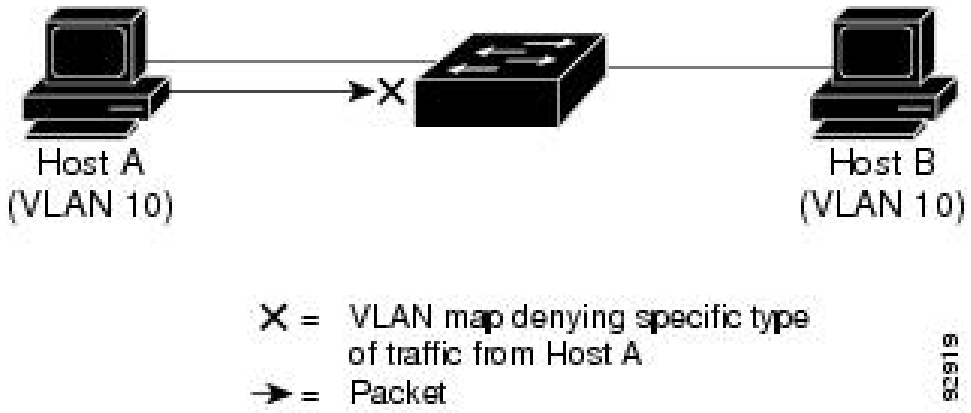
VLAN Maps

VLAN ACLs or VLAN maps are used to control the network traffic within a VLAN. You can apply VLAN maps to all packets that are bridged within a VLAN in the switch. VACLs are strictly for the security packet filtering and for redirecting traffic to specific physical interfaces. VACLs are not defined by direction (ingress or egress).

All non-IP protocols are access-controlled through MAC addresses and Ethertype using MAC VLAN maps. (IP traffic is not access-controlled by MAC VLAN maps.) You can enforce VLAN maps only on packets going through the switch; you cannot enforce VLAN maps on traffic between hosts on a hub or on another switch that is connected to this switch.

With VLAN maps, forwarding of packets is permitted or denied, based on the action specified in the map.

Figure 13: Using VLAN Maps to Control Traffic



ACEs and Fragmented and Unfragmented Traffic

IP packets can be fragmented as they cross the network. When this happens, only the fragment containing the beginning of the packet contains the Layer 4 information, such as TCP or UDP port numbers, ICMP type and code, and so on. All other fragments are missing this information.

Some access control entries (ACEs) do not check Layer 4 information and therefore can be applied to all packet fragments. ACEs that do test Layer 4 information cannot be applied in the standard manner to most of the fragments in a fragmented IP packet. When the fragment contains no Layer 4 information and the ACE tests some Layer 4 information, the matching rules are modified:

- Permit ACEs that check the Layer 3 information in the fragment (including protocol type, such as TCP, UDP, and so on) are considered to match the fragment regardless of what the missing Layer 4 information might have been.

Note For TCP ACEs with L4 Ops, the fragmented packets will be dropped per RFC 1858.

- Deny ACEs that check Layer 4 information never match a fragment unless the fragment contains Layer 4 information.

Standard and Extended IPv4 ACLs

An ACL is a sequential collection of permit and deny conditions. One by one, the device tests packets against the conditions in an access list. The first match determines whether the device accepts or rejects the packet. Because the device stops testing after the first match, the order of the conditions is critical. If no conditions match, the device denies the packet.

The software supports these types of ACLs or access lists for IPv4:

- Standard IP access lists use source addresses for matching operations.
- Extended IP access lists use source and destination addresses for matching operations and optional protocol-type information for finer granularity of control.

IPv4 ACL Switch Unsupported Features

The following ACL-related features are not supported:

- Non-IP protocol ACLs
- IP accounting
- Reflexive ACLs and dynamic ACLs are not supported.

Access List Numbers

The number you use to denote your ACL shows the type of access list that you are creating.

This lists the access-list number and corresponding access list type and shows whether or not they are supported in the switch. The switch supports IPv4 standard and extended access lists, numbers 1 to 199 and 1300 to 2699.

Table 11: Access List Numbers

Access List Number	Type	Supported
1–99	IP standard access list	Yes
100–199	IP extended access list	Yes
200–299	Protocol type-code access list	No
300–399	DECnet access list	No
400–499	XNS standard access list	No
500–599	XNS extended access list	No
600–699	AppleTalk access list	No
700–799	48-bit MAC address access list	No
800–899	IPX standard access list	No
900–999	IPX extended access list	No
1000–1099	IPX SAP access list	No
1100–1199	Extended 48-bit MAC address access list	No
1200–1299	IPX summary address access list	No
1300–1999	IP standard access list (expanded range)	Yes
2000–2699	IP extended access list (expanded range)	Yes

In addition to numbered standard and extended ACLs, you can also create standard and extended named IP ACLs by using the supported numbers. That is, the name of a standard IP ACL can be 1 to 99; the name of an extended IP ACL can be 100 to 199. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Numbered Standard IPv4 ACLs

When creating an ACL, remember that, by default, the end of the ACL contains an implicit deny statement for all packets that it did not find a match for before reaching the end. With standard access lists, if you omit the mask from an associated IP host address ACL specification, 0.0.0.0 is assumed to be the mask.

When using the **show ip access-list** *acl_name* or the **show run section** *acl_name* command, the ACEs are displayed in ascending order according to their sequence numbers.

After creating a numbered standard IPv4 ACL, you can apply it to VLANs, to terminal lines, or to interfaces.

Numbered Extended IPv4 ACLs

Although standard ACLs use only source addresses for matching, you can use extended ACL source and destination addresses for matching operations and optional protocol type information for finer granularity of control. When you are creating ACEs in numbered extended access lists, remember that after you create the ACL, any additions are placed at the end of the list. You cannot reorder the list or selectively add or remove ACEs from a numbered list.

The device does not support dynamic or reflexive access lists. It also does not support filtering based on the type of service (ToS) minimize-monetary-cost bit.

Some protocols also have specific parameters and keywords that apply to that protocol.

You can define an extended TCP, UDP, ICMP, IGMP, or other IP ACL. The device also supports these IP protocols:

Note ICMP echo-reply cannot be filtered. All other ICMP codes or types can be filtered.

These IP protocols are supported:

- Authentication Header Protocol (**ahp**)
- Encapsulation Security Payload (**esp**)
- Enhanced Interior Gateway Routing Protocol (**eigrp**)
- Generic routing encapsulation (**gre**)
- Internet Control Message Protocol (**icmp**)
- Internet Group Management Protocol (**igmp**)
- Any Interior Protocol (**ip**)
- IP in IP tunneling (**ipinip**)
- KA9Q NOS-compatible IP over IP tunneling (**nos**)
- Open Shortest Path First routing (**ospf**)
- Payload Compression Protocol (**pcp**)
- Protocol-Independent Multicast (**pim**)
- Transmission Control Protocol (**tcp**)
- User Datagram Protocol (**udp**)

Named IPv4 ACLs

You can identify IPv4 ACLs with an alphanumeric string (a name) rather than a number. You can use named ACLs to configure more IPv4 access lists in a device than if you were to use numbered access lists. If you identify your access list with a name rather than a number, the mode and command syntax are slightly different. However, not all commands that use IP access lists accept a named access list.

Note The name you give to a standard or extended ACL can also be a number in the supported range of access list numbers. That is, the name of a standard IP ACL can be 1 to 99. The advantage of using named ACLs instead of numbered lists is that you can delete individual entries from a named list.

Consider these guidelines before configuring named ACLs:

- Numbered ACLs are also available.
- A standard ACL and an extended ACL cannot have the same name.
- You can use standard or extended ACLs (named or numbered) in VLAN maps.

ACL Logging

The device software can provide logging messages about packets permitted or denied by a standard IP access list. That is, any packet that matches the ACL causes an informational logging message about the packet to be sent to the console. The level of messages logged to the console is controlled by the **logging console** commands controlling the syslog messages.

Note ACL logging is not supported for ACLs used with Unicast Reverse Path Forwarding (uRPF). ACL logging is supported only for router ACLs and not for port ACLs.

Note Because routing is done in hardware and logging is done in software, if a large number of packets match a *permit* or *deny* ACE containing a **log** keyword, the software might not be able to match the hardware processing rate, and not all packets will be logged.

The first packet that triggers the ACL causes a logging message right away, and subsequent packets are collected over 5-minute intervals before they appear or logged. The logging message includes the access list number, whether the packet was permitted or denied, the source IP address of the packet, and the number of packets from that source permitted or denied in the prior 5-minute interval.

Note The logging facility might drop some logging message packets if there are too many to be handled or if there is more than one logging message to be handled in 1 second. This behavior prevents the device from crashing due to too many logging packets. Therefore, the logging facility should not be used as a billing tool or an accurate source of the number of matches to an access list.

Hardware and Software Treatment of IP ACLs

ACL processing is performed in hardware. If the hardware reaches its capacity to store ACL configurations, all packets on that interface are dropped.

Note If an ACL configuration cannot be implemented in hardware due to an out-of-resource condition on a device, then only the traffic in that VLAN arriving on that device is affected.

For router ACLs, other factors can cause packets to be sent to the CPU:

- Using the **log** keyword
- Generating ICMP unreachable messages

When you enter the **show ip access-lists** privileged EXEC command, the match count displayed does not account for packets that are access controlled in hardware. Use the **show platform software fed switch** { *switch_num* | **active** | **standby** } **acl counters hardware** privileged EXEC command to obtain some basic hardware ACL statistics for switched and routed packets.

Router ACLs function as follows:

- The hardware controls permit and deny actions of standard and extended ACLs (input and output) for security access control.
- If **log** has not been specified, the flows that match a *deny* statement in a security ACL are dropped by the hardware if *ip unreachables* is disabled. The flows matching a *permit* statement are switched in hardware.
- Adding the **log** keyword to an ACE in a router ACL causes a copy of the packet to be sent to the CPU for logging only. If the ACE is a *permit* statement, the packet is still switched and routed in hardware.

VLAN Map Configuration Guidelines

VLAN maps are the only way to control filtering within a VLAN. VLAN maps have no direction. To filter traffic in a specific direction by using a VLAN map, you need to include an ACL with specific source or destination addresses. If there is a match clause for that type of packet (IP or MAC) in the VLAN map, the default action is to drop the packet if the packet does not match any of the entries within the map. If there is no match clause for that type of packet, the default is to forward the packet.

The following are the VLAN map configuration guidelines:

- If there is no ACL configured to deny traffic on an interface and no VLAN map is configured, all traffic is permitted.
- Each VLAN map consists of a series of entries. The order of entries in an VLAN map is important. A packet that comes into the device is tested against the first entry in the VLAN map. If it matches, the action specified for that part of the VLAN map is taken. If there is no match, the packet is tested against the next entry in the map.
- If the VLAN map has at least one match clause for the type of packet (IP or MAC) and the packet does not match any of these match clauses, the default is to drop the packet. If there is no match clause for that type of packet in the VLAN map, the default is to forward the packet.
- Logging is not supported for VLAN maps.
- When a device has an IP access list or MAC access list applied to a Layer 2 interface, and you apply a VLAN map to a VLAN that the port belongs to, the port ACL takes precedence over the VLAN map.

- If a VLAN map configuration cannot be applied in hardware, all packets in that VLAN are dropped.

VLAN Maps with Router ACLs

To access control both bridged and routed traffic, you can use VLAN maps only or a combination of router ACLs and VLAN maps. You can define router ACLs on both input and output routed VLAN interfaces, and you can define a VLAN map to access control the bridged traffic.

If a packet flow matches a VLAN-map deny clause in the ACL, regardless of the router ACL configuration, the packet flow is denied.

Note When you use router ACLs with VLAN maps, packets that require logging on the router ACLs are not logged if they are denied by a VLAN map.

