

Cisco Embedded Wireless Controller on Catalyst Access Points Configuration Guide, IOS XE Dublin 17.12.x

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Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
http://www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 527-0883

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Preface

This preface describes the conventions of this document and information on how to obtain other documentation. It also provides information on what's new in Cisco product documentation.

- Document Conventions , on page xlvii
- Related Documentation, on page xlix
- Communications, services, and additional information, on page xlix

Document Conventions

This document uses the following conventions:

Convention	Description
^ or Ctrl	Both the ^ symbol and Ctrl represent the Control (Ctrl) key on a keyboard. For example, the key combination ^**D** or **Ctrl-D** means that you hold down the Control key while you press the D key. (Keys are indicated in capital letters but are not case sensitive.)
bold font	Commands and keywords and user-entered text appear in **bold** font.
Italic font	Document titles, new or emphasized terms, and arguments for which you supply values are in *italic* font.
`Courier` font	Terminal sessions and information the system displays appear in `courier` font.
`Bold Courier` font	**`Bold Courier`** font indicates text that the user must enter.
[x]	Elements in square brackets are optional.
...	An ellipsis (three consecutive nonbolded periods without spaces) after a syntax element indicates that the element can be repeated.
|	A vertical line, called a pipe, indicates a choice within a set of keywords or arguments.
[x | y]	Optional alternative keywords are grouped in brackets and separated by vertical bars.

Convention	Description
{x | y}	Required alternative keywords are grouped in braces and separated by vertical bars.
[x {y | z}]	Nested set of square brackets or braces indicate optional or required choices within optional or required elements. Braces and a vertical bar within square brackets indicate a required choice within an optional element.
string	A nonquoted set of characters. Do not use quotation marks around the string or the string will include the quotation marks.
< >	Nonprinting characters such as passwords are in angle brackets.
[ ]	Default responses to system prompts are in square brackets.
!, #	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.

Reader Alert Conventions

This document may use the following conventions for reader alerts:



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



Tip Means *the following information will help you solve a problem.*



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



Timesaver Means *the described action saves time.* You can save time by performing the action described in the paragraph.

Take note of the following general safety warnings:

Warning IMPORTANT SAFETY INSTRUCTIONS

Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Read the installation instructions before using, installing, or connecting the system to the power source. Use the statement number at the beginning of each warning statement to locate its translation in the translated safety warnings for this device.

SAVE THESE INSTRUCTIONS



Related Documentation

Note Before installing or upgrading the deviceCiscoEmbedded Wireless Controller, refer to the release notes.

Communications, services, and additional information

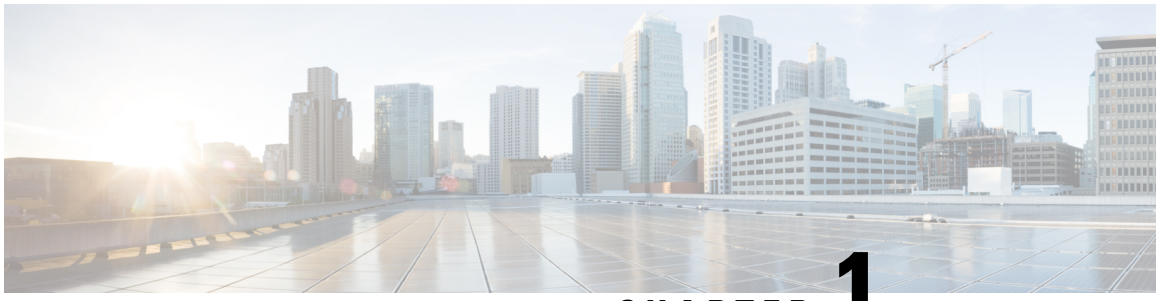
- To receive timely, relevant information from Cisco, sign up at Cisco Profile Manager.
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- To submit a service request, visit Cisco Support.
- To discover and browse secure, validated enterprise-class apps, products, solutions, and services, visit Cisco DevNet.
- To obtain general networking, training, and certification titles, visit Cisco Press.
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Cisco Bug Search Tool

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CHAPTER 1

Cisco Embedded Wireless Controller on Catalyst Access Points

Cisco Embedded Wireless Controller on Catalyst Access Points are the next generation wireless controllers that

- are IOS XE based and integrate the Radio Frequency (RF) performance excellence from Aironet systems,
- supports intent-based networking that are easy to adapt and scale, and
- are available in multiple physical and virtual form factors for flexible management options.

Available form factors and deployment options

You can deploy the controllers as physical appliances .

Management options

You can managed them the Cisco Embedded Wireless Controller on Catalyst Access Points with:

- Cisco Catalyst Center
- NETCONF or YANG, or
- GUI or CLI.

- New configuration model, tags, and profile, on page 1
- Configuration workflow, on page 2
- Initial Setup, on page 4
- Interactive help, on page 9
- Resetting Cisco Embedded Wireless Controller on Catalyst Access Points, on page 9
- Password Recovery, on page 10

New configuration model, tags, and profile

The new configuration model is a wireless network configuration approach that

- uses profiles to define feature-specific parameters
- uses tags to bundle and apply profiles to APs, and

- separates policy, site, RF, and WLAN definitions for modular deployment.

Profiles define attributes such as WLAN policy, RF behavior, and AP join characteristics. Tags are logical containers that map these profiles to APs, ensuring flexible and scalable configurations.

A tag is a logical container that

- is defined by the property of policies you associate with it
- maps multiple profiles—policy, site, and RF—to an AP or client, and determines that device's configuration and behavior, and
- enables modular and flexible deployment across sites.

Every tag has a default that is created when the system boots up.

A profile is a logical container that

- include feature-specific attributes and parameters applied to tags
- represent multiple attributes related to policy, site, and RF
- determine the configuration and behavior of applied APs and associated clients, and
- is a reusable entities that can be used across tags.

Configuration workflow

Configuring wireless networks involves establishing profiles and tags that link configurations to APs for effective wireless management.

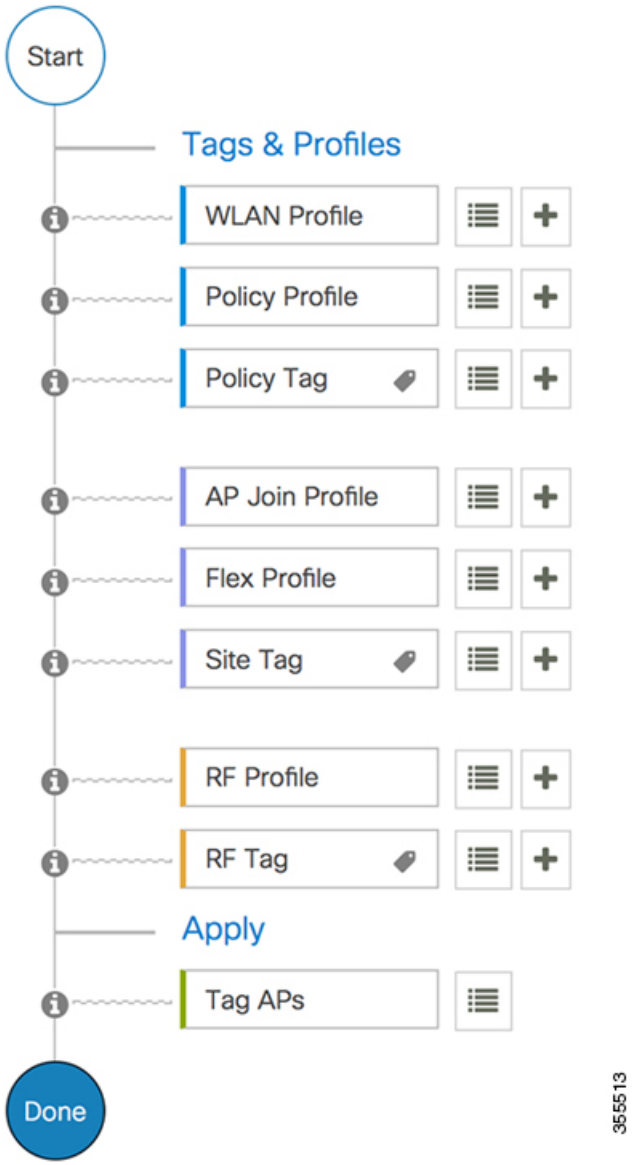
Summary

The key components involved in the process are:

- **Profiles**: Logical groupings of settings (such as WLAN, Policy, AP Join, Flex, and RF) used to configure APs.
- **Tags**: Logical containers or labels (such as Policy, Site, Tag) that help link profiles with APs.
- **APs**: Devices that implement the configurations provided by profiles and tags to deliver wireless connectivity.

Workflow

Figure 1: Configuration workflow



These are the stages of configuration:

1. **Profile creation** creates specific profiles:
    - WLAN profile for managing wireless network settings.
    - Policy profile for enforcing network rules.
    - AP Join profile for controlling AP associations.
    - Flex profile for handling local switching.
    - RF profile for optimizing radio frequency settings.

2. **Tag creation**: generates tags to complement profiles:
    - Policy tag to align with the Policy profile.
    - Site tag for specific location identification.
    - RF tag corresponding to the RF profile.
3. **Tag association**: associates the created tags with an AP to apply the configured settings and policies.

Result

The configuration workflow enables APs to be set up correctly with designated profiles and tags, resulting in efficient network operation and management.

Initial Setup

Setting Up the Controller

The initial configuration wizard in Cisco Embedded Wireless Controller on Catalyst Access Points is a simplified, out-of-the-box installation and configuration interface for the controller. This section provides instructions to set up a controller to operate in a small, medium, or large network wireless environment, where access points can join and together as a simple solution provide various services, such as corporate employee or guest wireless access on the network.

Configuring the Controller Using Day 0 Wizard (GUI)

To confugure the controller using day 0 wizard, complete the following steps:

Before you begin

When the AP has rebooted in the EWC mode, it broadcasts a provisioning SSID ending with the last digits of the MAC address. You can connect to provisioning SSID using the PSK **password**.

You can then open a browser and be redirected to mywifi.cisco.com, which takes you to the AP web UI. Enter the username as **webui** and password as **cisco**.

Note: The web redirection to the EWC configuration portal only works if you are connected to the provisioning SSID. It does not work if your laptop is connected to another wifi network or on the wired network. You cannot configure the AP from the wired network even if you enter the EWC IP address when it is in day0 wizard provisioning mode

Procedure

Step 1 Log on to the controller and in the **Configuration Setup Wizard**, go to the **General Settings** page.

Step 2 In the **Configuration Mode** option, select one of the following:

a) **Non Mesh**: Complete the following fields:

1. **Host Name**: Enter the hostname.

2. **Country**: From the drop-down list, choose the appropriate country code.

   Note
   As required by the End User License Agreement, please ensure appropriate country code selection so that the unleashed network does not violate local and national regulatory restrictions. Improper country code assignment can disrupt wireless transmissions and may result in government imposed penalties and sanctions on operators of wireless networks utilizing devices set to improper country codes.

3. In the **Management User Settings** section, enter the username and password.
4. In the **Wireless Management Settings** section, check the **DHCP** check box, to display the DHCP server IP address.
5. In the **Wireless Network** section, click **Add** to create atleast one WLAN.

b) **Mesh**: Complete the following fields:

1. **Host Name**: Enter the hostname.
2. **Country**: Click the '+' icon to enter the appropriate country code.
3. In the **Management User Settings** section, enter the username and password.
4. In the **Wireless Management Settings** section, check the **DHCP** check box, to display the DHCP server IP address.
5. In the Wireless Mesh Settings section, complete the following fields:
   - Check the **Enable Wireless Bridge** check box to enable the feature.
   - In the **Mesh AP MAC Address** field, enter the MAC address or click the '+' icon select the MAC address from the list of Mesh AP MAC addresses that are displayed.
6. In the **Wireless Network** section, click **Add** to create atleast one WLAN.

Step 3 Click **Finish**.

Configuring the Controller Using Day 0 Wizard (CLI)

To configure the controller using the Day 0 wizard, follow the steps given below. The following steps are common for configuring mesh and non-mesh APs. The existing Day 0 workflow enables the configuration with the **factory-reset** command.

Before you begin

- The available options in brackets after each configuration parameter. The default value in all uppercase letters.
- If you enter an incorrect response, the controller provides you with an appropriate error message, such as an invalid response, and returns you to the wizard prompt.
- Press the **hyphen** key to return to the previous command line.

Procedure

Step 1 Enter the **wireless ewc-ap factory-reset** command to initiate the Day 0 workflow. This command reboots the device when you confirm the action.

Step 2 When the device restarts and when you are prompted with the initial configuration dialog, enter **Yes** to start the dialog.

Example:

```
Would you like to enter the initial configuration dialog? [yes/no]: Yes
```

Step 3 Enter valid inputs to the following questions that are prompted for mesh and non-mesh APs:

a) Enter the country code for the operation.

Note
Enter help to view the list of available country codes.

You can enter more than one country code if you want to manage APs in multiple countries from a single controller. To do so, separate the country codes with a comma (for example, US,CA,MX). After the configuration wizard runs, you must assign each AP joined to the controller to a specific country.

Example:

```
Configure country code(s) for wireless operation in ISO format [US]: US,CH,CN,GB
```

b) Enter the country code to configure the AP profile.

Example:

```
Configure default wireless AP profile country code in ISO format [US]:
```

c) Enter the hostname.

Example:

```
Enter the hostname [EWC]: EWC
```

d) Enter the details to configure credentials for management access on the APs.

Example:

```
Configure credentials for management access on Access Points? [yes]: yes
 [AP] Enter the management username: EWC_User
 [AP] Enter the management password: ********
 [AP] Reenter the password: ********
 [AP] Enter the privileged mode access password: ********
 [AP] Reenter the password: ********
```

e) Enter the management credentials.

Example:

```
Enter the management username: EWC_User
Enter the password: ********
Reenter the password: ********
```

f) Configure the DHCP interface.

Example:

```
Configure interface as DHCP [yes/no]? [no]: yes
```

g) Configure the wireless network settings.

Example:

```
Configure Wireless network settings? [yes]: yes
 Enter the network name or service set identifier (SSID): test
 Choose the network type
   1. Employee
   2. Guest
 Enter your selection [1]: 1
 Choose the security type
   1. WPA Personal
   2. WPA Enterprise
 Enter your selection [2]: 1
 Enter the pre-shared key: ****
```

For non-mesh APs, the configuration ends here. Save or discard the configuration.

Step 4 To configure mesh capable APs, follow the steps given below:

a) Configure mesh mode on the AP.

Example:

```
Set Internal AP in mesh mode [yes/no]? [no]: yes
```

b) Configure additional mesh access points (MAPs).

Example:

```
Configure additional MAPs [yes/no]? [no]: yes
Enter a comma separated list of max 20 Mesh AP ethernet macs (format: 'aabbccddeeff' or
 'aabb.ccdd.eeff'): aabbccddeeff, 1122.3344.5566
```

c) Enable wireless bridging.

Example:

```
Enable wireless bridging [yes/no]? [no]: yes
```

Example

The configuration for mesh APs is complete. The following configuration script is generated from the entered choices:

```
!

ap profile default-ap-profile
country US

!
hostname EWC
!
ap profile default-ap-profile
mgmtuser username EWC_User password 0 test secret 0 test

!
username EWC_User privilege 15 secret 9
$x$xxxxxxxxxx9xxxxxxxxxxjxxxxxxxxxxzxxxxxxxxxxOxxxxxxxxxxxxxxx

!
wireless management interface GigabitEthernet0
```

```
!

interface GigabitEthernet0
ip address dhcp

!
wlan test 1 test
security wpa psk set-key ascii 0 test
no security wpa akm dot1x
security wpa akm psk
no shut

!

wireless tag policy default-policy-tag
wlan test policy default-policy-profile

!
end
wireless country US
wireless country CH
wireless country CN
wireless country GB
aaa new-model
aaa authentication login default local
aaa authorization credential-download default local
username 3C5731C58478 mac


!
ap profile default-ap-profile
ssid broadcast persistent
username aabbccddeeff mac
username 112233445566 mac


wireless mesh security psk provisioning
wireless mesh security psk provisioning default_psk

!
wireless profile mesh default-mesh-profile
security psk
ethernet-bridging
ethernet-vlan-transparent
```

What to do next

Save or discard the configuration.

```
[0] Go to the IOS command prompt without saving this config.
[1] Return back to the setup without saving this config.
[2] Save this configuration to nvram and exit.

Enter your selection:

Example:
Enter your selection: 2
```

Interactive help

Interactive help is a user interface feature that

- provides step-by-step guidance within the application
- adapts instructions and walk-throughs to the user's context, and
- assists users in completing complex configurations or navigating the system.

Modes of starting the interactive Help

You can start the interactive help in the these ways.

- Hover over the blue flap at the right-hand corner of a window in the GUI and clicking **Interactive Help**.
- Click **Walk-me Thru** in the left pane of a window in the GUI.
- Click **Show me How** whenever displayed in the GUI. Clicking **Show me How** triggers a specific interactive help that is relevant to the context you are in.

  For example, **Show me How** in **Configure** > **AAA** walks you through the various steps for configuring a RADIUS server. Choose **Configuration> Wireless Setup** > **Advanced** and click **Show me How** to trigger the interactive help that walks you through the steps relating to various kinds of authentication.

Additional troubleshooting information

If the WalkMe launcher is unavailable on Safari, modify the browser settings.

1. Choose **Preferences** > **Privacy**.
2. In the **Website tracking** section, uncheck the **Prevent cross-site tracking** check box to disable this action.
3. In the **Cookies and website data** section, uncheck the **Block all cookies** check box to disable this action.

Resetting Cisco Embedded Wireless Controller on Catalyst Access Points

To reset the controller on Catalyst APs to factory defaults, follow the steps given below:

Procedure

Step 1 Unplug the Access Point from its power source.

Step 2 Plug in the console cable and open serial session on your computer or laptop.

Step 3 Press and hold the **Mode/Reset** button on the AP.

Step 4 Plug in the AP back to its power source while still pressing the **Mode/Reset** button.

Step 5 Continue holding the button until a prompt is displayed in the serial session on your computer or laptop.

Note
The console session also displays for how long the button has been pressed. At least 20 seconds of button press is required for a complete restart.

What to do next

When the AP reboots, use the default credentials **Cisco/Cisco** to log in.

Password Recovery

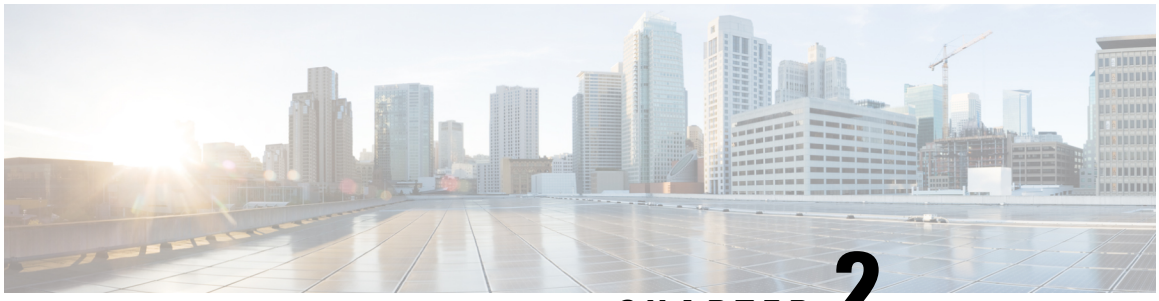
For password recovery, you must do a factory reset of the AP. For more information about resetting factory defaults, see the Resetting Cisco Embedded Wireless Controller on Catalyst Access Points section.



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System Configuration

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CHAPTER 2

System Configuration

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Information About New Configuration Model

The configuration of Cisco Embedded Wireless Controller on Catalyst Access Points is simplified using different tags, namely rf-tag, policy-tag, and site-tag. The access points would derive their configuration from the profiles that are contained within the tags.

Profiles are a collection of feature-specific attributes and parameters applied to tags. The rf-tag contains the radio profiles, the policy-tag contains the WLAN profile and policy profile, and the site-tag contains the flex profile and ap-join profile.

Policy Tag

The policy tag constitutes mapping of the WLAN profile to the policy profile. The WLAN profile defines the wireless characteristics of the WLAN. The policy profile defines the network policies and the switching policies for the client (Quality of Service [QoS] is an exception which constitutes AP policies as well).

The policy tag contains the map of WLAN policy profile. There can be a maximum of 16 such entries per policy tag. Changes to the map entries are effected based on the status of the WLAN profile and policy profile. For example, if a map (WLAN1 and Policy1) is added to the policy tag, and both the WLAN profile and the policy profile are enabled, the definitions are pushed to the APs using the policy tag. However, if one of them is in disabled state, the definition is not pushed to the AP. Similarly, if a WLAN profile is already being broadcast by an AP, it can be deleted using the no form of the command in the policy tag.

Site Tag

The site tag defines the properties of a site and contains the flex profile and the AP join profile. The attributes that are specific to the corresponding flex or remote site are part of the flex profile. Apart from the flex profile, the site tag also comprises attributes that are specific to the physical site (and hence cannot be a part of the profile that is a reusable entity). For example, the list of primary APs for efficient upgrade is a part of a site tag rather than that of a flex profile.

If a flex profile name or an AP profile name is changed in the site tag, the AP is forced to rejoin the controller by disconnecting the Datagram Transport Layer Security (DTLS) session. When a site tag is created, the AP and flex profiles are set to default values (default-ap-profile and default-flex-profile).

RF Tag

The RF tag contains the 2.4 GHz and 5 GHz RF profiles. The default RF tag contains the global configuration. Both these profiles contain the same default values for global RF profiles for the respective radios.

Profiles

Profiles are a collection of feature-specific attributes and parameters applied to tags. Profiles are reusable entities that can be used across tags. Profiles (used by tags) define the properties of the APs or its associated clients.

WLAN Profile

WLAN profiles are configured with same or different service set identifiers (SSIDs). An SSID identifies the specific wireless network for the controller to access. Creating WLANs with the same SSID allows to assign different Layer 2 security policies within the same wireless LAN.

To distinguish WLANs having the same SSID, create a unique profile name for each WLAN. WLANs with the same SSID must have unique Layer 2 security policies so that clients can select a WLAN based on the information advertised in the beacon and probe responses. The switching and network policies are not part of the WLAN definition.

Policy Profile

Policy profile broadly consists of network and switching policies. Policy profile is a reusable entity across tags. Anything that is a policy for a client that is applied on an AP or controller is moved to the policy profile, for example, VLAN, ACL, QoS, session timeout, idle timeout, AVC profile, bonjour profile, local profiling, device classification, BSSID QoS, and so on. However, all the wireless-related security attributes and features on the WLAN are grouped under the WLAN profile.

Flex Profile

Flex profile contains policy attributes and remote site-specific parameters. For example, the EAP profiles that can be used when the AP acts as an authentication server for local RADIUS server information, VLAN-ACL mapping, VLAN name-to-ID mapping, and so on.

AP Join Profile

The default AP join profile values will have the global AP parameters and the AP group parameters. The AP join profile contains attributes that are specific to AP, such as CAPWAP, IPv4 and IPv6, UDP Lite, High Availability, Retransmit config parameters, Global AP failover, Hyperlocation config parameters, Telnet and SSH, 11u parameters, and so on.