If the VLAN map has a match clause for the type of packet (IP or MAC) and the packet does not match the type, the default is to drop the packet. If there is no match clause in the VLAN map, and no action specified, the packet is forwarded if it does not match any VLAN map entry.

VLAN Maps and Router ACL Configuration Guidelines

These guidelines are for configurations where you need to have an router ACL and a VLAN map on the same VLAN. These guidelines do not apply to configurations where you are mapping router ACLs and VLAN maps on different VLANs.

If you must configure a router ACL and a VLAN map on the same VLAN, use these guidelines for both router ACL and VLAN map configuration:

- You can configure only one VLAN map and one router ACL in each direction (input/output) on a VLAN interface.
- Whenever possible, try to write the ACL with all entries having a single action except for the final, default action of the other type. That is, write the ACL using one of these two forms:
  - permit...

    permit...

    permit...

    deny ip any any

  or

  - deny...

    deny...

    deny...

    permit ip any any

- To define multiple actions in an ACL (permit, deny), group each action type together to reduce the number of entries.

- Avoid including Layer 4 information in an ACL; adding this information complicates the merging process. The best merge results are obtained if the ACLs are filtered based on IP addresses (source and destination) and not on the full flow (source IP address, destination IP address, protocol, and protocol ports). It is also helpful to use *don't care* bits in the IP address, whenever possible.

  If you need to specify the full-flow mode and the ACL contains both IP ACEs and TCP/UDP/ICMP ACEs with Layer 4 information, put the Layer 4 ACEs at the end of the list. This gives priority to the filtering of traffic based on IP addresses.

Time Ranges for ACLs

You can selectively apply extended ACLs based on the time of day and the week by using the **time-range** global configuration command. First, define a time-range name and set the times and the dates or the days of the week in the time range. Then enter the time-range name when applying an ACL to set restrictions to the access list. You can use the time range to define when the permit or deny statements in the ACL are in effect, for example, during a specified time period or on specified days of the week. The **time-range** keyword and argument are referenced in the named and numbered extended ACL task tables.

These are some benefits of using time ranges:

- You have more control over permitting or denying a user access to resources, such as an application (identified by an IP address/mask pair and a port number).
- You can control logging messages. ACL entries can be set to log traffic only at certain times of the day. Therefore, you can simply deny access without needing to analyze many logs generated during peak hours.

Time-based access lists trigger CPU activity because the new configuration of the access list must be merged with other features and the combined configuration loaded into the hardware memory. For this reason, you should be careful not to have several access lists configured to take affect in close succession (within a small number of minutes of each other.)

Note The time range relies on the device system clock; therefore, you need a reliable clock source. We recommend that you use Network Time Protocol (NTP) to synchronize the device clock.

IPv4 ACL Interface Considerations

For inbound ACLs, after receiving a packet, the device checks the packet against the ACL. If the ACL permits the packet, the device continues to process the packet. If the ACL rejects the packet, the device discards the packet.

For outbound ACLs, after receiving and routing a packet to a controlled interface, the device checks the packet against the ACL. If the ACL permits the packet, the device sends the packet. If the ACL rejects the packet, the device discards the packet.

By default, the input interface sends ICMP Unreachable messages whenever a packet is discarded, regardless of whether the packet was discarded because of an ACL on the input interface or because of an ACL on the output interface. ICMP Unreachables are normally limited to no more than one every one-half second per input interface, but this can be changed by using the **ip icmp rate-limit unreachable** global configuration command.

When you apply an undefined ACL to an interface, the device acts as if the ACL has not been applied to the interface and permits all packets. Remember this behavior if you use undefined ACLs for network security.

How to Configure IPv4 Access Control Lists

Configuring IPv4 ACLs

These are the steps to use IP ACLs on the switch:

SUMMARY STEPS

1. Create an ACL by specifying an access list number or name and the access conditions.
2. Apply the ACL to interfaces or terminal lines. You can also apply standard and extended IP ACLs to VLAN maps.

DETAILED STEPS

Procedure

Step 1 Create an ACL by specifying an access list number or name and the access conditions.

Step 2 Apply the ACL to interfaces or terminal lines. You can also apply standard and extended IP ACLs to VLAN maps.

Creating a Numbered Standard ACL

Follow these steps to create a numbered standard ACL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **access-list** *access-list-number* {**deny** | **permit**} *source source-wildcard*]
4. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**access-list** *access-list-number* {**deny** | **permit**} *source source-wildcard*] **Example:** `Device(config)# access-list 2 deny your_host`	Defines a standard IPv4 access list by using a source address and wildcard. The *access-list-number* is a decimal number from 1 to 99 or 1300 to 1999. Enter **deny** or **permit** to specify whether to deny or permit access if conditions are matched. The *source* is the source address of the network or host from which the packet is being sent specified as: • The 32-bit quantity in dotted-decimal format. • The keyword **any** as an abbreviation for *source* and *source-wildcard* of 0.0.0.0 255.255.255.255. You do not need to enter a source-wildcard. • The keyword **host** as an abbreviation for source and *source-wildcard* of *source* 0.0.0.0. (Optional) The *source-wildcard* applies wildcard bits to the source. **Note** Logging is supported only on ACLs attached to Layer 3 interfaces.
Step 4	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Creating a Numbered Extended ACL

Follow these steps to create a numbered extended ACL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **access-list** *access-list-number* {**deny** | **permit**} *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*] [**tos** tos] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*]
4. **access-list** *access-list-number* {**deny** | **permit**} **tcp** *source source-wildcard* [*operator port*] *destination destination-wildcard* [*operator port*] [**established**] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] [*flag*]

5. **access-list** *access-list-number* {**deny** | **permit**} **udp** *source source-wildcard* [*operator port*] *destination destination-wildcard* [*operator port*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*]
6. **access-list** *access-list-number* {**deny** | **permit**} **icmp** *source source-wildcard destination destination-wildcard* [*icmp-type* | [[*icmp-type icmp-code*] | [*icmp-message*]] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*]
7. **access-list** *access-list-number* {**deny** | **permit**} **igmp** *source source-wildcard destination destination-wildcard* [*igmp-type*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*]
8. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**access-list** *access-list-number* {**deny** | **permit**} *protocol source source-wildcard destination destination-wildcard* [**precedence** *precedence*] [**tos** tos] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] **Example:** `Device(config)# access-list 101 permit ip host 10.1.1.2 any precedence 0 tos 0 log`	Defines an extended IPv4 access list and the access conditions. The *access-list-number* is a decimal number from 100 to 199 or 2000 to 2699. Enter **deny** or **permit** to specify whether to deny or permit the packet if conditions are matched. Source, source-wildcard, destination, and destination-wildcard can be specified as: • The 32-bit quantity in dotted-decimal format. • The keyword **any** for 0.0.0.0 255.255.255.255 (any host). • The keyword **host** for a single host 0.0.0.0. The other keywords are optional and have these meanings: • **precedence**: Enter to match packets with a precedence level specified as a number from 0 to 7 or by name: **routine** (0), **priority** (1), **immediate** (2), **flash** (3), **flash-override** (4), **critical** (5), **internet** (6), **network** (7). • **fragments**: Enter to check non-initial fragments.

	Command or Action	Purpose
		• **tos**: Enter to match by type of service level, specified by a number from 0 to 15 or a name: **normal** (0), **max-reliability** (2), **max-throughput** (4), **min-delay** (8). • **time-range**: Specify the time-range name. • **dscp**: Enter to match packets with the DSCP value specified by a number from 0 to 63, or use the question mark (?) to see a list of available values. **Note** If you enter a **dscp** value, you cannot enter **tos** or **precedence**. You can enter both a **tos** and a **precedence** value with no **dscp**.
Step 4	**access-list** *access-list-number* {**deny** | **permit**} **tcp** *source source-wildcard* [*operator port*] *destination destination-wildcard* [*operator port*] [**established**] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] [*flag*] **Example:** `Device(config)# access-list 101 permit tcp any any eq 500`	Defines an extended TCP access list and the access conditions. The parameters are the same as those described for an extended IPv4 ACL, with these exceptions: (Optional) Enter an *operator* and *port* to compare source (if positioned after *source source-wildcard*) or destination (if positioned after *destination destination-wildcard*) port. Possible operators include **eq** (equal), **gt** (greater than), **lt** (less than), **neq** (not equal), and **range** (inclusive range). Operators require a port number (range requires two port numbers separated by a space). Enter the *port* number as a decimal number (from 0 to 65535) or the name of a TCP port. Use only TCP port numbers or names when filtering TCP. The other optional keywords have these meanings: • **established**: Enter to match an established connection. This has the same function as matching on the **ack** or **rst** flag. • *flag*: Enter one of these flags to match by the specified TCP header bits: **ack** (acknowledge), **fin** (finish), **psh** (push), **rst** (reset), **syn** (synchronize), or **urg** (urgent).
Step 5	**access-list** *access-list-number* {**deny** | **permit**} **udp** *source source-wildcard* [*operator port*] *destination destination-wildcard* [*operator port*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] **Example:** `Device(config)# access-list 101 permit udp any any eq 100`	(Optional) Defines an extended UDP access list and the access conditions. The UDP parameters are the same as those described for TCP except that the [operator [port]] port number or name must be a UDP port number or name, and the **flag** and **established** keywords are not valid for UDP.

	Command or Action	Purpose
Step 6	**access-list** *access-list-number* {**deny** | **permit**} **icmp** *source source-wildcard destination destination-wildcard* [*icmp-type* | [[*icmp-type icmp-code*] | [*icmp-message*]] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] **Example:** `Device(config)# access-list 101 permit icmp any any 200`	Defines an extended ICMP access list and the access conditions. The ICMP parameters are the same as those described for most IP protocols in an extended IPv4 ACL, with the addition of the ICMP message type and code parameters. These optional keywords have these meanings: • *icmp-type*: Enter to filter by ICMP message type, a number from 0 to 255. • *icmp-code*: Enter to filter ICMP packets that are filtered by the ICMP message code type, a number from 0 to 255. • *icmp-message*: Enter to filter ICMP packets by the ICMP message type name or the ICMP message type and code name.
Step 7	**access-list** *access-list-number* {**deny** | **permit**} **igmp** *source source-wildcard destination destination-wildcard* [*igmp-type*] [**precedence** *precedence*] [**tos** *tos*] [**fragments**] [**time-range** *time-range-name*] [**dscp** *dscp*] **Example:** `Device(config)# access-list 101 permit igmp any any 14`	(Optional) Defines an extended IGMP access list and the access conditions. The IGMP parameters are the same as those described for most IP protocols in an extended IPv4 ACL, with this optional parameter. *igmp-type*: To match IGMP message type, enter a number from 0 to 15, or enter the message name: **dvmrp**, **host-query**, **host-report**, **pim**, or **trace**.
Step 8	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Creating Named Standard ACLs

Follow these steps to create a standard ACL using names:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list standard** *name*
4. Use one of the following:
   - **deny** {*source* [*source-wildcard*] | **host** *source* | **any**} [**log**]
   - **permit** {*source* [*source-wildcard*] | **host** *source* | **any**} [**log**]
5. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip access-list standard** *name* **Example:** `Device(config)# ip access-list standard 20`	Defines a standard IPv4 access list using a name, and enter access-list configuration mode. The name can be a number from 1 to 99.

Step 4	Use one of the following:
	• **deny** {*source* [*source-wildcard*] | **host** *source* | **any**} [**log**]
	• **permit** {*source* [*source-wildcard*] | **host** *source* | **any**} [**log**]
	Example:
	`Device(config-std-nacl)# deny 192.168.0.0 0.0.255.255 255.255.0.0 0.0.255.255`
	or
	`Device(config-std-nacl)# permit 10.108.0.0 0.0.0.0 255.255.255.0 0.0.0.0`
		In access-list configuration mode, specify one or more conditions denied or permitted to decide if the packet is forwarded or dropped.
		• **host** *source*: A source and source wildcard of *source* 0.0.0.0.
		• **any**: A source and source wildcard of 0.0.0.0 255.255.255.255.

Step 5	**end** **Example:** `Device(config-std-nacl)# end`	Exits access-list configuration mode and returns to privileged EXEC mode.

Creating Extended Named ACLs

Follow these steps to create an extended ACL using names:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list extended** *name*
4. {**deny** | **permit**} *protocol* {*source* [*source-wildcard*] | **host** *source* | **any**} {*destination* [*destination-wildcard*] | host *destination* | **any**} [**precedence** *precedence*] [**tos** *tos*] [**established**] [**log**] [**time-range** *time-range-name*]

5. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip access-list extended** *name* **Example:** `Device(config)# ip access-list extended 150`	Defines an extended IPv4 access list using a name, and enter access-list configuration mode. The name can be a number from 100 to 199.
Step 4	{**deny** | **permit**} *protocol* {*source* [*source-wildcard*] | **host** *source* | **any**} {*destination* [*destination-wildcard*] | host *destination* | **any**} [**precedence** *precedence*] [**tos** *tos*] [**established**] [**log**] [**time-range** *time-range-name*] **Example:** `Device(config-ext-nacl)# permit 0 any any`	In access-list configuration mode, specify the conditions allowed or denied. Use the **log** keyword to get access list logging messages, including violations. • **host** *source*: A source and source wildcard of *source* 0.0.0.0. • **host** *destintation*: A destination and destination wildcard of *destination* 0.0.0.0. • **any**: A source and source wildcard or destination and destination wildcard of 0.0.0.0 255.255.255.255.
Step 5	**end** **Example:** `Device(config-ext-nacl)# end`	Exits access-list configuration mode and returns to privileged EXEC mode.

When you are creating extended ACLs, remember that, by default, the end of the ACL contains an implicit deny statement for everything if it did not find a match before reaching the end. For standard ACLs, if you omit the mask from an associated IP host address access list specification, 0.0.0.0 is assumed to be the mask.

After you create an ACL, any additions are placed at the end of the list. You cannot selectively add ACL entries to a specific ACL. However, you can use **no permit** and **no deny** access-list configuration mode commands to remove entries from a named ACL.

Being able to selectively remove lines from a named ACL is one reason you might use named ACLs instead of numbered ACLs.

What to do next

After creating a named ACL, you can apply it to interfaces or to VLANs .

Configuring Time Ranges for ACLs

Follow these steps to configure a time-range parameter for an ACL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **time-range** *time-range-name*
4. Use one of the following:
   - **absolute** [**start** *time date*] [**end** *time date*]
   - **periodic** *day-of-the-week hh:mm to* [*day-of-the-week*] *hh:mm*
   - **periodic** {**weekdays** | **weekend** | **daily**} *hh:mm to hh:mm*
5. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**time-range** *time-range-name* **Example:** `Device(config)# time-range workhours`	Assigns a meaningful name (for example, *workhours*) to the time range to be created, and enters time-range configuration mode. The name cannot contain a space or quotation mark and must begin with a letter.

Step 4	Use one of the following:
	• **absolute** [**start** *time date*] [**end** *time date*]
	• **periodic** *day-of-the-week hh:mm to* [*day-of-the-week*] *hh:mm*
	• **periodic** {**weekdays** | **weekend** | **daily**} *hh:mm to hh:mm*
	Example:
	`Device(config-time-range)# absolute start 00:00 1 Jan 2006 end 23:59 1 Jan 2006`
	or
	`Device(config-time-range)# periodic weekdays 8:00 to 12:00`
		Specifies when the function it will be applied to is operational.
		• You can use only one **absolute** statement in the time range. If you configure more than one absolute statement, only the one configured last is executed.
		• You can enter multiple **periodic** statements. For example, you could configure different hours for weekdays and weekends.

	Command or Action	Purpose
Step 5	**end** **Example:** `Device(config-time-range)# end`	Exits time-range configuration mode and returns to privileged EXEC mode.

What to do next

Repeat the steps if you have multiple items that you want in effect at different times.

Applying an IPv4 ACL to a Terminal Line

You can use numbered ACLs to control access to one or more terminal lines. You cannot apply named ACLs to lines. You must set identical restrictions on all the virtual terminal lines because a user can attempt to connect to any of them.

Follow these steps to restrict incoming and outgoing connections between a virtual terminal line and the addresses in an ACL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **line** [**console** | **vty**] *line-number*
4. **access-class** *access-list-number* {**in** | **out**}
5. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**line** [**console**	**vty**] *line-number* **Example:** `Device(config)# line console 0`	Identifies a specific line to configure, and enter in-line configuration mode. • **console**: Specifies the console terminal line. The console port is DCE. • **vty**: Specifies a virtual terminal for remote console access.

	Command or Action	Purpose
		The *line-number* is the first line number in a contiguous group that you want to configure when the line type is specified. The range is from 0 to 16.
Step 4	**access-class** *access-list-number* {**in** | **out**} **Example:** `Device(config-line)# access-class 10 in`	Restricts incoming and outgoing connections between a particular virtual terminal line (into a device) and the addresses in an access list.
Step 5	**end** **Example:** `Device(config-line)# end`	Exits line configuration mode and returns to privileged EXEC mode.

Applying an IPv4 ACL to an Interface

This section describes how to apply IPv4 ACLs to network interfaces.

Beginning in privileged EXEC mode, follow these steps to control access to an interface:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **ip access-group** {*access-list-number* | *name*} {**in** | **out**}
5. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet1/0/1`	Identifies a specific interface for configuration, and enters interface configuration mode. The interface can be a Layer 2 interface (port ACL), or a Layer 3 interface (router ACL).

	Command or Action	Purpose
Step 4	**ip access-group** {*access-list-number* | *name*} {**in** | **out**} **Example:** `Device(config-if)# ip access-group 2 in`	Controls access to the specified interface.
Step 5	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Creating Named MAC Extended ACLs

You can filter non-IPv4 traffic on a VLAN or on a Layer 2 interface by using MAC addresses and named MAC extended ACLs. The procedure is similar to that of configuring other extended named ACLs.

Follow these steps to create a named MAC extended ACL:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **mac access-list extended** *name*
4. {**deny** | **permit**} {**any** | **host** *source MAC address* | *source MAC address mask*} {**any** | **host** *destination MAC address* | *destination MAC address mask*} [*type mask* | **lsap** *lsap mask* | **aarp** | **amber** | **dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** | **vines-ip** | **xns-idp** | 0-*65535*] [**cos** *cos*]
5. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**mac access-list extended** *name* **Example:**	Defines an extended MAC access list using a name.

	Command or Action	Purpose
	`Device(config)# mac access-list extended mac1`	

Step 4	{**deny** | **permit**} {**any** | **host** *source MAC address* | *source MAC address mask*} {**any** | **host** *destination MAC address* | *destination MAC address mask*} [*type mask* | **lsap** *lsap mask* | **aarp** | **amber** | **dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** | **vines-ip** | **xns-idp** | 0-*65535*] [**cos** *cos*]
	Example:
	`Device(config-ext-macl)# deny any any decnet-iv`
	or
	`Device(config-ext-macl)# permit any any`
		In extended MAC access-list configuration mode, specifies to **permit** or **deny** any source MAC address, a source MAC address with a mask, or a specific **host** source MAC address and **any** destination MAC address, destination MAC address with a mask, or a specific destination MAC address.
		(Optional) You can also enter these options:
		• *type mask*—An arbitrary EtherType number of a packet with Ethernet II or SNAP encapsulation in decimal, hexadecimal, or octal with optional mask of *don't care* bits applied to the EtherType before testing for a match.
		• **lsap** *lsap mask*—An LSAP number of a packet with IEEE 802.2 encapsulation in decimal, hexadecimal, or octal with optional mask of *don't care* bits.
		• **aarp** | **amber** | **dec-spanning** | **decnet-iv** | **diagnostic** | **dsm** | **etype-6000** | **etype-8042** | **lat** | **lavc-sca** | **mop-console** | **mop-dump** | **msdos** | **mumps** | **netbios** | **vines-echo** | **vines-ip** | **xns-idp**—A non-IP protocol.
		• **cos** *cos*—An IEEE 802.1Q cost of service number from 0 to 7 used to set priority.

Step 5	**end** **Example:** `Device(config-ext-macl)# end`	Exits extended MAC access-list configuration mode and returns to privileged EXEC mode.

Applying a MAC ACL to a Layer 2 Interface

Follow these steps to apply a MAC access list to control access to a Layer 2 interface:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **mac access-group** {*name*} {**in** | **out** }
5. **end**
6. **show mac access-group** [**interface** *interface-id*]

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet1/0/1`	Identifies a specific interface, and enters interface configuration mode. The interface must be a physical Layer 2 interface (port ACL).
Step 4	**mac access-group** {*name*} {**in** | **out** } **Example:** `Device(config-if)# mac access-group mac1 in`	Controls access to the specified interface by using the MAC access list. Port ACLs are supported in the outbound and inbound directions .
Step 5	**end** **Example:** `Device(config-if)# end`	Exits interface configuration mode and returns to privileged EXEC mode.
Step 6	**show mac access-group** [**interface** *interface-id*] **Example:** `Device# show mac access-group interface gigabitethernet1/1`	Displays the MAC access list applied to the interface or all Layer 2 interfaces.

After receiving a packet, the device checks it against the inbound ACL. If the ACL permits it, the device continues to process the packet. If the ACL rejects the packet, the device discards it. When you apply an undefined ACL to an interface, the device acts as if the ACL has not been applied and permits all packets. Remember this behavior if you use undefined ACLs for network security.

Configuring an IPv4 ACL in Template Mode

Note You can configure **ip access-group** command in the template configuration mode. You can configure the **source template** command only once to an interface.

Beginning in privileged EXEC mode, follow these steps to configure ACL in a template:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ip access-list extended** *name*
4. **ip access-list extended** {*name*|*number*|*ext_number*}
5. **exit**
6. **template**
7. **ip access-group** {*access-list-number* | *name*} {**in** | **out**}
8. **exit**
9. **interface** *interface-id*
10. **ip access-group** {*access-list-number* | *name*} {**in** | **out**}
11. **source template** *name*
12. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ip access-list extended** *name* **Example:** `Device(config)# ip access-list extended 150`	Defines an extended IPv4 access list using a name, and enter access-list configuration mode. Enter *name* to define access-list name. Enter *number* to define extended IP access-list number. The range is from 100 to 199. Enter *ext_number* to define extended IP access-list number. The expanded range is from 2000 to 2699.
Step 4	**ip access-list extended** {*name*|*number*|*ext_number*} **Example:** `Device(config)# ip access-list extended 151`	Defines an extended IPv4 access list using a name, and enter access-list configuration mode. Enter *name* to define access-list name. Enter *number* to define extended IP access-list number. The range is from 100 to 199. Enter *ext_number* to define extended IP access-list number. The expanded range is from 2000 to 2699.

	Command or Action	Purpose
Step 5	**exit** **Example:** `Device(config-ext-nacl)# exit`	Exits access-list configuration mode.
Step 6	**template** **Example:** `Device# template test`	Creates a user template and enters template configuration mode.
Step 7	**ip access-group** {*access-list-number* | *name*} {**in** | **out**} **Example:** `Device(config-template)# ip access-group 150 in`	Controls access to the specified interface. Enter *access-list-number* to define the access list. The access list can be a number. Enter *name* to define the access list. The access list can be a name. Enter **in** to direct the access list in the incoming direction of the interface. Enter **out** to direct the access list in the outgoing direction of the interface.
Step 8	**exit** **Example:** `Device(config-template)# exit`	Exits template configuration mode and returns to privileged EXEC mode.
Step 9	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet1/0/1`	Identifies a specific interface for configuration, and enters interface configuration mode. The interface can be a Layer 2 interface (port ACL), or a Layer 3 interface (router ACL).
Step 10	**ip access-group** {*access-list-number* | *name*} {**in** | **out**} **Example:** `Device(config-if)# ip access-group 151 out`	Controls access to the specified interface. Enter *access-list-number* to define the access list. The access list can be a number. Enter *name* to define the access list. The access list can be a name. Enter **in** to direct the access list in the incoming direction of the interface. Enter **out** to direct the access list in the outgoing direction of the interface.
Step 11	**source template** *name* **Example:** `Device(config)# source template test`	Applies an interface template to a target. The accesss list 150 is the incoming access list that is configured.
Step 12	**end** **Example:**	Exits global configuration mode and returns to privileged EXEC mode.