Note Telnet is not supported for the following Cisco AP models: 1542D, 1542I, 1562D, 1562E, 1562I, 1562PS, 1800S, 1800T, 1810T, 1810W,1815M, 1815STAR, 1815TSN, 1815T, 1815W, 1832I, 1840I, 1852E, 1852I, 2802E, 2802I, 2802H, 3700C, 3800, 3802E, 3802I, 3802P, 4800, IW6300, ESW6300, 9105AXI, 9105AXW, 9115AXI, 9115AXE, 9117I, APVIRTUAL, 9120AXI, 9120AXE, 9124AXI, 9124AXD, 9130AXI, 9130AXE, 9136AXI, 9162I, 9164I, and 9166I.

RF Profile

RF profile contains the common radio configuration for the APs. RF profiles are applied to all the APs that belong to an AP group, where all the APs in that group have the same profile settings.

Association of APs

APs can be associated using different ways. The default option is by using Ethernet MAC address, where the MAC is associated with policy-tag, site tag, and RF tag.

In filter-based association, APs are mapped using regular expressions. A regular expression (regex) is a pattern to match against an input string. Any number of APs matching that regex will have policy-tag, site tag, and RF tag mapped to them, which is created as part of the AP filter.

In AP-based association, tag names are configured at the PnP server and the AP stores them and sends the tag name as part of discovery process.

In location-based association, tags are mapped as per location and are pushed to any AP Ethernet MAC address mapped to that location.

Modifying AP Tags

Modifying an AP tag results in DTLS connection reset, forcing the AP to rejoin the controller. If only one tag is specified in the configuration, default tags are used for other types, for example, if only policy tag is specified, the default-site-tag and default-rf-tag will be used for site tag and RF tag.

Configure a wireless profile policy (GUI)

Define and apply a wireless profile policy to manage network behavior and access for wireless clients.

Use this task to create or modify a policy profile, ensuring wireless network policies suit your organization's needs.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 On the **Policy Profile** page, click **Add**.

Step 3 In the **Add Policy Profile** window, in **General** tab, enter a name and description for the policy profile. The name can be ASCII characters from 32 to 126, without leading and trailing spaces. Do not use spaces as it causes system instability.

Step 4 To enable the policy profile, set **Status** as **Enabled**.

Step 5 In the WLAN Switching Policy section, choose the following, as required:

- No Central Switching: Tunnels both the wireless user traffic and all control traffic via CAPWAP to the centralized controller where the user traffic is mapped to a dynamic interface/VLAN on the controller. This is the normal CAPWAP mode of operation.
- Central Authentication: Tunnels client data to the controller, as the controller handles client authentication.
- No Central DHCP: The DHCP packets received from AP are centrally switched to the controller and then forwarded to the corresponding VLAN based on the AP and the SSID.
- Central Association Enable: When central association is enabled, all switching is done on the controller.
- Flex NAT/PAT: Enables Network Address Translation(NAT) and Port Address Translation (PAT) mode.

Step 6 Click **Save & Apply to Device**.

The wireless profile policy is successfully created and applied. Devices use the updated policy settings for wireless client management.

Configure a wireless policy profile (CLI)

Define and apply a wireless policy profile on your device using command-line interface commands.

Use this task to configure wireless profile policies on Cisco wireless controllers. Policy profiles specify settings such as VLAN mapping, idle timeouts, and accounting lists for wireless networks.



Note When a client moves from an old controller to a new controller (managed by Cisco Prime Infrastructure), the old IP address of the client is retained, if the IP address is learned by ARP or data gleaning. To avoid this scenario, ensure that you enable **ipv4 dhcp required** command in the policy profile. Otherwise, the IP address gets refreshed only after a period of 24 hours.

Follow the procedure given to configure a wireless profile policy:

Before you begin

- Ensure you have administrator privileges to access and configure the device.
- Have the required VLAN ID, idle timeout value, and accounting list details available, if applicable.

Follow these steps to configure a wireless profile policy:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN policy profile and enters wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy rr-xyz-policy-1
```

Step 3 (Optional) Configure the duration of idle timeout in seconds.

Example:

```
Device(config-wireless-policy)# idle-timeout 1000
```

Step 4 Configure the VLAN name or VLAN ID.

Example:

```
Device(config-wireless-policy)# vlan 24
```

Step 5 Save the configuration, exit configuration mode, and return to privileged EXEC mode.

Example:

```
Device(config-wireless-policy)# no shutdown
```

Step 6 (Optional) View detailed information about a policy profile, using the **show wireless profile policy detailed** *policy-profile-name* command.

Example:

```
Device# show wireless profile policy summary
```

The wireless policy profile is configured and enabled on the device. All specified settings are applied to the selected policy.

What to do next

- Associate the policy profile with a WLAN as needed.
- Review and validate the applied settings by connecting a client device and confirming expected behavior.

Configure a flex profile

Create or modify a flex profile to customize wireless network behavior for specific sites or device groups.

Use flex profiles within your network management system to define site-specific configurations such as VLANs, SSIDs, or access policies.

Before you begin

Identify the devices or sites to apply the flex profile.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a flex profile and enter flex profile configuration mode.

Example:

```
Device(config)# wireless profile flex rr-xyz-flex-profile
```

Step 3 (Optional) Enable default parameters for the flex profile.

Example:

```
Device(config-wireless-flex-profile)# description xyz-default-flex-profile
```

Step 4 (Optional) Enable ARP caching.

Example:

```
Device(config-wireless-flex-profile)# arp-caching
```

Step 5 Save the configuration, exit configuration mode, and return to privileged EXEC mode.

Example:

```
Device(config-wireless-flex-profile)# end
```

Step 6 (Optional) View detailed parameters about the flex profile, use the **show wireless profile flex detailed** *flex-profile-name* command.

Example:

```
Device# show wireless profile flex summary
```

The flex profile is created or updated and available for assignment to devices or sites.

What to do next

Assign the flex profile to the relevant site, device, or group as needed.

Configure an AP profile (GUI)

Configure and customize AP join profiles for your wireless deployment.

Use this task to define, modify, or apply AP profile parameters such as country code, LED state, timers, VLAN tagging, security settings, management options, and advanced features, using the device's graphical interface.

Before you begin

- Review the default AP join profile to update parameters for your environment (For example, Control and Provisioning of Wireless Access Points (CAPWAP), IPv4 or IPv6, UDP Lite, High Availability, retransmit configuration parameters, global AP failover, Hyperlocation configuration parameters, Telnet or SSH, 11u parameters, and so on.)
- Obtain required information, such as network-specific settings, controller addresses, credentials, and profile names.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **AP Join**.

Step 2 On the **AP Join Profile** window, click **Add** .

The **Add AP Join Profile** window is displayed.

Step 3 In the **General** tab, enter a name and description for the AP join profile.

Step 4 Check the **LED State** check box to set the LED state of all APs connected to the device to blink, making them easier to locate.

Step 5 In the **Client** tab and **Statistics Timer** section, enter the time in seconds that the AP sends its 802.11 statistics to the controller.

Step 6 In the **TCP MSS Configuration** section, check the **Adjust MSS Enable** check box to enter value for Adjust MSS. You can enter or update the maximum segment size (MSS) for transient packets that traverse a router. TCP MSS adjustment enables the configuration of the maximum segment size (MSS) for transient packets that traverse a router, specifically TCP segments with the SYN bit set.

In a CAPWAP environment, a lightweight AP discovers a device by using CAPWAP discovery mechanisms, and then sends a CAPWAP join request to the device. The device sends a CAPWAP join response to the AP that allows the AP to join the device.

When the AP joins the device, the device manages its configuration, firmware, control transactions, and data transactions.

Step 7 In the **AP** tab, you can configure various options:

- General

a) In the **General** tab, check the **Switch Flag** check box to enable switches.
b) Check the **Power Injector State** check box if power injector is being used. Use power injectors to provide flexible powering options for APs, such as local power, multiport switches with inline power, or multiport power patch panels.
c) From the **Power Injector Type** drop-down list, choose power injector type from the following options:

- Installed: If you want the AP to examine and remember the MAC address of the currently connected switch port. (This selection assumes that a power injector is connected.)
- Override: To enable the AP to operate in high-power mode without first verifying a matching MAC address.

d) In the **Injector Switch MAC** field, enter the MAC address of the switch.
e) From the **EAP Type** drop-down list, choose the EAP type as *EAP-FAST* , *EAP-TLS* , or *EAP-PEAP* .

f) From the **AP Authorization Type** drop-down list, choose the type as either *CAPWAP DTLS +* or *CAPWAP DTLS* .
g) In the **Client Statistics Reporting Interval** section, enter the interval for 5 GHz and 2.4 GHz radios in seconds.
h) Check the **Enable** check box to enable extended module.
i) From the **Profile Name** drop-down list, choose a profile name .
j) Click **Save & Apply to Device** .

- Hyperlocation: Cisco Hyperlocation is a location solution that allows to track the location of wireless clients with the accuracy of one meter. Selecting this option disables all other fields in the screen except for NTP Server.

a) In the **Hyperlocation** tab, check the **Enable Hyperlocation** check box.
b) Enter the **Detection Threshold** value to filter out packets with low RSSI. The valid range is –100 dBm to –50 dBm.
c) Enter the **Trigger Threshold** value to set the number of scan cycles before sending a BAR to clients. The valid range is 0 to 99.
d) Enter the **Reset Threshold** value to reset value in scan cycles after trigger. The valid range is 0 to 99.
e) Enter the **NTP Server** IP address.
f) Click **Save & Apply to Device** .

- BLE: If your APs are Bluetooth Low Energy (BLE) enabled, they can transmit beacon messages that are packets of data or attributes transmitted over a low-energy link. These BLE beacons are used for health monitoring, proximity detection, asset tracking, and in-store navigation. You can customize BLE beacon settings for each AP, even if they are configured globally.

a) In the **BLE** tab, enter a value in the **Beacon Interval** field to indicate how often you want your APs to send out beacon advertisements to nearby devices. The range is from one to 10, with a default value of one.
b) In the **Advertised Attenuation Level** field, enter the attenuation level. The range is from 40 to 100, with a default of 59.
c) Click **Save & Apply to Device**.

Step 8 In the **Management** tab, you can configure the following:

- Device

a) In the **Device** tab, enter the **IPv4/IPv6 Address** of the TFTP server, **TFTP Downgrade** section.
b) In the **Image File Name** field, enter the name of the software image file.
c) From the **Facility Value** drop-down list, choose the appropriate facility.
d) Enter the IPv4 or IPv6 address of the host.
e) Choose the appropriate **Log Trap Value**.
f) Enable Telnet, SSH or both configurations, if required.
g) Enable core dump, if required.
h) Click **Save & Apply to Device**.

- User

a) In the **User** tab, enter username and password details.
b) Choose the appropriate password type.
c) In the **Secret** field, enter a custom secret code.

d) Choose the appropriate secret type.
e) Choose the appropriate encryption type.
f) Click **Save & Apply to Device**.

- Credentials

a) In the **Credentials** tab, enter local username and password details.
b) Choose the appropriate local password type.
c) Enter 802.1x username and password details.
d) Choose the appropriate 802.1x password type.
e) Enter the time in seconds after which the session should expire.
f) Enable local credentials, 802.1x credentials, or both as required.
g) Click **Save & Apply to Device**.

a) In the **CDP Interface** tab, enable the CDP state, if required.
b) Click **Save & Apply to Device**.

Step 9 In the **Rogue AP** tab, check the **Rogue Detection** check box to enable rogue detection.

Step 10 In the **Rogue Detection Minimum RSSI** field, enter the RSSI value.

This field specifies the minimum RSSI value for which a Rogue AP should be reported. All Rogue APs with RSSI lower than what is configured will not be reported to controller.

Step 11 In the **Rogue Detection Transient Interval** field, enter the transient interval value.

This field indicates how long the Rogue AP should be seen before reporting the controller.

Step 12 In the **Rogue Detection Report Interval** field, enter the report interval value.

This field indicates the frequency (in seconds) of Rogue reports sent from AP to controller.

Step 13 Check the **Rogue Containment Automatic Rate Selection** check box to enable rogue containment automatic rate selection.

The AP selects the best rate for the target Rogue, based on its RSSI.

Step 14 Check the **Auto Containment on FlexConnect Standalone** check box to enable the feature.

The AP continues containment if it moves to FlexConnect standalone mode.

Step 15 Click **Save & Apply to Device**.

The AP join profile is created or updated. Devices assigned to this profile use its configuration for network operation and management.

What to do next

- Verify that APs have successfully joined and received the new settings by reviewing AP status.
- Adjust profile settings as necessary for site-specific needs or to resolve configuration issues.

Configure an AP profile (CLI)

Set up and customize an AP profile using CLI commands to apply network-wide AP configurations.

Use this procedure when you need to define or modify an AP profile for your wireless controller, typically to standardize AP settings or apply feature-specific options.

Before you begin

Identify the name and required settings for your AP profile.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an AP profile and enter AP profile configuration mode.

Example:

```
Device(config)# ap profile xyz-ap-profile
```

Note

- In an AP profile, the **EAP-FAST** is the default EAP type.
- When you delete a named profile, the APs associated with that profile does not revert to the default profile.

Step 3 Add a description for the AP profile.

Example:

```
Device(config-ap-profile)# description "xyz ap profile"
```

Step 4 Enable CDP for all Cisco APs.

Example:

```
Device(config-ap-profile)# cdp
```

Step 5 Save the configuration, exit configuration mode, and return to privileged EXEC mode.

Example:

```
Device(config-ap-profile)# end
```

Step 6 (Optional) Display detailed information about an AP join profile.

Example:

```
Device# show ap profile name xyz-ap-profile detailed
```

The AP profile is created or updated with specified settings, and changes are active on the controller.

What to do next

Assign APs to the new profile as required, and verify AP behavior matches the intended configuration.

Configure an RF profile (GUI)

Create and enable an RF profile to optimize radio frequency settings for your wireless network.

Use this task to define an RF profile that sets parameters for radio bands and device operation. This ensures consistent performance across your wireless deployment.

Before you begin

Use the same RF profile name when configuring the wireless RF tag. If the RF tag contains an RF profile that does not exist, the radios do not operate.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **RF**.

Step 2 On the **RF Profile** window, click **Add**.

Step 3 In the **General** tab, enter a name for the RF profile. The name can be ASCII characters from 32 to 126, without leading and trailing spaces.

Step 4 Choose the appropriate **Radio Band**.

Step 5 To enable the profile, set the status as **Enable**.

Step 6 Enter a **Description** for the RF profile.

Step 7 Click **Save & Apply to Device**.

The new RF profile is created, enabled, and applied to the device.

What to do next

- Verify that the RF profile settings are visible and active on your device.
- Assign the profile to RF tags or APs, if required, to complete your configuration.

Configure an RF profile (CLI)

Create and enable an RF profile to optimize radio frequency settings for your wireless network.

Use this task to define an RF profile that sets parameters for radio bands and device operation. This ensures consistent performance across your wireless deployment.

Before you begin

Use the same RF profile name when configuring the wireless RF tag. If the RF tag contains an RF profile that does not exist, the radios do not operate.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an RF profile, and enter RF profile configuration mode.

Example:

```
Device(config)# ap dot11 24ghz rf-profile rfprof24_1
```

Note
Use the **24ghz** command to configure the 802.11b parameters. Use the **5ghz** command to configure the 802.11a parameters.

Step 3 (Optional) Enable default parameters for the RF profile.

Example:

```
Device(config-rf-profile)# default
```

Step 4 Enable the RF profile on the device.

Example:

```
Device(config-rf-profile)# no shutdown
```

Step 5 Exit configuration mode and return to privileged EXEC mode.

Example:

```
Device(config-rf-profile)# end
```

Step 6 (Optional) Display a summary of available RF profiles.

Example:

```
Device# show ap rf-profile summary
```

Step 7 (Optional) Display detailed information about a particular RF profile.

Example:

```
Device# show ap rf-profile name rfprof24_1 detail
```

You have created and enabled a new RF profile, and applied it to the device.

What to do next

- Verify that the RF profile settings are visible and active on your device.
- Assign the profile to RF tags or APs as required to complete your configuration.

Enhanced Site Tag-Based Load Balancing

Feature History for Enhanced Site Tag-Based Load Balancing

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

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 1: Feature History for Enhanced Site Tag-Based Load Balancing

Release	Feature	Feature Information
Cisco IOS XE Dublin 17.10.1	Enhanced Site Tag-Based Load Balancing	The Site Tag-based load balancing is available from Cisco IOS-XE Gibraltar 16.10.1 release. When the first AP from a site joins the controller, it takes the decision to load balance the entire site. However, this is done without knowing the site load. The enhancement to load balancing feature introduced in Cisco IOS-XE 17.10.1 specifies a site load to help with better load balancing.

Enhanced site tag-based load balancing

A site tag-based load balancing is a controller mechanism that

- distributes APs across Wireless Network Control Daemon (WNCD) processes based on site tags,
- allows configuration of a site load for each site tag to optimize AP assignment considering site size, and
- automatically retains site tags in persistent memory and balances them during controller bootup in descending order of the configured site load.

The controller takes the load balancing decision for a site tag when the first AP from that site tag joins.

Table 2: Feature History

Feature	Release	Feature Information
Enhanced Site Tag-Based Load Balancing	Cisco IOS XE Dublin 17.10.1	When the first AP from a site joins the controller, it takes the decision to load balance the entire site. However, this is done without knowing the site load.

How controllers functioned before load balancing

Previously, controllers did not consider the actual size of sites when making load balancing decisions. The system functioned optimally only when all sites were of approximately equal size. Unequal distribution caused some WNCDs to be overloaded while others remained underused.

The enhanced feature enables administrators to specify a site load for each site tag, ensuring the controller takes site size into account when distributing APs and thus resulting in improved load distribution among WNCDs.

Behavior during controller reboot

- After you configure site load balancing in one or more site tags and reboot the controller, The feature retains actively used site tags and balances them at bootup by prioritizing those with higher configured site load before any APs join.
- If load balancing is configured for a site tag with APs already joined, load balancing assignments remain unchanged unless all APs, including those not in the site tag, disconnect or the controller is rebooted.

assigning a higher site load to one site over the other

Suppose Site Tag X is assigned a higher site load than Site Tag Y. Upon controller bootup, APs from Site Tag X are distributed among WNCDs before those from Site Tag Y, helping prevent excessive load on any single WNCD even if Site Tag X contains many more APs than Site Tag Y.

Analogy: assigning classes to school buses

Think of enhanced site tag-based load balancing like assigning students from different-sized classes (site tags) to school buses (WNCDs). If you ignore class size, you might put all students from the largest class on a single bus, overloading it while leaving other buses half empty. By taking class sizes into account when assigning students, you distribute them more evenly and efficiently among the buses, preventing overcrowding and making better use of all resources. Similarly, by setting site load values, the controller assigns APs more fairly to WNCDs, balancing the work and avoiding overload.

Prerequisites for Enhanced Site Tag-Based Load Balancing

- Ensure that you configure the site load.
- We recommended that you configure all the named sites with a load value.



Note The configured load is only an estimate. It will only be used for site load balancing. Specifically, it does not prevent APs, or clients from joining or associating.

Use cases

The site load configuration uses a load factor instead of an absolute number to address different use cases. Although the load factor does not have to match the number of APs in a site, using the AP count often provides a practical approximation of the site load.

Here are the use cases:

- Sites with normal client density and roaming load can use AP count as a good approximation of site load. Examples include cubicle areas in offices and hospitals.

- For sites with high client density and roaming load, configure a load factor greater than the number of APs. For example, when a site has 200 APs, use a load factor of 300 or 400 to accommodate the increased client load. Examples include stadiums, cafeterias, and conference floors.

Configure site load (CLI)

Assign a relative load value to a site tag using CLI. This helps the system optimize resource allocation and network performance for wireless deployments.

Use this task when you need to set or adjust the load recommendation for a specific site on your wireless controller. The load value influences how resources are distributed across sites.

Before you begin

Identify the name of the site tag you want to configure.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure site tag and enter site tag configuration mode.

Example:

```
Device(config)# wireless tag site area1
```

Step 3 Configure the site load.

Example:

```
Device(config-site-tag)# load 200
```

The *load* is the estimate of the relative load reserved for the site. Values range between zero to 1000. The default value zero means no load recommendation for the site.

Step 4 Return to privileged EXEC mode.

Example:

```
Device(config-site-tag)# end
```

The controller uses the configured load value for the specified site tag to optimize network resource allocation for that site

What to do next

Optionally, verify your changes by displaying the site tag configuration and confirming the new load value.

Verify enhanced site tag-based load balancing configuration

To view detailed information about a site, use the command:

```
Device# show wireless tag site detailed area1
Site Tag Name        : area1
Description          :
-------------------------------------
AP Profile           : default-ap-profile
Local-site           : Yes
Image Download Profile: default
Fabric AP DHCP Broadcast : Disabled
Fabric Multicast Group IPv4 Address : 239.1.1.1
Site Load            : 200
```

To view the default site tag type for Wireless Network Controller daemon (WNCD) instances, use the command:

```
Device# show wireless loadbalance tag affinity
Tag           Tag type    No of AP's Joined   Wncd Instance
-----------------------------------------------------------------------
area1         SITE TAG                  50         0
area2         SITE TAG                  50         0
area3         SITE TAG                  100        1
area4         SITE TAG                  150        2
```

Configure policy tag (GUI)

Create and apply a policy tag to group wireless local area network (WLAN) and policy profiles for your network configuration.

Use this task when you need to define or update policy tags for your wireless network devices using the GUI.

Before you begin

- Prepare unique names for policy tags using ASCII characters (32 to 126, no leading or trailing spaces).
- Identify the WLAN and policy profiles you plan to map.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags** > **Policy**.

Step 2 Click **Add** to view the **Add Policy Tag** window.

Step 3 Enter a name and description for the policy tag. You can use ASCII characters from 32 to 126, but do not include any leading or trailing spaces.

Step 4 Click **Add** to map WLAN and policy.

Step 5 Choose the WLAN profile to map with the appropriate policy profile, and click the tick icon.

Step 6 Click **Save & Apply to Device**.

Your device has the new policy tag applied. The mapped WLAN and policy profiles are now active based on your configuration.

What to do next

Verify that connected devices use the updated policy tag and that expected network policies are enforced.

Configure a policy tag (CLI)

Create and apply a policy tag to group wireless local area network (WLAN) and policy profiles for your network configuration.

Use this task when you need to define or update policy tags for your wireless network devices using the CLI.

Before you begin

- Prepare unique names for policy tags using ASCII characters (32 to 126, no leading or trailing spaces).
- Identify the WLAN and policy profiles you plan to map.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure policy tag and enter policy tag configuration mode.

Example:

```
Device(config-policy-tag)# wireless tag policy default-policy-tag
```

Note
When performing local web authentication, the clients connected to a controller get disconnected intermittently before session timeout.

Step 3 Add a description to a policy tag.

Example:

```
Device(config-policy-tag)# description "default-policy-tag"
```

Step 4 Map a remote-LAN profile to a policy profile.

Example:

```
Device(config-policy-tag)# remote-lan remote-lan-name policy profile-policy-name port-id
port-id-number
```

Step 5 Map a policy profile to a WLAN profile.

Example:

```
Device(config-policy-tag)# wlan wlan-name policy profile-policy-name
```

Step 6 Exit policy tag configuration mode, and return to privileged EXEC mode.

Example:

```
Device(config-policy-tag)# end
```

Step 7 (Optional) Display the configured policy tags.

Example:

```
Device# show wireless tag policy summary
```

Note
To view detailed information about a policy tag, use the **show wireless tag policy detailed** *policy-tag-name* command.

Your device has the new policy tag applied. The mapped WLAN and policy profiles are now active based on your configuration.

What to do next

Verify that connected devices use the updated policy tag and the expected network policies are applied.

Configure wireless RF tag (GUI)

Create and apply an RF tag that defines radio frequency profiles for device groups.

Procedure

Step 1 a) Choose **Configuration** > **Tags & Profiles** > **Tags** > **RF**.

Step 2 Click **Add** to view the **Add RF Tag** window.

Step 3 Enter a name and description for the RF tag. The name can be ASCII characters from 32 to 126 and must not include leading or trailing spaces.

Step 4 Choose the required **5 GHz Band RF Profile**, **5 GHz Band RF Profile**, and **2.4 GHz Band RF Profile** to be associated with the RF tag.

Step 5 Click **Update & Apply to Device**.

The RF tag is created with the specified RF profiles and applied to the device.

Configure wireless RF tag (CLI)

Assign and configure an radio frequency (RF) tag on your wireless device using the CLI, to manage radio profile settings per tag.

Perform this task to create or modify a wireless RF tag. This allows you to apply specific 2.4 GHz, 5 GHz, or 6 GHz RF profiles to associated APs.

Before you begin

- You can use only two profiles (2.4-GHz and 5-GHz band RF profiles) in an RF tag.
- Ensure you use the same AP tag name you created during the AP configuration task.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create an RF tag to enter wireless RF tag configuration mode.

Example:

```
Device(config)# wireless tag rf rftag1
```

Step 3 Attach an IEEE 802.11b RF policy to the RF tag.

Example:

```
Device(config-wireless-rf-tag)# 24ghz-rf-policy rfprof24_1
```

To configure a dot11a policy, use the **5ghz-rf-policy** command.

Step 4 Add a description for the RF tag.

Example:

```
Device(config-wireless-rf-tag)# description Test
```

Step 5 Exit configuration mode to return to privileged EXEC mode.

Example:

```
Device(config-wireless-rf-tag)# end
```

Step 6 Display the available RF tags.

Example:

```
Device# show wireless tag rf summary
```

Step 7 Display detailed information of a particular RF tag.

Example:

```
Device# show wireless tag rf detailed rftag1
```

You have configured the RF tag and it is now available for assignment.

What to do next

Assign the RF tag to the appropriate AP tag or APs if you have not already done so.

Attach a policy tag and site tag to an AP (GUI)

Assign a policy tag and site tag to an AP using the GUI.

Use this procedure to associate specific network policies and locations with an AP in your Cisco wireless deployment.

Before you begin

Make sure you have the wired MAC address of the AP.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

The **All Access Points** section displays details of all the APs on your network.

Step 2 To edit the configuration details of an AP, select the row for that AP.

The **Edit AP** window is displayed.

Step 3 In the **General** tab and **Tags** section, specify the appropriate policy, site, and RF tags that you created on the **Configuration** > **Tags & Profiles** > **Tags** window.

Step 4 Click **Update & Apply to Device**.

The AP is now associated with the specified policy, site, and optionally RF tags you selected.

Attach policy tag and site tag to an AP (CLI)

Assign a policy tag and site tag to an AP using the CLI.

Use this procedure to associate specific network policies and locations with an AP in your Cisco wireless deployment.

Before you begin

Make sure you have the wired MAC address of the AP.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a Cisco AP and enters AP profile configuration mode.

Example:

```
Device(config)# ap F866.F267.7DFB
```

Note
The *mac-address* should be a wired mac address.

Step 3 Map a policy tag to the AP.

Example:

```
Device(config-ap-tag)# policy-tag rr-xyz-policy-tag
```

Step 4 Map a site tag to the AP.

Example:

```
Device(config-ap-tag)# site-tag rr-xyz-site
```

Step 5 Associate the RF tag.

Example:

Step 6 Save the configuration, exit configuration mode, and return to privileged EXEC mode.

Example:

```
Device(config-ap-tag)# end
```

Step 7 (Optional) Display AP details and the tags associated to it.

Example:

```
Device# show ap tag summary
```

Step 8 Display the AP name with tag information.

Example:

```
Device# show ap name "ap-name" tag info
```

Step 9 (Optional) Display the AP name with tag details.

Example:

```
Device# show ap name ap-name tag detail
```

The AP is now associated with the specified policy, site, and optionally, RF tags you selected

Time Management

The date and time of the system on EWC is configured when you run the initial wireless express setup wizard. You can change or configure the time from the GUI menu by choosing **Administration** > **Time**.

You can configure a Network Time Protocol (NTP) server to synchronize date and time, if it was not configured during the wireless express setup. Greenwich Mean Time (GMT) is used as the standard for setting the time zone on the controller. You can also update or add the specific NTP server to EWC.

Note EWC APs do not track time when powered off. Therefore, we recommned you to configure NTP to keep a proper time across reboots on the EWC.

AP Filter

AP filters

An AP filter is a global tagging mechanism that

- associates APs with specific tag sources based on defined filter criteria
- organizes and applies tag sources in priority order according to configuration, and
- enables flexible control over which tags are assigned to each AP throughout the device discovery and onboarding process.

Additional reference information

AP filters function similarly to access control lists (ACLs) on the controller and operate at the global level. You can create AP filters based on AP names or other attributes, and incorporate filter criteria into discovery requests. Tag sources for APs can originate from static configuration, the AP filter engine, per-AP Plug and Play (PnP), or default configuration. The AP filter feature determines tag precedence, ensuring the correct tags are assigned according to organizational policies.

You cannot disable the AP filter feature. However, you can configure the priority of tag sources using the **ap filter-priority <priority> <filter-name>** command.

You can specify tag names at the PnP server (similarly to Flex groups or AP groups). During AP discovery and join requests, the AP stores and sends the allocated tag name as part of the request, allowing for automated and dynamic tag assignment.

Analogy: ticket sorting gate

An AP filter is like a ticket sorting gate at an event venue. Each attendee (AP) presents information at the entrance, and the sorting gate (filter) checks their details to assign them to the right group or area (tag source) based on predefined criteria and priorities. Just as event organizers use sorting gates to efficiently direct attendees, network administrators use AP filters to efficiently assign tags and manage APs in large wireless environments.

Set tag priority (GUI)

Set the order of priority for tag sources in AP configuration using the GUI

Use this task whenever you want to control which tag source is applied first to your AP configurations in the system. This helps ensure the desired tag assignment behavior.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags** > **AP** > **Tag Source**.

Step 2 Drag and drop the tag sources to change priorities.

The system saves and applies the new tag source priority for AP configuration.

Set tag priority

Resolve ambiguity in tag assignment by defining the priority of tag sources for access points.

-

When an AP joins the wireless controller, it picks up tags from multiple sources. Setting tag source priorities ensures APs use tags from the preferred source. If you do not configure precedence, default priorities are used.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 (Optional) Configure AP tag source priority. Default priorities for Static, Filter, and PnP.

Example:

```
Device(config)# ap tag-source-priority 2 source pnp
```

Step 3 Exit configuration mode and return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Step 4 Revalidate AP tag sources. The priorities become active only after this command is run.

Example:

```
Device# ap tag-sources revalidate
```

Note
If you change the priorities for Filter and PnP, and need to verify the changes, run the **revalidate** command.

The controller applies the new tag source priorities, and APs assign tags based on your configured precedence.

Create an AP filter (GUI)

Define an AP filter to automatically apply tags to APs that match specific naming patterns.

Use this task to organize and manage access points by creating filter rules based on AP names and assigning tags for policy, site, or RF profiles.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags** > **AP** > **Filter** .

Step 2 Click **Add** .

Step 3 In the **Associate Tags to AP** dialog box that is displayed, enter the **Rule Name** , the **AP name regex** , and the **Priority** .

Step 4 (Optional) You can also choose the policy tag from the **Policy Tag Name** drop-down list, the site tag from the **Site Tag Name** drop-down list and the RF tag from the **RF Tag Name** drop-down list.

Step 5 Click **Apply to Device** .

The AP filter is created. Any AP that matches the specified pattern is automatically assigned the designated tags.

Create an AP filter (CLI)

Configure an AP filter using the CLI to apply specific policy, RF, and site tags to APs matching a name pattern.

- Identify the regular expression pattern for the AP names you want to filter.
- Determine the appropriate policy, RF, and site tag names to use.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an AP filter.

Example:

```
Device(config)# ap filter filter-1
```

Step 3 Configure the AP filter based on regular expression.

Example:

```
Device(config-ap-filter)# ap name-regex testany
```

For example, if you have named an AP as **ap-lab-12**, then you can configure the filter with a regular expression, such as **ap-lab-\d+** , to match the AP name.

Step 4 Configure a policy tag for this filter.

Example:

```
Device(config-ap-filter)# tag policy pol-tag1
```

Step 5 Configure an RF tag for this filter.

Example:

```
Device(config-ap-filter)# tag rf rf-tag1
```

Step 6 Configure a site tag for this filter.

Example:

```
Device(config-ap-filter)# tag site site1
```

Step 7 Exit configuration mode to return to privileged EXEC mode.

Example:

```
Device(config-ap-filter)# end
```

The AP filter is configured with the specified criteria and tag associations. APs with names matching your pattern will have the corresponding tags applied.

Configure filter priority (GUI)

Configure and manage the priority of AP filters to control tag associations on APs.

Perform this task when you need to add a new AP filter or change the priority of an existing AP filter using the GUI.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags** > **AP** > **Filter**.

Step 2 Choose:

a) To set up a new AP filter, click **Add**. In the **Associate Tags to AP** dialog box that is displayed, enter the **Rule Name**, the **AP name regex** and the **Priority**. Optionally, you can also select the **Policy Tag Name**, the **Site Tag Name** and the **RF Tag Name**. Click **Apply to Device**.

b) To update the priority of an existing AP filter, click on the filter and in the **Edit Tags** dialog box and change the **Priority**. In case the filter is inactive, you cannot configure a priority. Click **Update and Apply to Device**.

The AP filter priority is configured or updated and applied to the specified devices.

Configure filter priority (CLI)

Configure and manage the priority of AP filters to control tag associations on APs.

Perform this task when you need to add a new AP filter or change the priority of an existing AP filter using the GUI.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure AP filter priority. Valid values range from zero to 1023. The value zero represents the highest priority.

Example:

```
Device(config)# ap filter priority 10 filter-name test1
```

This step is necessary to activate the filter.

Step 3 Exit configuration mode and return to privileged EXEC mode.

Example:

```
Device(config-ap)# end
```

The AP filter priority is configured or updated and applied to the specified devices.

Verify AP filter configuration

These **show** commands are used to display tag sources and filters, and their priorities.

To view the tag source priorities, use the command:

```
Device# show ap tag sources

Priority Tag source
--------------------------------
0 Static
1 Filter
2 AP
3 Default
```

To view the available filters, use the command:

```
Device# show ap filter all

Filter Name             regex             Policy Tag               RF Tag              Site
 Tag
-------------------------------------------------------------------------------------------------
first                    abcd              pol-tag1                 rf-tag1
site-tag1
test1                   testany                                                        site1

filter1                  testany
```

To view the list of active filters, use the command:

```
Device# show ap filters active

Priority   Filter Name       regex          Policy Tag              RF Tag
Site Tag
-------------------------------------------------------------------------------------------------------------------
10         test1             testany
site1
```

To view the source of an AP tag, use the command:

```
Device# show ap tag summary

Number of APs: 4

AP Name          AP Mac         Site Tag Name    Policy Tag Name    RF Tag Name
Misconfigured Tag Source
-------------------------------------------------------------------------------------------------------------------
AP002A.1034.CA78 002a.1034.ca78 named-site-tag   named-policy-tag   named-rf-tag   No Filter

AP00A2.891C.2480 00a2.891c.2480 named-site-tag   named-policy-tag   named-rf-tag   No Filter
```

```
AP58AC.78DE.9946 58ac.78de.9946 default-site-tag default-policy-tag default-rf-tag No AP
AP0081.C4F4.1F34 0081.c4f4.1f34 default-site-tag default-policy-tag default-rf-tag No Default
```

Configuring Access Point for Location Configuration

Location configuration

This feature works in conjunction with the existing tag resolution scheme. The location is considered as a new tag source to the existing system.

A location is a network entity that

- represents a site or physical area where one or more APs are deployed
- associates a specific set of tags—policy, RF, and site tags—with those APs, and
- links each tag set to a collection of Ethernet MAC addresses corresponding to APs at that location.

Location features and usage

Locations serve as a new tag source within the tag resolution scheme, functioning similarly to static tag sources. During location configuration, you can

- configure a site or location for an AP
- assign a set of tags for the location, and
- add APs to the location.

The combination of unique tags and associated MAC addresses distinguishes each location and enables organized network management.

Restriction for location configuration

If you configure an AP in one location, you cannot configure the same AP in another location.

Configure a location for an AP (GUI)

Create and classify a new location for an AP. Apply the appropriate type and client density settings.

Use this task when you need to add a location for AP deployment and associate location-specific policies or tags.

Before you begin

When you create local and remote sites in the basic setup workflow, the corresponding policies and tags are created automatically. Tags and policies created in the basic setup cannot be modified using the advanced workflow. Similarly, items created with the advanced workflow cannot be changed in the basic setup.

Procedure

Step 1 Choose **Configuration** > **Wireless Setup** > **Basic**.
Step 2 On the **Basic Wireless Setup** window, click **Add**.
Step 3 In the **General** tab, enter a name and description for the location.
Step 4 Set the **Location Type** as either *Local* or *Flex*.
Step 5 Use the slider to set **Client Density** as *Low*, *Typical*, or *High*.
Step 6 Click **Apply**.

The new location is saved and ready for assignment and policy application.

Configure a location for an AP (CLI)

Assign and configure a location for an AP using CLI commands.

Use this task to logically organize APs by location for better device management and policy assignment.
Before you begin

Confirm the AP is registered and operational.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a location for an AP.

Example:

```
Device(config)# ap location name location1
```

Run the **no** form of this command to remove location for an AP.

Step 3 Configure tags for the location.

Example:

```
Device(config-ap-location)# tag policy policy_tag

Device(config-ap-location)# tag rf rf_tag

Device(config-ap-location)# tag site site_tag
```

Step 4 Add description to the location.

Example:

```
Device(config-ap-location)# location description
```

Step 5 Return to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Example:

```
Device(config-ap-location)# end
```

The AP location is set and the associated tags and a description are configured.

Add an AP to location (GUI)

Add an AP to a specific location using the GUI.

Use this task to associate APs with a defined location, which enables accurate AP count and location tagging in the GUI. Ensure the AP tag source is set to **location** for correct display—if needed, run the **no ap** *ap-mac* command on the controller to reset the AP tag source to default.

Before you begin

- Confirm you have the MAC address of the APs to be added.
- Optionally, prepare a CSV file with AP MAC addresses for bulk upload.

Procedure

Step 1 Choose **Configuration** > **Wireless Setup** > **Basic**.

Step 2 In the **Basic Wireless Setup** window, click **Add** to configure these options:

- General
- Wireless Networks
- AP Provisioning

Step 3 In the **AP Provisioning** tab and **Add/Select APs** section, enter the AP MAC address and click the right arrow to add the AP to the associated list.

You can also add a CSV file from your system. Ensure that the CSV has the MAC Address column.

Step 4 Use the search option in the **Available AP List** to select the APs from the **Selected AP** list and click the right arrow to add the AP to the associated list.

Step 5 Click **Apply**.

The selected APs are added to the specified location, and location tagging is updated in the GUI.

Adding an Access Point to the Location (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**ap location name** *location_name* **Example:** `Device(config)# ap location name location1`	Configures a location for an access point.
Step 3	**ap-eth-mac** *ap_ethernet_mac* **Example:** `Device(config-ap-location)# ap-eth-mac 188b.9dbe.6eac`	Adds an access point to the location.
Step 4	**end** **Example:** `Device(config-ap-location)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode. **Note** After adding an AP to a location, the AP may reset automatically to get the new configuration

Configuring SNMP in Location Configuration

SNMP

EWC does not support SNMP and does not implement the SNMP MIBs of Cisco Catalyst 9800 Series Wireless Controllers, although EWC might respond to some of the object identifiers (OIDs).

Verify location configuration

To view the summary of AP location configuration, use the command:

```
Device# show ap location summary

Location Name    Description     Policy Tag           RF Tag           Site Tag
-------------------------------------------------------------------------------------------
first            first floor     default-policy-tag   default-rf-tag   default-site-tag
second           second floor    default-policy-tag   default-rf-tag   default-site-tag
```

To view the AP location configuration details for a specific location, use the command:

```
Device# show ap location details first
```

```
Location Name.....................: first
Location description..............: first floor
Policy tag........................: default-policy-tag
Site tag..........................: default-site-tag
RF tag............................: default-rf-tag

Configured list of APs
005b.3400.0af0
005b.3400.0bf0
```

To view the AP tag summary, use the command:

```
Device# show ap tag summary

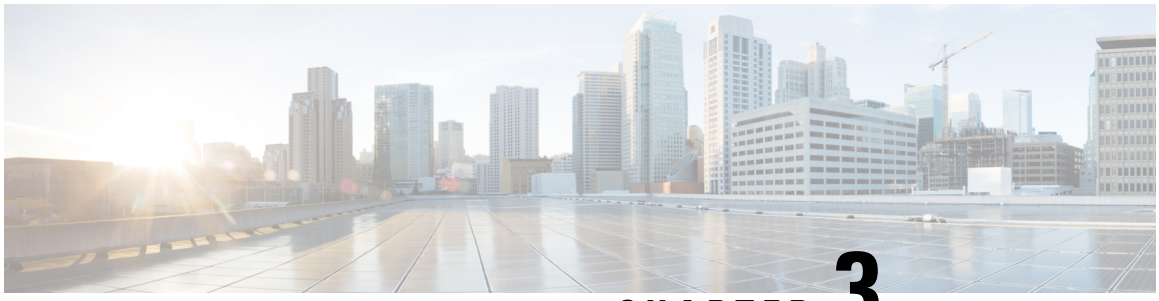
Number of APs: 4
AP Name      AP Mac           Site Tag Name      Policy Tag Name      RF Tag Name
Misconfigured  Tag Source
-------------------------------------------------------------------------------------------------------
Asim_5-1     005b.3400.02f0   default-site-tag   default-policy-tag   default-rf-tag   Yes
            Filter
Asim_5-2     005b.3400.03f0   default-site-tag   default-policy-tag   default-rf-tag   No
            Default
Asim_5-9     005b.3400.0af0   default-site-tag   default-policy-tag   default-rf-tag   No
            Location
Asim_5-10    005b.3400.0bf0   default-site-tag   default-policy-tag   default-rf-tag   No
            Location
```

Verify location statistics

To view the AP location statistics, use the command:

```
Device# show ap location stats

Location name    APs joined     Clients joined     Clients on 11a     Clients on 11b
-------------------------------------------------------------------------------------------------
first             2             0                   3                  4
second            0             0                   0                  0
```



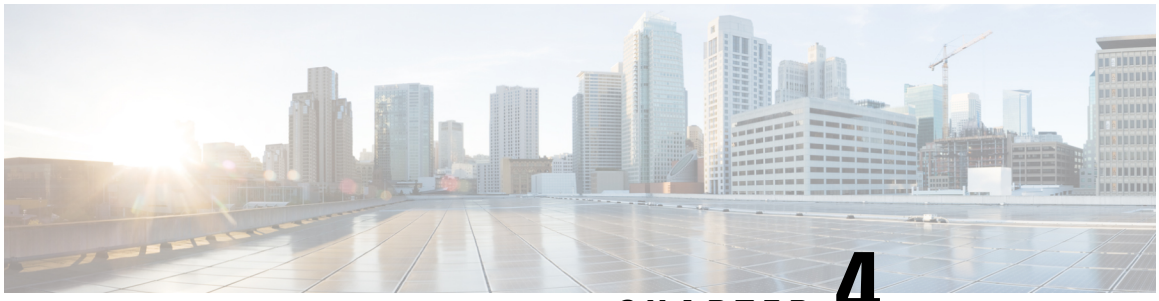
CHAPTER 3

Smart Licensing Using Policy

• Smart Licensing Using Policy, on page 45

Smart Licensing Using Policy

The Smart Licensing Using Policy feature is automatically enabled on the controller. This is also the case when you upgrade to this release. By default, your Smart Account and Virtual Account in Cisco Smart Software Manager (CSSM) are enabled for Smart Licensing Using Policy. For more information, see Smart Licensing Using Policy.



CHAPTER 4

Conversion and Migration

- Conversion and Migration in Embedded Wireless Controller Capable APs , on page 47
- Types of Conversion, on page 47
- Access Point Conversion, on page 48
- Network Conversion, on page 51
- SKU Conversion Scenarios, on page 53
- Converting AireOS Mobility Express Network to Embedded Wireless Controller Network , on page 54

Conversion and Migration in Embedded Wireless Controller Capable APs

The Cisco Embedded Wireless Controller on Catalyst Access Points is not supported on any non-802.11ax (non-11ax) based access points (AP). It is only supported on 802.11ax (11ax) based APs. The embedded wireless controller is the only supported form of Cisco Mobility Express on 11ax based APs.

The conversion enables you to convert the 11ax APs running CAPWAP to embedded wireless controller and vice-versa.

Types of Conversion

The types of conversion scenarios supported are:

- AP Conversion – The following AP conversions are supported:
  - Converting a CAPWAP AP to Embedded Wireless Controller - This conversion is required when you have an AP with a CAPWAP image, and you want to use the AP to deploy a embedded wireless controller based network. In order to do this, you must convert the CAPWAP AP to a embedded wireless controller.
  - Converting an Embedded Wireless Controller AP to a CAPWAP AP – This conversion is required if you want to migrate the APs from an embedded wireless controller network to a non-embedded wireless controller network; or if you do not want the APs to participate in the primary AP election process.
- Network Conversion

- SKU Conversion

Note The request for conversion of an EWC non-capable AP, (for example, Cisco Aironet 1830 Series Access Points), to the EWC mode, is now verified and rejected, because the AP cannot be converted.

Access Point Conversion

This section gives the details of converting a CAPWAP access point to anembedded wireless controller.

Converting a CAPWAP AP to an Embedded Wireless Controller Capable AP

Note Before converting from CAPWAP to embedded wireless controller (EWC), ensure that you upgrade the corresponding AP with the CAPWAP image in Cisco AireOS Release 8.10.105.0. If this upgrade is not performed, the conversion will fail.

To convert an 802.11ax AP with a CAPWAP image to an embedded wireless controller capable image, either download the controller image based on the automated image download process, use the conversion command, or convert through the WebUI.

Note When the AP is embedded wireless controller capable, the AP can participate in the primary AP election process. Only if the AP is elected as a primary, can it perform the controller functionality.

Converting an Embedded Wireless Controller Capable AP to a CAPWAP AP

To convert an 802.11ax AP from the embedded wireless controller network to a non-embedded wireless controller network, set the AP type to CAPWAP using the conversion command or the WebUI, respectively, and then plug it on to the controller network so that it joins the controller. If the image on the controller is different from the image on the AP, a new CAPWAP image is requested from the controller.

Converting a Single AP to CAPWAP or Embedded Wireless Controller Capable AP (CLI)

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:**	Enters privileged EXEC mode.

	Command or Action	Purpose
	`>enable`	
Step 2	**wireless ewc ap ap-type** *ap-name* {**capwap** | **ewc**} **Example:** `Device#wireless ewc-ap ap ap-type ap-name capwap`	Changes the AP to CAPWAP type or to the embedded controller type.

Example

```
wireless ewc-ap ap ap-type ap-name {capwap | ewc}
```

AP Conversion Deployment Scenarios

1. Standalone 802.11ax CAPWAP AP to start an embedded wireless controller network:

802.11ax AP	Embedded Wireless Controller Capable APs	Use-Case	Automatic Conversion
Standalone 802.11ax CAPWAP AP	Network does not exist.	To use a the standalone 802.11ax CAPWAP AP as the first AP for setting up the embedded wireless controller network.	Automatic conversion is not possible. You must download both the controller and the AP image using the supported image transfer protocols with AP command: `ap-type {capwap | ewc-ap} [<sftp/tftp>://<server ip>/<AP imagepath> <sftp/tftp>://<server ip> Controller ImagePath>]`

2. Non-802.11ax CAPWAP AP joining an existing embedded wireless controller network:

CAPWAP AP	Embedded Wireless Controller Capable APs	Use-Case	Automatic Conversion
CAPWAP AP - Neither AireOS-Mobility Express capable, or, embedded wireless controller capable AP, or, AireOS-Mobility Express capable Wave 2 APs.	Existing network	To bring in a CAPWAP AP which is not embedded wireless controller capable, into an existing embedded wireless controller network, to add one more AP to the existing network.	Yes, automatic conversion is possible. This is automatically taken care through the AP Join image download process.

3. 802.11ax AP joining an existing embedded wireless controller network:

Embedded Wireless Controller Capable AP	Embedded Wireless Controller Network	Use-Case	Automatic Conversion

802.11ax AireOS-CAPWAP AP or 802.11ax Catalyst CAPWAP AP or 802.11ax embedded wireless controller capable AP	Existing network	To bring in an 802.11ax AP from an AireOS-CAPWAP network, or, a CAPWAP network, or, from another embedded wireless controller network into an existing embedded wireless controller network, to add one more AP to the existing network.	Yes, automatic conversion takes place.
			This is automatically taken care through the AP Join image download process.
			If the AP type is explicitly set to CAPWAP, then the AP continues to act as a CAPWAP AP unless it is converted back again to embedded wireless controller AP using the AP command, Controller command, or the WebUI.
			The following command is used for conversion as well as AP image download:
			`ap-type {capwap | ewc-ap} [<sftp/tftp>://<server ip>/<AP imagepath> <sftp/tftp>://<server ip>Controller ImagePath>]`
			The following command is used to convert a specific AP to CAPWAP or embedded wireless controller:
			`wireless ewc-ap ap ap-type ap-name {capwap | ewc-ap}`

4. 802.11ax embedded wireless controller AP joining an AireOS CAPWAP network or a CAPWAP network:

802.11 AX Embedded Wireless Controller Capable AP	Embedded Wireless Controller Network	Use-Case	Automatic Conversion

802.11ax AP which was earlier an embedded wireless controller AP	Existing network	To bring an existing 802.11ax embedded wireless controller AP and add it to the CAPWAP network or the AireOS-CAPWAP network to add one more AP to the existing network.	It is recommended to convert the AP to CAPWAP type before bringing it to the CAPWAP network. This conversion can be done manually by using the AP command, the Controller command, Controller WebUI, or by using the DHCP option.
			After conversion, the normal image download process should be followed.
			`ap-type {capwap | ewc-ap} [<sftp/tftp>://<server ip>/<AP imagepath> <sftp/tftp>://<server ip>Controller ImagePath>]`
			`wireless ewc-ap ap ap-type ap-name {capwap | ewc-ap}`

Network Conversion

This section describes network conversion thorugh the conversion command and the network conversion deployment scenarios.

Converting the Network (CLI)

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `>enable`	Enters privileged EXEC mode.

	Command or Action	Purpose
Step 2	**Wireless ewc-ap ap capwap** *primary-controller-name* {**A:B:C:D** | **X:X:X:X::X**} **Example:** `Device#wireless ewc-ap ap capwap wlc-name 10.0.0.0`	Specifies the wireless controller name and IP address to which all the APs currently connected to the embedded wireless controller network should join.

Network Conversion Deployment Scenarios

1. Converting an existing centralized CAPWAP network or AireOS CAPWAP network to the embedded wireless controller network

Existing Network	Embedded Wireless Controller Network	Use-Case	Automatic Conversion
CAPWAP Network: Centralized CAPWAP network or AireOS-CAPWAP network with at least one 802.11ax AP.	Network does not exist.	To convert the existing centralized CAPWAP network or the AireOS-CAPWAP network to theembedded wireless controller network.	No, automatic conversion does not take place. You need to pick one 802.11ax AP to download both the controller and AP image using the supported image transfer protocols with the AP command. `ap-type {capwap | ewc-ap} <sftp/tftp>://<server ip>/<AP imagepath> <sftp/tftp>://<server ip> Controller ImagePath>]`

2. Converting an existing embedded wireless controller network to an AireOS CAPWAP network or to a centralized CAPWAP network

Existing Network	Embedded Wireless Controller Network	Use-Case	Automatic Conversion
Embedded wireless controller network with many APs.	Existing network	To convert the existing embedded wireless controller network to an AireOS-CAPWAP network or to a centralized CAPWAP network.	No automatic conversion. You must convert all the APs or one AP at a time using the controller command to specify the IP address of the controller to which the AP has to join. You can also use the WebUI to convert the selected APs or all the APs by specifying the IP address of the controller to which the AP has to join.

SKU Conversion Scenarios

1. 802.11ax Embedded Wireless Controller SKU instead of CAPWAP SKU

SKU	Network	Use-Case	Automatic Conversion
802.11ax embedded wireless controller SKU instead of CAPWAP SKU	Network does not exist.	For an order placed for 802.11ax embedded wireless controller SKU instead of CAPWAP SKU, it should be converted to CAPWAP SKU.	No automatic conversion available. You can use **DHCP option 43** to point to the Catalyst 9800 controller so that the APs join the Catalyst 9800 controller as a CAPWAP AP.

	SKU	Network	Use-Case	Automatic Conversion
2.	802.11ax CAPWAP SKU instead of the embedded wireless controller SKU.	Network does not exist.	For an order placed for the 802.11ax CAPWAP SKU instead of the embedded wireless controller SKU and now would like to convert it to embedded wireless controller SKU.	No automatic conversion available. You should pick one 802.11ax AP to download both the controller and AP image using the supported image transfer protocols with AP command.`ap-type ewc-ap <sftp/tftp>://<server ip>/<AP imagepath> <sftp/tftp>://<server ip> Controller ImagePath>`

Converting AireOS Mobility Express Network to Embedded Wireless Controller Network

Procedure

Step 1 Remove the **Next Preferred Master** configuration from the existing AireOS Mobility Express network and save the configuration.

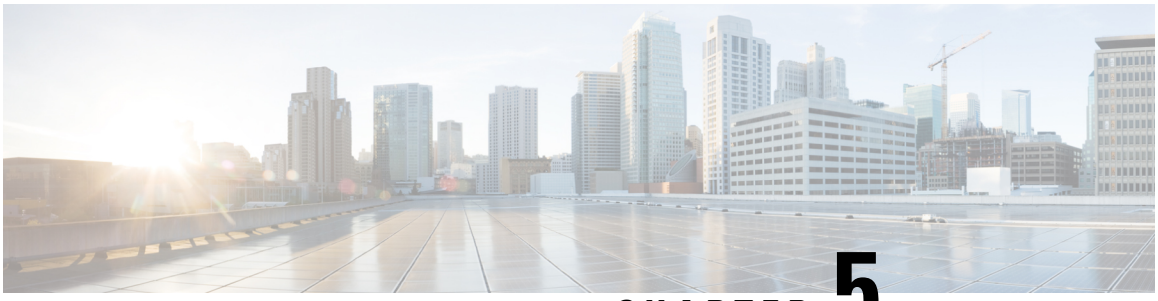
Step 2 Power down all the APs in the AireOS Mobility Express network including the primary AP.

Step 3 Power-on the 11 AX AP with the embedded wireless controller SKU so that it launches the controller.

Step 4 Provision the 11 AX AP with the required configuration (if the box is in Day-0, provision the mandatory configuration to get to Day-1).

Step 5 Copy, Translate, and Apply all the AireOS Mobility Express configurations to the 11 AX embedded wireless controller AP, add image download configuration.

Step 6 Power-on all the APs in the AireOS Mobility Express network. All the APs from the earlier AireOS Mobility Express network will join as regular APs in the embedded wireless controller network.



CHAPTER 5

Best Practices

- Introduction, on page 55

Introduction

This chapter covers the best practices recommended for configuring a typical Cisco Catalyst 9800 Series wireless infrastructure. The objective is to provide common settings that you can apply to most wireless network implementations. However, not all networks are the same. Therefore, some of the tips might not be applicable to your installation. Always verify them before you perform any changes on a live network.

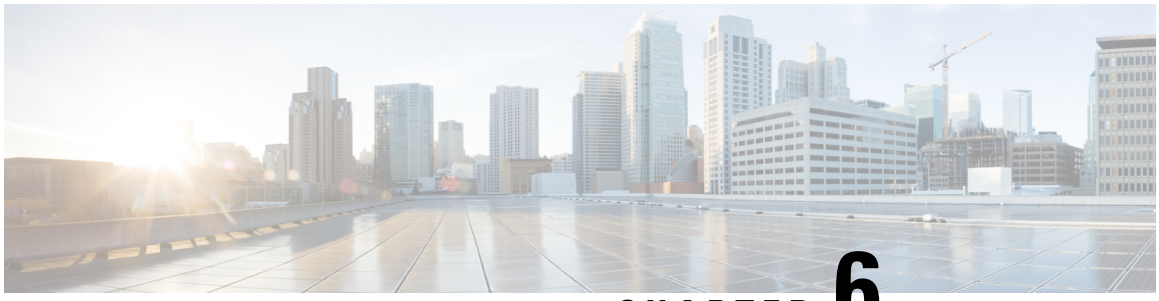
For more information, see Cisco Catalyst 9800 Series Configuration Best Practices guide.



PART II

Lightweight Access Points

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CHAPTER 6

Country Codes

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- Prerequisites for Configuring Country Codes, on page 59
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- How to Configure Country Codes , on page 60
- Configuration examples for configuring country codes, on page 62

Information About Country Codes

Controllers and access points are designed for use in many countries with varying regulatory requirements. The radios within the access points are assigned to a specific regulatory domain at the factory (such as -E for Europe), but the country code enables you to specify a particular country of operation within that regulatory domain (such as FR for France or ES for Spain). Configuring a country code ensures that each radio's broadcast frequency bands, interfaces, channels, and transmit power levels are compliant with country-specific regulations.

Information About Japanese Country Codes

Country codes define the channels that can be used legally in each country. These country codes are available for Japan:

- JP: Allows only –J radios to join the controller
- J2: Allows only –P radios to join the controller
- J3: Uses the –U frequencies, but allows –U, –P, and –Q radios to join the controller
- J4: Allows 2.4G JPQU and 5G PQU to join the controller.

See the Channels and Maximum Power Settings for Cisco Aironet Lightweight Access Points document for the list of channels and power levels supported by access points in the Japanese regulatory domains.

Prerequisites for Configuring Country Codes

- Generally, you should configure one country code per device; you configure one code that matches the physical location of the device and its access points. You can configure up to 20 country codes per device. This multiple-country support enables you to manage access points in various countries from a single device.

- When the multiple-country feature is used, all the devices that are going to join the same RF group must be configured with the same set of countries, configured in the same order.
- Access points are capable of using all the available legal frequencies. However, access points are assigned to the frequencies that are supported in their relevant domains.
- The country list configured on the RF group leader determines which channels the members will operate on. This list is independent of which countries have been configured on the RF group members.
- For devices in the Japan regulatory domain, you must have at least one access point with a -J regulatory domain joined to your device.
- You cannot delete any country code using the configuration command **wireless country country-code** if the specified country was configured using the **ap country list** command and vice-versa.

Configure country codes (GUI)

Set the allowed country codes on wireless APs to comply with local regulations.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points** > **Country**.

Step 2 On the **Country** page, check the check box for each country where your APs are installed. If you select more than one check box, a message displays that RRM channels and power levels are limited to common channels and power levels.

Step 3 Click **Apply**.

How to Configure Country Codes

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
Step 2	**show wireless country supported** **Example:** `Device# show wireless country supported`	Displays a list of all the available country codes.
Step 3	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Device# configure terminal`	
Step 4	**ap dot11 24ghz shutdown** **Example:** `Device(config)# ap dot11 24ghz shutdown`	Disables the 802.11b/g network.
Step 5	**ap dot11 5ghz shutdown** **Example:** `Device(config)# ap dot11 5ghz shutdown`	Disables the 802.11a network.
Step 6	**ap dot11 6ghz shutdown** **Example:** `Device(config)# ap dot11 6ghz shutdown`	Disables the 802.11 6 GHz network.
Step 7	**ap country** *country_code* **Example:** `Device(config)# ap country IN`	
Step 8	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.
Step 9	**show wireless country channels** **Example:** `Device# show wireless country channels`	Displays the list of available channels for the country codes configured on your device. **Note** Perform Steps 9 through 17 only if you have configured multiple country codes in Step 6.
Step 10	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 11	**no ap dot11 5ghz shutdown** **Example:** `Device(config)# no ap dot11 5ghz shutdown`	Enables the 802.11a network.
Step 12	**no ap dot11 24ghz shutdown** **Example:** `Device(config)# no ap dot11 24ghz shutdown`	Enables the 802.11b/g network.
Step 13	**no ap dot11 6ghz shutdown** **Example:** `Device(config)# no ap dot11 6ghz shutdown`	Enables the 802.11 6GHz network.

	Command or Action	Purpose
Step 14	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.
Step 15	**ap name** *cisco-ap* **shutdown** **Example:** `Device# ap name AP02 shutdown`	Disables the access point. **Note** Ensure that you disable only the access point for which you are configuring country codes.
Step 16	**ap name** *cisco-ap* **no shutdown** **Example:** `Device# ap name AP02 no shutdown`	Enables the access point.

Configuration examples for configuring country codes

View channel list for country codes

These examples show how to display the list of available channels for the country codes on your devicedevice:

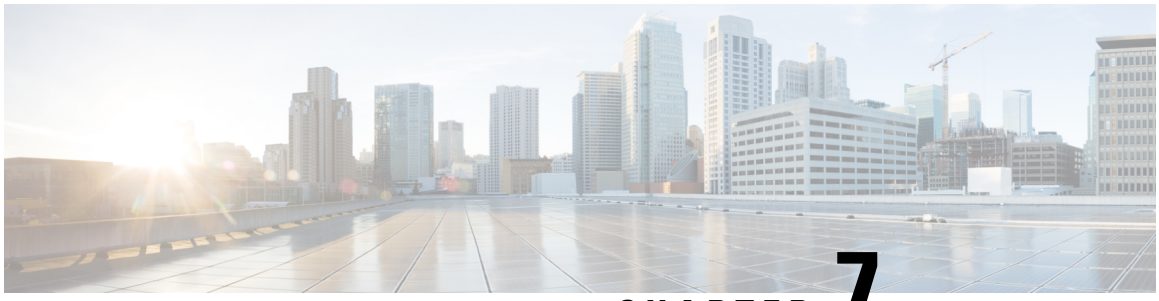
```
DeviceDevice# show wireless country channels