	Command or Action	Purpose
	`Device(config)# end`	

Configuring VLAN Maps

To create a VLAN map and apply it to one or more VLANs, perform these steps:

Before you begin

Create the standard or extended IPv4 ACLs or named MAC extended ACLs that you want to apply to the VLAN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vlan access-map** *name* [**number**]
4. **match** {**ip** | **mac**} **address** {*name* | *number*} [*name* | *number*]
5. Enter one of the following commands to specify an IP packet or a non-IP packet (with only a known MAC address) and to match the packet against one or more ACLs (standard or extended):
   - **action** { **forward**}

     ```
     Device(config-access-map)# action forward
     ```

   - **action** { **drop**}

     ```
     Device(config-access-map)# action drop
     ```

6. **exit**
7. **vlan filter** *mapname* **vlan-list** *list*
8. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**vlan access-map** *name* [**number**] **Example:** `Device(config)# vlan access-map map1 20`	Creates a VLAN map, and give it a name and (optionally) a number. The number is the sequence number of the entry within the map. When you create VLAN maps with the same name, numbers are assigned sequentially in increments of 10. When modifying or deleting maps, you can enter the number of the map entry that you want to modify or delete. VLAN maps do not use the specific permit or deny keywords. To deny a packet by using VLAN maps, create an ACL that would match the packet, and set the action to drop. A permit in the ACL counts as a match. A deny in the ACL means no match. Entering this command changes to access-map configuration mode.
Step 4	**match** {**ip** | **mac**} **address** {*name* | *number*} [*name* | *number*] **Example:** `Device(config-access-map)# match ip address ip2`	Match the packet (using either the IP or MAC address) against one or more standard or extended access lists. Note that packets are only matched against access lists of the correct protocol type. IP packets are matched against standard or extended IP access lists. Non-IP packets are only matched against named MAC extended access lists. **Note** If the VLAN map is configured with a match clause for a type of packet (IP or MAC) and the map action is drop, all packets that match the type are dropped. If the VLAN map has no match clause, and the configured action is drop, all IP and Layer 2 packets are dropped.

Step 5	Enter one of the following commands to specify an IP packet or a non-IP packet (with only a known MAC address) and to match the packet against one or more ACLs (standard or extended):
	• **action** { **forward**}
	`Device(config-access-map)# action forward`
	• **action** { **drop**}
	`Device(config-access-map)# action drop`
		Sets the action for the map entry.

Step 6	**exit** **Example:** `Device(config-access-map)# exit`	Exits access-map configuration mode. and returns to global configuration mode.
Step 7	**vlan filter** *mapname* **vlan-list** *list* **Example:**	Applies the VLAN map to one or more VLAN IDs.

	Command or Action	Purpose
	`Device(config)# vlan filter map1 vlan-list 20-22`	The list can be a single VLAN ID (22), a consecutive list (10-22), or a string of VLAN IDs (12, 22, 30). Spaces around the comma and hyphen are optional.
Step 8	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Applying a VLAN Map to a VLAN

To apply a VLAN map to one or more VLANs, perform these steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vlan filter** *mapname* **vlan-list** *list*
4. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**vlan filter** *mapname* **vlan-list** *list* **Example:** `Device(config)# vlan filter map 1 vlan-list 20-22`	Applies the VLAN map to one or more VLAN IDs. The list can be a single VLAN ID (22), a consecutive list (10-22), or a string of VLAN IDs (12, 22, 30). Spaces around the comma and hyphen are optional.
Step 4	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Monitoring IPv4 ACLs

You can monitor IPv4 ACLs by displaying the ACLs that are configured on the device, and displaying the ACLs that have been applied to interfaces and VLANs.

When you use the **ip access-group** interface configuration command to apply ACLs to a Layer 2 or 3 interface, you can display the access groups on the interface. You can also display the MAC ACLs applied to a Layer 2 interface. You can use the privileged EXEC commands as described in this table to display this information.

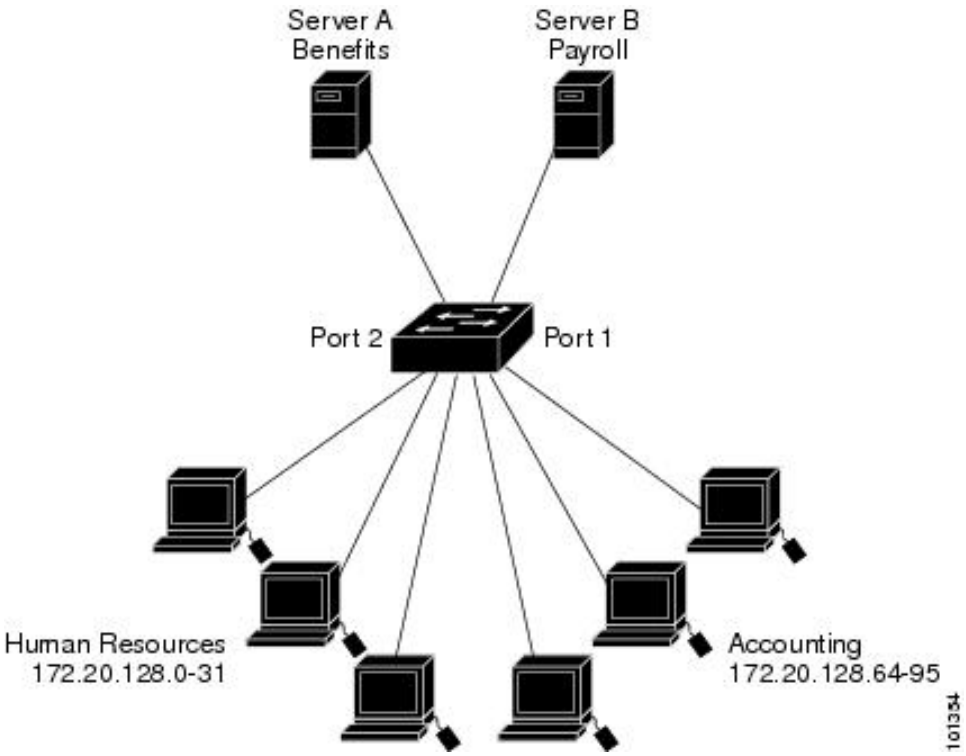
Table 12: Commands for Displaying Access Lists and Access Groups

Command	Purpose
show access-lists [*number* | *name*]	Displays the contents of one or all current IP and MAC address access lists or a specific access list (numbered or named).
show ip access-lists [*number* | *name*]	Displays the contents of all current IP access lists or a specific IP access list (numbered or named).
show ip interface *interface-id*	Displays detailed configuration and status of an interface. If IP is enabled on the interface and ACLs have been applied by using the **ip access-group** interface configuration command, the access groups are included in the display.
show running-config [**interface** *interface-id*]	Displays the contents of the configuration file for the device or the specified interface, including all configured MAC and IP access lists and which access groups are applied to an interface.
show mac access-group [**interface** *interface-id*]	Displays MAC access lists applied to all Layer 2 interfaces or the specified Layer 2 interface.

Configuration Examples for IPv4 Access Control Lists

ACLs in a Small Networked Office

Figure 14: Using Router ACLs to Control Traffic



Use router ACLs to do this in one of two ways:

- Create a standard ACL, and filter traffic coming to the server from Port 1.
- Create an extended ACL, and filter traffic coming from the server into Port 1.

Examples: ACLs in a Small Networked Office

This example uses a standard ACL to filter traffic coming into Server B from a port, permitting traffic only from Accounting's source addresses 172.20.128.64 to 172.20.128.95. The ACL is applied to traffic coming out of routed Port 1 from the specified source address.

```
Device> enable
Device# configure terminal
Device(config)# access-list 6 permit 172.20.128.64 0.0.0.31
Device(config)# exit
Device# show access-lists

Standard IP access list 6
    10 permit 172.20.128.64, wildcard bits 0.0.0.31
```

```
Device# configure terminal
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 6 out
Device(config-if)# end
```

This example uses an extended ACL to filter traffic coming from Server B into a port, permitting traffic from any source address (in this case Server B) to only the Accounting destination addresses 172.20.128.64 to 172.20.128.95. The ACL is appliDeviceed to traffic going into routed Port 1, permitting it to go only to the specified destination addresses. Note that with extended ACLs, you must enter the protocol (IP) before the source and destination information.

```
Device(config)# access-list 106 permit ip any 172.20.128.64 0.0.0.31
Device(config)# exit
Device# show access-lists

Extended IP access list 106
    10 permit ip any 172.20.128.64 0.0.0.31


Device# configure terminal
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 106 in
Device(config-if)# end
```

Example: Numbered ACLs

In this example, network 10.0.0.0 is a Class A network whose second octet specifies a subnet; that is, its subnet mask is 255.255.0.0. The third and fourth octets of a network 10.0.0.0 address specify a particular host. Using access list 2, the switch accepts one address on subnet 48 and reject all others on that subnet. The last line of the list shows that the switch accepts addresses on all other network 10.0.0.0 subnets. The ACL is applied to packets entering a port.

```
Device> enable
Device# configure terminal
Device(config)# access-list 2 permit 10.48.0.3
Device(config)# access-list 2 deny 10.48.0.0 0.0.255.255
Device(config)# access-list 2 permit 10.0.0.0 0.255.255.255
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 2 in
Device(config-if)# end
```

Examples: Extended ACLs

In this example, the first line permits any incoming TCP connections with destination ports greater than 1023. The second line permits incoming TCP connections to the Simple Mail Transfer Protocol (SMTP) port of host 172.16.0.0. The third line permits incoming ICMP messages for error feedback.

```
Device> enable
Device# configure terminal
Device(config)# access-list 102 permit tcp any 172.16.0.0 0.0.255.255 gt 1023
Device(config)# access-list 102 permit tcp any host 172.16.1.2 eq 25
Device(config)# access-list 102 permit icmp any any
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 102 in
Device(config-if)# end
```

In this example, suppose that you have a network connected to the Internet, and you want any host on the network to be able to form TCP connections to any host on the Internet. However, you do not want IP hosts to be able to form TCP connections to hosts on your network, except to the mail (SMTP) port of a dedicated mail host.

SMTP uses TCP port 25 on one end of the connection and a random port number on the other end. The same port numbers are used throughout the life of the connection. Mail packets coming in from the Internet have a destination port of 25. Because the secure system of the network always accepts mail connections on port 25, the incoming sevices are separately controlled.

```
Device> enable
Device# configure terminal
Device(config)# access-list 102 permit tcp any 172.16.0.0 0.0.255.255 eq 23
Device(config)# access-list 102 permit tcp any 172.16.0.0 0.0.255.255 eq 25
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 102 in
Device(config-if)# end
```

In this example, the network is a Class B network with the address 172.16.0.0, and the mail host address is 172.16.1.2. The **established** keyword is used only for the TCP to show an established connection. A match occurs if the TCP datagram has the ACK or RST bits set, which show that the packet belongs to an existing connection. Gigabit Ethernet interface 1 is the interface that connects the device to the Internet.

```
Device> enable
Device# configure terminal
Device(config)# access-list 102 permit tcp any 172.16.0.0 0.0.255.255 established
Device(config)# access-list 102 permit tcp any host 172.16.1.2 eq 25
Device(config)# interface gigabitethernet1/0/1
Device(config-if)# ip access-group 102 in
Device(config-if)# end
```

Examples: Named ACLs

Creating named standard and extended ACLs

This example creates a standard ACL named *internet_filter* and an extended ACL named *marketing_group*. The *internet_filter* ACL allows all traffic from the source address 10.2.3.4.

```
Device> enable
Device# configure terminal
Device(config)# ip access-list standard Internet_filter
Device(config-ext-nacl)# permit 10.2.3.4
Device(config-ext-nacl)# exit
Device(config-ext-nacl)# end
```

The *marketing_group* ACL allows any TCP Telnet traffic to the destination address and wildcard 172.16.0.0 0.0.255.255 and denies any other TCP traffic. It permits ICMP traffic, denies UDP traffic from any source to the destination address range 172.16.0.0 through 172.16.255.255 with a destination port less than 1024, denies any other IP traffic, and provides a log of the result.

```
Device> enable
Device# configure terminal
Device(config)# ip access-list extended marketing_group
Device(config-ext-nacl)# permit tcp any 172.16.0.0 0.0.255.255 eq telnet
Device(config-ext-nacl)# deny tcp any any
Device(config-ext-nacl)# permit icmp any any
Device(config-ext-nacl)# deny udp any 172.16.0.0 0.0.255.255 lt 1024
Device(config-ext-nacl)# deny ip any any log
```

```
Device(config-ext-nacl)# end
```

The *Internet_filter* ACL is applied to outgoing traffic and the *marketing_group* ACL is applied to incoming traffic on a Layer 3 port.

```
Device> enable
Device# configure terminal
Device(config)# interface gigabitethernet1/0/2
Device(config-if)# no switchport
Device(config-if)# ip address 10.0.5.1 255.255.255.0
Device(config-if)# ip access-group Internet_filter out
Device(config-if)# ip access-group marketing_group in
Device(config-if)# end
```

Deleting Individual ACEs from Named ACLs

This example shows how to delete individual ACEs from the named access list *border-list*:

```
Device> enable
Device# configure terminal
Device(config)# ip access-list extended border-list
Device(config-ext-nacl)# no permit ip host 10.1.1.3 any
Device(config-ext-nacl)# end
```

Examples: ACL Logging

Two variations of logging are supported on router ACLs. The **log** keyword sends an informational logging message to the console about the packet that matches the entry; the **log-input** keyword includes the input interface in the log entry.

In this example, standard named access list *stan1* denies traffic from 10.1.1.0 0.0.0.255, allows traffic from all other sources, and includes the **log** keyword.

```
Device> enable
Device# configure terminal
Device(config)# ip access-list standard stan1
Device(config-std-nacl)# deny 10.1.1.0 0.0.0.255 log
Device(config-std-nacl)# permit any log
Device(config-std-nacl)# exit
Device(config)# interface gigabitethernet1/0/1

Device(config-if)# ip access-group stan1 in
Device(config-if)# end
Device# show logging

Syslog logging: enabled (0 messages dropped, 0 flushes, 0 overruns)
    Console logging: level debugging, 37 messages logged
    Monitor logging: level debugging, 0 messages logged
    Buffer logging: level debugging, 37 messages logged
    File logging: disabled
    Trap logging: level debugging, 39 message lines logged

Log Buffer (4096 bytes):

00:00:48: NTP: authentication delay calculation problems

<output truncated>

00:09:34:%SEC-6-IPACCESSLOGS:list stan1 permitted 0.0.0.0 1 packet
```

```
00:09:59:%SEC-6-IPACCESSLOGS:list stan1 denied 10.1.1.15 1 packet
00:10:11:%SEC-6-IPACCESSLOGS:list stan1 permitted 0.0.0.0 1 packet
```

This example is a named extended access list *ext1* that permits ICMP packets from any source to 10.1.1.0 0.0.0.255 and denies all UDP packets.

```
Device> enable
Device# configure terminal
Device(config)# ip access-list extended ext1
Device(config-ext-nacl)# permit icmp any 10.1.1.0 0.0.0.255 log
Device(config-ext-nacl)# deny udp any any log
Device(config-std-nacl)# exit
Device(config)# interface gigabitethernet1/0/1

Device(config-if)# ip access-group ext1 in
Device(config)# end
```

This is a an example of a log for an extended ACL:

```
01:24:23:%SEC-6-IPACCESSLOGDP:list ext1 permitted icmp 10.1.1.15 -> 10.1.1.61 (0/0), 1
packet
01:25:14:%SEC-6-IPACCESSLOGDP:list ext1 permitted icmp 10.1.1.15 -> 10.1.1.61 (0/0), 7
packets
01:26:12:%SEC-6-IPACCESSLOGP:list ext1 denied udp 0.0.0.0(0) -> 255.255.255.255(0), 1 packet
01:31:33:%SEC-6-IPACCESSLOGP:list ext1 denied udp 0.0.0.0(0) -> 255.255.255.255(0), 8 packets
```

Note that all logging entries for IP ACLs start with %SEC-6-IPACCESSLOG with minor variations in format depending on the kind of ACL and the access entry that has been matched.

This is an example of an output message when the **log-input** keyword is entered:

```
00:04:21:%SEC-6-IPACCESSLOGDP:list inputlog permitted icmp 10.1.1.10 (Vlan1 0001.42ef.a400)
 ->
10.1.1.61 (0/0), 1 packet
```

A log message for the same sort of packet using the **log** keyword does not include the input interface information:

```
00:05:47:%SEC-6-IPACCESSLOGDP:list inputlog permitted icmp 10.1.1.10 -> 10.1.1.61 (0/0), 1
 packet
```

Example: ACEs and Fragmented and Unfragmented Traffic

Consider access list 102, configured with these commands, applied to three fragmented packets:

```
Device> enable
Device# configure terminal
Device(config)# access-list 102 permit tcp any host 10.1.1.1 eq smtp
Device(config)# access-list 102 deny tcp any host 10.1.1.2 eq telnet
Device(config)# access-list 102 permit tcp any host 10.1.1.2
Device(config)# access-list 102 deny tcp any any
Device(config)# end
```

Note In the first and second ACEs in the examples, the *eq* keyword after the destination address means to test for the TCP-destination-port well-known numbers equaling Simple Mail Transfer Protocol (SMTP) and Telnet, respectively.

- Packet A is a TCP packet from host 10.2.2.2., port 65000, going to host 10.1.1.1 on the SMTP port. If this packet is fragmented, the first fragment matches the first ACE (a permit) as if it were a complete

packet because all Layer 4 information is present. The remaining fragments also match the first ACE, even though they do not contain the SMTP port information, because the first ACE only checks Layer 3 information when applied to fragments. The information in this example is that the packet is TCP and that the destination is 10.1.1.1.

- Packet B is from host 10.2.2.2, port 65001, going to host 10.1.1.2 on the Telnet port. If this packet is fragmented, the first fragment matches the second ACE (a deny) because all Layer 3 and Layer 4 information is present. The remaining fragments in the packet do not match the second ACE because they are missing Layer 4 information. Instead, they match the third ACE (a permit).

  Because the first fragment was denied, host 10.1.1.2 cannot reassemble a complete packet, so packet B is effectively denied. However, the later fragments that are permitted will consume bandwidth on the network and resources of host 10.1.1.2 as it tries to reassemble the packet.

- Fragmented packet C is from host 10.2.2.2, port 65001, going to host 10.1.1.3, port ftp. If this packet is fragmented, the first fragment matches the fourth ACE (a deny). All other fragments also match the fourth ACE because that ACE does not check any Layer 4 information and because Layer 3 information in all fragments shows that they are being sent to host 10.1.1.3, and the earlier permit ACEs were checking different hosts.

Examples: Using Time Ranges with ACLs

This example shows how to verify after you configure time ranges for *workhours* and to configure January 1, 2006, as a company holiday.

```
Device# show time-range

time-range entry: new_year_day_2003 (inactive)
   absolute start 00:00 01 January 2006 end 23:59 01 January 2006
time-range entry: workhours (inactive)
   periodic weekdays 8:00 to 12:00
   periodic weekdays 13:00 to 17:00
```

To apply a time range, enter the time-range name in an extended ACL that can implement time ranges. This example shows how to create and verify extended access list 188 that denies TCP traffic from any source to any destination during the defined holiday times and permits all TCP traffic during work hours.

```
Device> enable
Device# configure terminal
Device(config)# access-list 188 deny tcp any any time-range new_year_day_2006
Device(config)# access-list 188 permit tcp any any time-range workhours
Device(config)# exit
Device# show access-lists

Extended IP access list 188
   10 deny tcp any any time-range new_year_day_2006 (inactive)
   20 permit tcp any any time-range workhours (inactive)
```

This example uses named ACLs to permit and deny the same traffic.

```
Device> enable
Device# configure terminal
Device(config)# ip access-list extended deny_access
Device(config-ext-nacl)# deny tcp any any time-range new_year_day_2006
Device(config-ext-nacl)# exit
Device(config)# ip access-list extended may_access
Device(config-ext-nacl)# permit tcp any any time-range workhours
Device(config-ext-nacl)# end
Device# show ip access-lists
```

```
Extended IP access list lpip_default
    10 permit ip any any
Extended IP access list deny_access
    10 deny tcp any any time-range new_year_day_2006 (inactive)
Extended IP access list may_access
    10 permit tcp any any time-range workhours (inactive)
```

Examples: Time Range Applied to an IP ACL

This example denies HTTP traffic on IP on Monday through Friday between the hours of 8:00 a.m. and 6:00 p.m (18:00). The example allows UDP traffic only on Saturday and Sunday from noon to 8:00 p.m. (20:00).

```
Device> enable
Device# configure terminal
Device(config)# time-range no-http
Device(config)# periodic weekdays 8:00 to 18:00
Device(config)# time-range udp-yes
Device(config)# periodic weekend 12:00 to 20:00
Device(config)# ip access-list extended strict
Device(config-ext-nacl)# deny tcp any any eq www time-range no-http
Device(config-ext-nacl)# permit udp any any time-range udp-yes
Device(config-ext-nacl)# exit
Device(config)# interface gigabitethernet1/0/1

Device(config-if)# ip access-group strict in
Device(config-if)# end
```

Examples: Including Comments in ACLs

You can use the **remark** keyword to include comments (remarks) about entries in any IP standard or extended ACL. The remarks make the ACL easier for you to understand and scan. Each remark line is limited to 100 characters.

The remark can go before or after a permit or deny statement. You should be consistent about where you put the remark so that it is clear which remark describes which permit or deny statement. For example, it would be confusing to have some remarks before the associated permit or deny statements and some remarks after the associated statements.

To include a comment for IP numbered standard or extended ACLs, use the **access-list** *access-list number* **remark** *remark* global configuration command. To remove the remark, use the **no** form of this command.

In this example, the workstation that belongs to user1 is allowed access, and the workstation that belongs to user2 is not allowed access:

```
Device> enable
Device# configure terminal
Device(config)# access-list 1 remark Permit only user1 workstation through
Device(config)# access-list 1 permit 171.69.2.88
Device(config)# access-list 1 remark Do not allow user2 through
Device(config)# access-list 1 deny 171.69.3.13
Device(config)# end
```

For an entry in a named IP ACL, use the **remark** access-list configuration command. To remove the remark, use the **no** form of this command.

In this example, the subnet1 subnet is not allowed to use outbound Telnet:

```
Device> enable
Device# configure terminal
Device(config)# ip access-list extended telnetting
Device(config-ext-nacl)# remark Do not allow subnet1 subnet to telnet out
Device(config-ext-nacl)# deny tcp host 171.69.2.88 any eq telnet
Device(config-ext-nacl)# end
```

Example: Creating an ACL and a VLAN Map to Deny a Packet

This example shows how to create an ACL and a VLAN map to deny a packet. In the first map, any packets that match the *ip1* ACL (TCP packets) would be dropped. You first create the *ip1* ACL to permit any TCP packet and no other packets. Because there is a match clause for IP packets in the VLAN map, the default action is to drop any IP packet that does not match any of the match clauses.

```
Device> enable
Device# configure terminal
Device(config)# ip access-list extended ip1
Device(config-ext-nacl)# permit tcp any any
Device(config-ext-nacl)# exit
Device(config)# vlan access-map map_1 10
Device(config-access-map)# match ip address ip1
Device(config-access-map)# action drop
Device(config-access-map)# end
```

Example: Creating an ACL and a VLAN Map to Permit a Packet

This example shows how to create a VLAN map to permit a packet. ACL *ip2* permits UDP packets and any packets that match the *ip2* ACL are forwarded. In this map, any IP packets that did not match any of the previous ACLs (that is, packets that are not TCP packets or UDP packets) would get dropped.

```
Device> enable
Device# configure terminal
Device(config)# ip access-list extended ip2
Device(config-ext-nacl)# permit udp any any
Device(config-ext-nacl)# exit
Device(config)# vlan access-map map_1 20
Device(config-access-map)# match ip address ip2
Device(config-access-map)# action forward
Device(config-access-map)# exit
```

Example: Default Action of Dropping IP Packets and Forwarding MAC Packets

In this example, the VLAN map has a default action of drop for IP packets and a default action of forward for MAC packets. Used with standard ACL 101 and extended named access lists **igmp-match** and **tcp-match**, the map will have the following results:

- Forward all UDP packets
- Drop all IGMP packets
- Forward all TCP packets
- Drop all other IP packets
- Forward all non-IP packets

```
Device> enable
Device# configure terminal
Device(config)# access-list 101 permit udp any any
Device(config)# ip access-list extended igmp-match
Device(config-ext-nacl)# permit igmp any any
Device(config)# action forward
Device(config-ext-nacl)# permit tcp any any
Device(config-ext-nacl)# exit
Device(config)# vlan access-map drop-ip-default 10
Device(config-access-map)# match ip address 101
Device(config-access-map)# action forward
Device(config-access-map)# exit
Device(config)# vlan access-map drop-ip-default 20
Device(config-access-map)# match ip address igmp-match
Device(config-access-map)# action drop
Device(config-access-map)# exit
Device(config)# vlan access-map drop-ip-default 30
Device(config-access-map)# match ip address tcp-match
Device(config-access-map)# action forward
Device(config-access-map)# end
```

Example: Default Action of Dropping MAC Packets and Forwarding IP Packets

In this example, the VLAN map has a default action of drop for MAC packets and a default action of forward for IP packets. Used with MAC extended access lists **good-hosts** and **good-protocols**, the map will have the following results:

- Forward MAC packets from hosts 0000.0c00.0111 and 0000.0c00.0211
- Forward MAC packets with decnet-iv or vines-ip protocols
- Drop all other non-IP packets
- Forward all IP packets

```
Device> enable
Device# configure terminal
Device(config)# mac access-list extended good-hosts
Device(config-ext-macl)# permit host 000.0c00.0111 any
Device(config-ext-macl)# permit host 000.0c00.0211 any
Device(config-ext-nacl)# exit
Device(config)# action forward
Device(config-ext-macl)# mac access-list extended good-protocols
Device(config-ext-macl)# permit any any vines-ip
Device(config-ext-nacl)# exit
Device(config)# vlan access-map drop-mac-default 10
Device(config-access-map)# match mac address good-hosts
Device(config-access-map)# action forward
Device(config-access-map)# exit
Device(config)# vlan access-map drop-mac-default 20
Device(config-access-map)# match mac address good-protocols
Device(config-access-map)# action forward
Device(config-access-map)# end
```

Example: Default Action of Dropping All Packets

In this example, the VLAN map has a default action of drop for all packets (IP and non-IP). Used with access lists **tcp-match** and **good-hosts** from Examples 2 and 3, the map will have the following results:

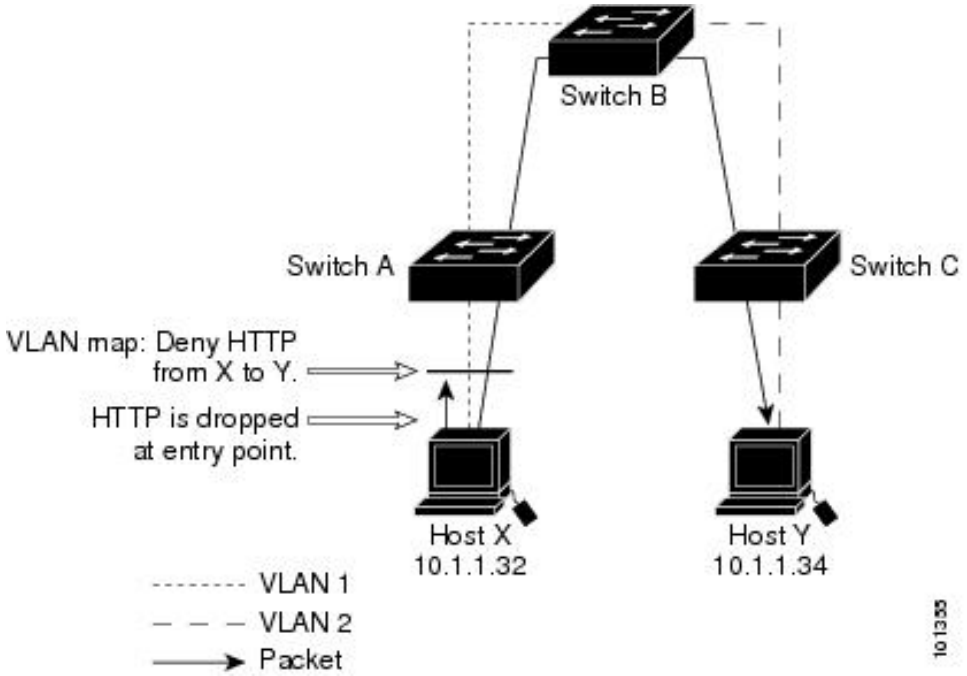
- Forward all TCP packets
- Forward MAC packets from hosts 0000.0c00.0111 and 0000.0c00.0211
- Drop all other IP packets
- Drop all other MAC packets

```
Device> enable
Device# configure terminal
Device(config)# vlan access-map drop-all-default 10
Device(config-access-map)# match ip address tcp-match
Device(config-access-map)# action forward
Device(config-access-map)# exit
Device(config)# vlan access-map drop-all-default 20
Device(config-access-map)# match mac address good-hosts
Device(config-access-map)# action forward
Device(config-access-map)# end
```

Example: Using VLAN Maps in a Network

Example: Wiring Closet Configuration

Figure 15: Wiring Closet Configuration



If you do not want HTTP traffic switched from Host X to Host Y, you can configure a VLAN map on Switch A to drop all HTTP traffic from Host X (IP address 10.1.1.32) to Host Y (IP address 10.1.1.34) at Switch A and not bridge it to Switch B.

First, define the IP access list *http* that permits (matches) any TCP traffic on the HTTP port.

```
Device> enable
Device# configure terminal
```

```
Device(config)# ip access-list extended http
Device(config-ext-nacl)# permit tcp host 10.1.1.32 host 10.1.1.34 eq www
Device(config-ext-nacl)# end
```

Next, create VLAN access map *map2* so that traffic that matches the *http* access list is dropped and all other IP traffic is forwarded.

```
Device> enable
Device# configure terminal
Device(config)# vlan access-map map2 10
Device(config-access-map)# match ip address http
Device(config-access-map)# action drop
Device(config-access-map)# exit
Device(config)# ip access-list extended match_all
Device(config-ext-nacl)# permit ip any any
Device(config-ext-nacl)# exit
Device(config)# vlan access-map map2 20
Device(config-access-map)# match ip address match_all
Device(config-access-map)# action forward
Device(config-access-map)# end
```

Then, apply VLAN access map *map2* to VLAN 1.

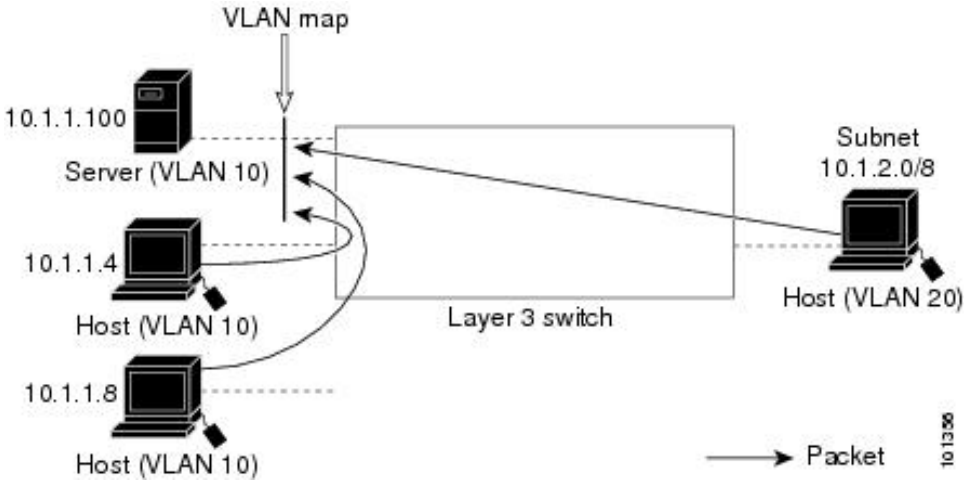
```
Device> enable
Device# configure terminal
Device(config)# vlan filter map2 vlan 1
Device(config)# end
```

Example: Restricting Access to a Server on Another VLAN

Figure 16: Restricting Access to a Server on Another VLAN

You can restrict access to a server on another VLAN. For example, server 10.1.1.100 in VLAN 10 needs to have access denied to these hosts:

- Hosts in subnet 10.1.2.0/8 in VLAN 20 should not have access.
- Hosts 10.1.1.4 and 10.1.1.8 in VLAN 10 should not have access.



Example: Denying Access to a Server on Another VLAN

This example shows how to deny access to a server on another VLAN by creating the VLAN map SERVER 1 that denies access to hosts in subnet 10.1.2.0.8, host 10.1.1.4, and host 10.1.1.8 and permits other IP traffic. The final step is to apply the map SERVER1 to VLAN 10.

Define the IP ACL that will match the correct packets.

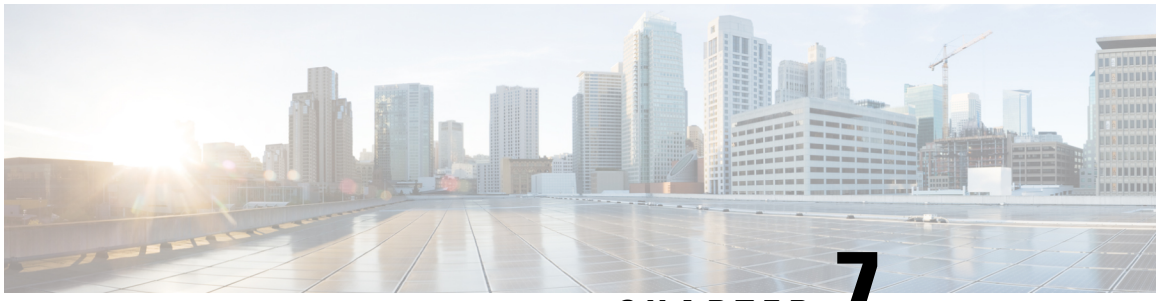
```
Device> enable
Device# configure terminal
Device(config)# ip access-list extended SERVER1_ACL
Device(config-ext-nacl)# permit ip 10.1.2.0 0.0.0.255 host 10.1.1.100
Device(config-ext-nacl)# permit ip host 10.1.1.4 host 10.1.1.100
Device(config-ext-nacl)# permit ip host 10.1.1.8 host 10.1.1.100
Device(config-ext-nacl)# end
```

Define a VLAN map using this ACL that will drop IP packets that match SERVER1_ACL and forward IP packets that do not match the ACL.

```
Device> enable
Device# configure terminal
Device(config)# vlan access-map SERVER1_MAP
Device(config-access-map)# match ip address SERVER1_ACL
Device(config-access-map)# action drop
Device(config)# vlan access-map SERVER1_MAP 20
Device(config-access-map)# action forward
Device(config-access-map)# end
```

Apply the VLAN map to VLAN 10.

```
Device> enable
Device# configure terminal
Device(config)# vlan filter SERVER1_MAP vlan-list 10
Device(config)# end
```



CHAPTER 7

IPv6 ACLs

Restrictions for IPv6 ACLs

IPv6 supports only named ACLs. With IPv4 ACLs, you can configure standard and extended numbered IP ACLs, named IP ACLs, and MAC ACLs.

The switch supports most Cisco IOS-supported IPv6 ACLs with some exceptions:

- The switch does not support matching on these keywords: **flowlabel**, **routing header**, and **undetermined-transport**.
- The switch does not support reflexive ACLs (the **reflect** keyword).
- The **vrf-also** keyword is mutually exclusive of IPv6 access-class line command.
- The switch does not apply MAC-based ACLs on IPv6 frames.
- When configuring an ACL, there is no restriction on keywords that are entered in the ACL, regardless of whether they are supported or not on the platform. When you apply the ACL to an interface that requires hardware forwarding (physical ports or SVIs), the switch checks to determine whether ACL can be supported on the interface or not. If the ACL is not supported on the interface, the ACL is rejected.
- If an ACL is applied to an interface and you attempt to add an access control entry (ACE) with an unsupported keyword, the switch does not allow the ACE to be added to the ACL that is currently attached to the interface.
- When you apply a scale ACL to an interface that does not program TCAM for a protocol and the ACLs that have been unloaded, it can impact the existing normal movement of traffic for other protocols. The restriction is applicable to .
- Time-to-live (TTL) classification is not supported on ACLs.
- If a downloadable ACL contains any type of duplicate entries, the entries are not auto merged. As a result, the 802.1X session authorization fails. Ensure that the downloadable ACL is optimized without any duplicate entries, for example port-based and name-based entries for the same port.

- Egress ACL lookup is not supported for injected traffic that is forwarded by the software.
- ACLs support only Layer 3 interfaces (such as routed interfaces and VLAN interfaces).

Information About IPv6 ACLs

The following sections provide information about IPv6 ACLs.

IPv6 ACL Overview

This topic provides an overview of IPv6 ACL.

An access control list (ACL) is a set of rules that are used to limit access to a particular interface. ACLs are configured on the device and applied to the management interface and to any of the dynamic interfaces.

You can also create a preauthentication ACL for web authentication. Such an ACL is used to allow certain types of traffic before authentication is complete.

IPv6 ACLs support the same options as IPv4 ACLs including source, destination, source, and destination ports.

Supported ACLs

The switch supports three types of ACLs to filter the traffic:

- Port ACLs access-control traffic entering a Layer 2 interface. You can apply port ACLs to a Layer 2 interface in each direction to each access list type—IPv4, IPv6, and MAC.
- Router ACLs access-control traffic routed between VLANs and are applied to Layer 3 interfaces in a specific direction (inbound or outbound).

Types of ACL

The following sections provide information on the types of ACL:

Per-User IPv6 ACL

For the per-user ACL, the full access control entries (ACE) as the text strings are configured on the Cisco Secure Access Control Server (Cisco Secure ACS).

Filter ID IPv6 ACL

For the filter-Id ACL, the full ACEs and the `acl name(filter-id)` is configured on the device and only the `filter-id` is configured on the Cisco Secure ACS.

ACL Precedence

When Port ACLs, and router ACLs are configured on the same switch, the filtering precedence, from greatest to least for ingress traffic is port ACL, and then router ACL. For egress traffic, the filtering precedence is router ACL, and then port ACL.

The following examples describe simple use cases:

- When an input router ACL and input port ACL exist in a switch virtual interface (SVI), incoming packets that are received on ports to which a port ACL is applied are filtered by the port ACL. Incoming routed IP packets received on other ports are filtered by the router ACL. Other packets are not filtered.
- When an output router ACL and input port ACL exist in an SVI, incoming packets that are received on the ports to which a port ACL is applied are filtered by the port ACL. Outgoing routed IP packets are filtered by the router ACL. Other packets are not filtered.

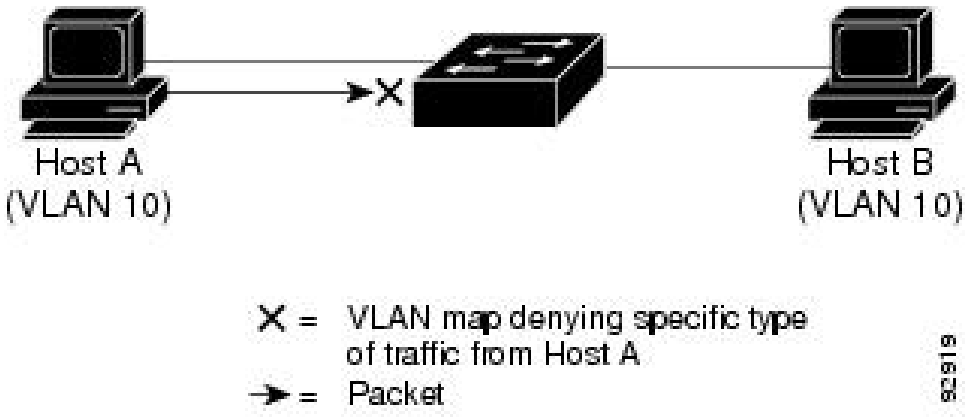
VLAN Maps

VLAN ACLs or VLAN maps are used to control the network traffic within a VLAN. You can apply VLAN maps to all packets that are bridged within a VLAN in the switch. VACLs are strictly for the security packet filtering and for redirecting traffic to specific physical interfaces. VACLs are not defined by direction (ingress or egress).

All non-IP protocols are access-controlled through MAC addresses and Ethertype using MAC VLAN maps. (IP traffic is not access-controlled by MAC VLAN maps.) You can enforce VLAN maps only on packets going through the switch; you cannot enforce VLAN maps on traffic between hosts on a hub or on another switch that is connected to this switch.

With VLAN maps, forwarding of packets is permitted or denied, based on the action specified in the map.

Figure 17: Using VLAN Maps to Control Traffic



Interactions with Other Features and Switches

- If an IPv6 router ACL is configured to deny a packet, the packet is not routed. A copy of the packet is sent to the Internet Control Message Protocol (ICMP) queue to generate an ICMP unreachable message for the frame.

- If a bridged frame is to be dropped due to a port ACL, the frame is not bridged.
- You can create both IPv4 and IPv6 ACLs on a switch, and you can apply both IPv4 and IPv6 ACLs to the same interface. Each ACL must have a unique name; an error message appears if you try to use a name that is already configured.

  You use different commands to create IPv4 and IPv6 ACLs and to attach IPv4 or IPv6 ACLs to the same Layer 2 or Layer 3 interface. If you use the wrong command to attach an ACL (for example, an IPv4 command to attach an IPv6 ACL), you receive an error message.
- You cannot use MAC ACLs to filter IPv6 frames. MAC ACLs can only filter non-IP frames.
- If the hardware memory is full, packets are dropped on the interface and an unload error message is logged.

  If the hardware memory is full, for any additional configured ACLs, packets are dropped to the CPU, and the ACLs are applied in software. When the hardware is full a message is printed to the console indicating the ACL has been unloaded and the packets will be dropped on the interface.

How to Configure an IPv6 ACL

The following sections display information on how to configure an IPv6 ACL.

Default Configuration for IPv6 ACLs

The default IPv6 ACL configuration is as follows:

```
Device# show access-lists preauth_ipv6_acl

IPv6 access list preauth_ipv6_acl (per-user)
permit udp any any eq domain sequence 10
permit tcp any any eq domain sequence 20
permit icmp any any nd-ns sequence 30
permit icmp any any nd-na sequence 40
permit icmp any any router-solicitation sequence 50
permit icmp any any router-advertisement sequence 60
permit icmp any any redirect sequence 70
permit udp any eq 547 any eq 546 sequence 80
permit udp any eq 546 any eq 547 sequence 90
deny ipv6 any any sequence 100
```

Configuring IPv6 ACLs

To filter IPv6 traffic, perform this procedure.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**ipv6 access-list** {*list-name* | **log-update threshold** | **role-based** *list-name*} **Example:** `Device(config)# ipv6 access-list example_acl_list`	Defines an IPv6 ACL name, and enters IPv6 access list configuration mode.
Step 4	{**deny** | **permit**} protocol {*source-ipv6-prefix/* |*prefix-length* |**any threshold**| **host** *source-ipv6-address*} [operator [*port-number*]] { *destination-ipv6-prefix/ prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]][**dscp** *value*] [**fragments**] [**log**] [**log-input**][**sequence** *value*] [**time-range** *name*] **Example:** `Device(config-ipv6-acl)# permit tcp 2001:DB8:0300:0201::/32 eq telnet any`	Specifies permit or deny conditions for an IPv6 ACL. • For protocol, enter the name or number of an IP: **ahp**, **esp**, **icmp**, **ipv6**, **pcp**, **stcp**, **tcp**, or **udp**, or an integer in the range 0 to 255 representing an IPv6 protocol number. • The *source-ipv6-prefix/prefix-length* or *destination-ipv6-prefix/ prefix-length* is the source or destination IPv6 network or class of networks for which to set deny or permit conditions, specified in hexadecimal and using 16-bit values between colons (see RFC 2373). • Enter **any** as an abbreviation for the IPv6 prefix ::/0. • For **host** *source-ipv6-address* or *destination-ipv6-address*, enter the source or destination IPv6 host address for which to set deny or permit conditions, specified in hexadecimal using 16-bit values between colons. • (Optional) For operator, specify an operand that compares the source or destination ports of the specified protocol. Operands are **lt** (less than), **gt** (greater than), **eq** (equal), **neq** (not equal), and **range**. If the operator follows the *source-ipv6-prefix/prefix-length* argument, it must match the source port. If the operator follows the *destination-ipv6- prefix/prefix-length* argument, it must match the destination port. • (Optional) The **port-number** is a decimal number from 0 to 65535 or the name of a TCP or UDP port. You can use TCP port names only when filtering TCP. You can use UDP port names only when filtering UDP. • (Optional) Enter **dscp** value to match a differentiated services code point value against the traffic class value in the Traffic Class field of each IPv6 packet header. The acceptable range is from 0 to 63.

	Command or Action	Purpose
		• (Optional) Enter **fragments** to check noninitial fragments. This keyword is visible only if the protocol is ipv6. • (Optional) Enter **log** to cause an logging message to be sent to the console about the packet that matches the entry. Enter **log-input** to include the input interface in the log entry. Logging is supported only for router ACLs. • (Optional) Enter **sequence** *value* to specify the sequence number for the access list statement. The acceptable range is from 1 to 4,294,967,295. • (Optional) Enter **time-range** name to specify the time range that applies to the deny or permit statement.
Step 5	{**deny** | **permit**} **tcp** {*source-ipv6-prefix/prefix-length* | **any** | **host** *source-ipv6-address*} [**operator** [**port-number**]] {*destination-ipv6- prefix/prefix-length* | **any** | **host** *destination-ipv6-address*} [operator [*port-number*]] [**ack**] [**dscp** *value*] [**established**] [**fin**] [**log**] [**log-input**] [**neq** {**port** | protocol}] [**psh**] [**range** {**port** | **protocol**}] [**rst**] [**sequence** *value*] [**syn**] [**time-range** *name*] [**urg**] **Example:** `Device(config-ipv6-acl)# deny tcp host 2001:DB8:1::1 any log-input`	Specifies permit or deny conditions for an IPv6 ACL. Enter **tcp** for Transmission Control Protocol. The parameters are the same as those described in Step 3a, with these additional optional parameters: • **ack**: Acknowledgment bit set. • **established**: An established connection. A match occurs if the TCP datagram has the ACK or RST bits set. • **fin**: Finished bit set; no more data from sender. • **neq** { *port* |**protocol**}: Matches only packets that are not on a given port number. • **psh**: Push function bit set. • **range** { *port* |**protocol**}: Matches only packets in the port number range. • **rst**: Reset bit set. • **syn**: Synchronize bit set. • **urg**: Urgent pointer bit set.
Step 6	**end** **Example:** `Device(config-ipv6-acl)# end`	Exits IPv6 access list configuration mode and returns to privileged EXEC mode.
Step 7	**show ipv6 access-list** **Example:** `Device# show ipv6 access-list`	Verifies that IPv6 ACLs are configured correctly.

Attaching an IPv6 ACL to an Interface

You can apply an ACL to outbound or inbound traffic on Layer 3 interfaces, or to inbound traffic on Layer 2 interfaces. You can also apply ACLs only to inbound management traffic on Layer 3 interfaces.

Follow these steps to control access to an interface.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **interface** *interface-id*
4. **no switchport**
5. **ipv6 address** *ipv6-address*
6. **ipv6 traffic-filter** *access-list-name* {**in** | **out**}
7. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet1/0/1`	Identifies a Layer 2 interface (for port ACLs) or Layer 3 interface (for router ACLs) on which to apply an access list, and enters interface configuration mode.
Step 4	**no switchport** **Example:** `Device(config-if)# no switchport`	Returns the interface to the routed-interface status and erases all further Layer 2 configuration.
Step 5	**ipv6 address** *ipv6-address* **Example:** `Device(config-if)# ipv6 address 2001:DB8::1`	Configures an IPv6 address on a Layer 3 interface (for router ACLs).
Step 6	**ipv6 traffic-filter** *access-list-name* {**in**	**out**} **Example:** `Device(config-if)# ipv6 traffic-filter acl1 in`	Applies the access list to incoming or outgoing traffic on the interface.

	Command or Action	Purpose
Step 7	**end** **Example:** `Device(config-ipv6-acl)# end`	Exits interface configuration mode and returns to privileged EXEC mode.

Configuring an IPv6 ACL in Template Mode

Note You can configure **ipv6 traffic-filter** command in the template configuration mode. You can configure the **source template** command only once to an interface.

Beginning in privileged EXEC mode, follow these steps to configure ACL in a template:

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **ipv6 access-list** {*list-name* | **log-update threshold** | **role-based** *list-name*}
4. **ipv6 access-list** {*list-name* | **log-update threshold** | **role-based** *list-name*}
5. **exit**
6. **template**
7. **ipv6 traffic-filter** {*access-list-number* | *name*} {**in** | **out**}
8. **exit**
9. **interface** *interface-id*
10. **ipv6 traffic-filter** {*access-list-number* | *name*} {**in** | **out**}
11. **source template** *name*
12. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**ipv6 access-list** {*list-name* | **log-update threshold** | **role-based** *list-name*} **Example:** `Device(config)# ipv6 access-list v6acl10`	Defines an IPv6 ACL name, and enters IPv6 access list configuration mode.
Step 4	**ipv6 access-list** {*list-name* | **log-update threshold** | **role-based** *list-name*} **Example:** `Device(config-ipv6-acl)#ipv6 access-list v6acl11`	Defines an IPv6 ACL name, and enters IPv6 access list configuration mode.
Step 5	**exit** **Example:** `Device(config-ipv6-acl)#exit`	Exits access-list configuration mode.
Step 6	**template** **Example:** `Device(config)# template test`	Creates a user template and enters template configuration mode.
Step 7	**ipv6 traffic-filter** {*access-list-number* | *name*} {**in** | **out**} **Example:** `Device(config-template)# ipv6 traffic-filter v6acl10 in`	Controls access to the specified interface. Enter *access-list-number* to define the access list. The access list can be a number. Enter *name* to define the access list. The access list can be a name. Enter **in** to direct the access list in the incoming direction of the interface. Enter **out** to direct the access list in the outgoing direction of the interface.
Step 8	**exit** **Example:** `Device(config-template)# exit`	Exits template configuration mode and returns to privileged EXEC mode.
Step 9	**interface** *interface-id* **Example:** `Device(config)# interface gigabitethernet1/0/1`	Identifies a specific interface for configuration, and enters interface configuration mode. The interface can be a Layer 2 interface (port ACL), or a Layer 3 interface (router ACL).
Step 10	**ipv6 traffic-filter** {*access-list-number* | *name*} {**in** | **out**} **Example:** `Device(config-if)# ipv6 traffic-filter v6acl11 out`	Controls access to the specified interface. Enter *access-list-number* to define the access list. The access list can be a number. Enter *name* to define the access list. The access list can be a name. Enter **in** to direct the access list in the incoming direction of the interface.

	Command or Action	Purpose
		Enter **out** to direct the access list in the outgoing direction of the interface.
Step 11	**source template** *name* **Example:** `Device(config)# source template test`	Applies an interface template to a target. The accesss list *v6acl10* is the incoming access list that is configured.
Step 12	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Configuring a VLAN Map

To create a VLAN map and apply it to one or more VLANs, perform these steps:

Before you begin

Create the IPv6 ACL that you want to apply to the VLAN.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vlan access-map** *name* [**number**]
4. **match** {**ip** | **ipv6** | **mac**} **address** {*name* | *number*} [*name* | *number*]
5. Enter one of the following commands to specify an IP packet or a non-IP packet (with only a known MAC address) and to match the packet against one or more ACLs:
   - **action** { **forward**}

     ```
     Device(config-access-map)# action forward
     ```

   - **action** { **drop**}

     ```
     Device(config-access-map)# action drop
     ```

6. **vlan filter** *mapname* **vlan-list** *list*
7. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**vlan access-map** *name* [**number**] **Example:** `Device(config)# vlan access-map map_1 20`	Creates a VLAN map, and enters VLAN access-map command mode VLAN map can have a name or (optionally) a number. The number is the sequence number of the entry within the map. When you create VLAN maps with the same name, numbers are assigned sequentially in increments of 10. When modifying or deleting maps, you can enter the number of the map entry that you want to modify or delete. VLAN maps do not use the specific permit or deny keywords. To deny a packet by using VLAN maps, create an ACL that would match the packet, and set the action to drop. A permit in the ACL counts as a match. A deny in the ACL means no match.
Step 4	**match** {**ip** | **ipv6** | **mac**} **address** {*name* | *number*} [*name* | *number*] **Example:** `Device(config-access-map)# match ipv6 address ip_net`	Matches the packet against one or more access lists. Note that packets are only matched against access lists of the correct protocol type. IP packets are matched against IP access lists. Non-IP packets are only matched against named MAC access lists. **Note** If the VLAN map is configured with a match clause for a type of packet (IP or MAC) and the map action is drop, all packets that match the type are dropped. If the VLAN map has no match clause, and the configured action is drop, all IP and Layer 2 packets are dropped.

Step 5	Enter one of the following commands to specify an IP packet or a non-IP packet (with only a known MAC address) and to match the packet against one or more ACLs:
	• **action** { **forward**}
	`Device(config-access-map)# action forward`
	• **action** { **drop**}
	`Device(config-access-map)# action drop`
		Sets the action for the map entry.

Step 6	**vlan filter** *mapname* **vlan-list** *list* **Example:** `Device(config)# vlan filter map 1 vlan-list 20-22`	Applies the VLAN map to one or more VLAN IDs. The list can be a single VLAN ID (22), a consecutive list (10-22), or a string of VLAN IDs (12, 22, 30). Spaces around the comma and hyphen are optional.

	Command or Action	Purpose
Step 7	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Applying a VLAN Map to a VLAN

To apply a VLAN map to one or more VLANs, perform these steps.

SUMMARY STEPS

1. **enable**
2. **configure terminal**
3. **vlan filter** *mapname* **vlan-list** *list*
4. **end**

DETAILED STEPS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**vlan filter** *mapname* **vlan-list** *list* **Example:** `Device(config)# vlan filter map 1 vlan-list 20-22`	Applies the VLAN map to one or more VLAN IDs. The list can be a single VLAN ID (22), a consecutive list (10-22), or a string of VLAN IDs (12, 22, 30). Spaces around the comma and hyphen are optional.
Step 4	**end** **Example:** `Device(config)# end`	Exits global configuration mode and returns to privileged EXEC mode.

Monitoring IPv6 ACLs

You can display information about all configured access lists, all IPv6 access lists, or a specific access list by using one or more of the privileged EXEC commands shown in the table below:

Table 13: show ACL commands

Command	Purpose
show access-lists	Displays all access lists configured on the switch.
show ipv6 access-list [*access-list-name*]	Displays all configured IPv6 access lists or the access list specified by name.
show vlan access-map [*map-name*]	Displays VLAN access map configuration.
show vlan filter [**access-map** *access-map* | **vlan** *vlan-id*]	Displays the mapping between VACLs and VLANs.

Configuration Examples for IPv6 ACL

This following sections display configuration examples for IPv6 ACL.

Example: Creating an IPv6 ACL

This example configures the IPv6 access list named IPv6-ACL. The first deny entry in the list denies all packets that have a destination TCP port number greater than 5000. The second deny entry denies packets that have a source UDP port number less than 5000. The second deny also logs all matches to the console. The first permit entry in the list permits all ICMP packets. The second permit entry in the list permits all other traffic. The second permit entry is necessary because an implicit deny -all condition is at the end of each IPv6 access list.

Note Logging is supported only on Layer 3 interfaces.

```
Device> enable
Device(config)# ipv6 access-list IPv6_ACL
Device(config-ipv6-acl)# deny tcp any any gt 5000
Device (config-ipv6-acl)# deny ::/0 lt 5000 ::/0 log
Device(config-ipv6-acl)# permit icmp any any
Device(config-ipv6-acl)# permit any any
Device(config-ipv6-acl)# end
```

Example: Displaying IPv6 ACLs

The following is a sample output from the **show access-lists** command. The output shows all access lists that are configured on the device.

```
Device# show access-lists

Extended IP access list hello
10 permit ip any any
IPv6 access list ipv6
permit ipv6 any any sequence 10
```

The following is a sample output from the **show ipv6 access-lists** command. The output shows only IPv6 access lists configured on the switch.

```
Device# show ipv6 access-list

IPv6 access list inbound
permit tcp any any eq bgp (8 matches) sequence 10
permit tcp any any eq telnet (15 matches) sequence 20
permit udp any any sequence 30
IPv6 access list outbound
deny udp any any sequence 10
deny tcp any any eq telnet sequence 20
```

Example: Displaying VLAN Access Map Configuration

The following is a sample output from the **show vlan access-map** privileged EXEC command:

```
Device# show vlan access-map

Vlan access-map "m1"  10
  Match clauses:
    ipv6 address: ip2
  Action: drop
```

The following is a sample output from the **show ipv6 access-lists** privileged EXEC command. The output shows only IPv6 access lists configured on the switch.

```
Device# show ipv6 access-list

IPv6 access list inbound
permit tcp any any eq bgp (8 matches) sequence 10
permit tcp any any eq telnet (15 matches) sequence 20
permit udp any any sequence 30
IPv6 access list outbound
deny udp any any sequence 10
deny tcp any any eq telnet sequence 20
```