Configured Country.......................: US - United States
KEY: * = Channel is legal in this country and may be configured manually.
     A = Channel is the Auto-RF default in this country.
     . = Channel is not legal in this country.
     C = Channel has been configured for use by Auto-RF.
     x = Channel is available to be configured for use by Auto-RF.
  (-,-) = (indoor, outdoor) regulatory domain allowed by this country.
-----------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-
802.11bg         :
Channels         :                   1 1 1 1 1
                  1 2 3 4 5 6 7 8 9 0 1 2 3 4
-----------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-
(-A ,-AB ) US    : A * * * * A * * * * A . . .
Auto-RF          : . . . . . . . . . . . . . .
-----------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
802.11a          :                         1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Channels         :3 3 3 4 4 4 4 4 5 5 6 6 0 0 0 1 1 2 2 2 3 3 4 4 5 5 6 6
                  4 6 8 0 2 4 6 8 2 6 0 4 0 4 8 2 6 0 4 8 2 6 0 9 3 7 1 5
-----------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
(-A ,-AB ) US    : . A . A . A . A A A A A * * * * * . . . * * * A A A A*
Auto-RF          : . . . . . . . . . . . . . . . . . . . . . . . . . . . .
-----------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
4.9GHz 802.11a   :
Channels         :                   1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2
                  1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
-----------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
US (-A ,-AB )    : * * * * * * * * * * * * * * * * * * * * A * * * * * A
Auto-RF          : . . . . . . . . . . . . . . . . . . . . . . . . . .

Device# show wireless country configured
```

```
Configured Country..................... US - United States
Configured Country Codes
US - United States 802.11a Indoor,Outdoor/ 802.11b Indoor,Outdoor/ 802.11g Indoor,Outdoor
```

View channel list for country codes



CHAPTER 7

Regulatory Compliance (Rest of the World) for Domain Reduction

- Regulatory compliance domain, on page 65
- Ensure 6 GHz radio band persistence after CAPWAP reset, on page 66

Regulatory compliance domain

A regulatory domain is a set of country-specific rules that

- are designed for use in multiple countries with varying regulatory requirements
- enables you to specify a particular country of operation, such as FR for France or ES for Spain, and
- ensures that each radio's broadcast frequency bands, interfaces, channels, and transmit power levels comply with country-specific regulations.

This feature reduces the number of regulatory domains by updating the pre-provisioned domains workflow. It determines the regulatory domain at runtime for each country code. The new Rest of World (RoW) domain includes the nine earlier domains. Each AP selects its regulatory domain from these options by referencing the regulated power table and allowed radio channels.

The transmission power value in the TPC IE of the beacon may differ from the AP's transmission power value by up to 2 dB. You can check this difference by using the **show controllers dot11radio** command. The maximum allowed deviation in the TPC IE of the beacon is two dB.

Global country-level domains

This topic lists detailed information about the power table and supported channels of countries in the global domain for 2.4GHz, 5GHz, 6GHz, and Rest of World domains.

- Use this information to determine the allowed configurations for each region.
- For additional technical details and Rest of World/6GHz support, see the Cisco Catalyst 9100AX Access Points Technical Reference.

Ensure 6 GHz radio band persistence after CAPWAP reset

This procedure describes how to configure the AP radio role to manual for slot 2. This change ensures that the 6 GHz radio band remains active, even after a CAPWAP reset. If the radio role is set to auto, the AP might revert to the 5 GHz band upon reset.

Before you begin

Ensure you have CLI access to the AP.

Procedure

Step 1 Verify the current radio role configuration. From the AP CLI, check the current radio configuration for slot 2.

Example:

```
show capwap client config | i Radio
```

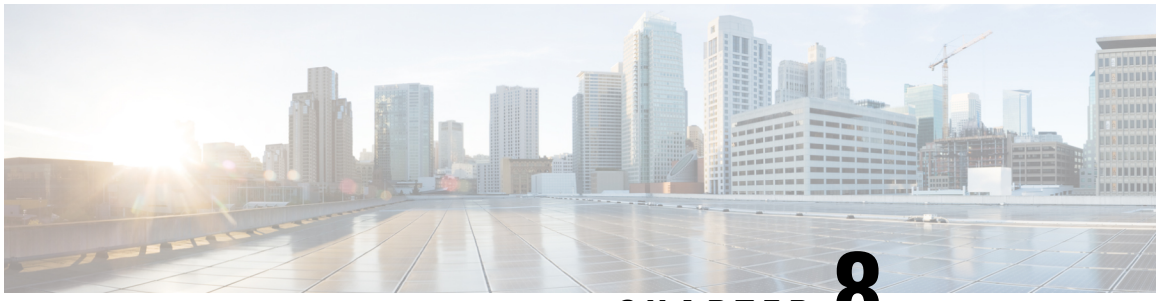
If the output shows the radio role for slot 2 as auto, proceed to Step 2.

If the output shows the radio role for slot 2 as manual, no further action is required for this setting

Step 2 Configure the radio role to manual and set the 6 GHz band. Execute these commands on the AP CLI to set the radio role for slot 2 to manual and configure it for the 6 GHz band. This step ensures the controller applies the manual radio role to the AP.

Example:

```
ap name NAME dot11 dual-band slot 2 shutdown
ap name NAME dot11 dual-band slot 2 radio role manual client-serving
ap name NAME dot11 dual-band slot 2 band 5ghz
ap name NAME dot11 no dual-band slot 2 shutdown
ap name NAME dot11 dual-band slot 2 shutdown
ap name NAME dot11 dual-band slot 2 band 6ghz
```



CHAPTER 8

AP Priority

- Failover priority for APs, on page 67
- Guidelines to configure AP failover priority, on page 67
- Set AP priority (GUI), on page 67
- Set AP priority (CLI), on page 68

Failover priority for APs

A failover priority for APs is a configuration setting that:

- assigns priority levels to APs for controller association
- determines which APs will be favored when controller capacity is limited, and
- allows administrators to ensure high-priority devices maintain connectivity during failover scenarios

Each controller supports a set number of AP connections. If you deploy multiple controllers on the network and one fails, your APs can automatically connect to another available controller.

Guidelines to configure AP failover priority

Use these guidelines to configure AP failover priority:

- Failover priority does not impact normal wireless operation. It only applies when AP connection requests exceed the controller's available capacity.
- The system checks AP priority as each AP connects. When capacity is full, or the primary controller fails, APs connect to the secondary controller.
- Enable failover priority and set priority levels for APs that need them.
- By default, all APs have priority level one (lowest). Assign higher levels only where needed.

Set AP priority (GUI)

Assign a failover priority to an AP to ensure high availability in the event of a controller failure.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.
Step 2 Click the Access Point.
Step 3 In the **Edit AP** dialog box, go to the **High Availability** tab.
Step 4 Select the priority from the **AP failover priority** drop-down list.
Step 5 Click **Update and Apply to Device**.

Set AP priority (CLI)

Assign a priority level to an AP to determine the order in which APs connect and operate using commands.



Note Priority of APs ranges from one to four, with four being the highest.

Procedure

Step 1 Specify the priority of an AP.

Example:

```
Device# ap name ap-name AP44d3.ca52.48b5 priority 1
```

Step 2 Display common information for all APs.

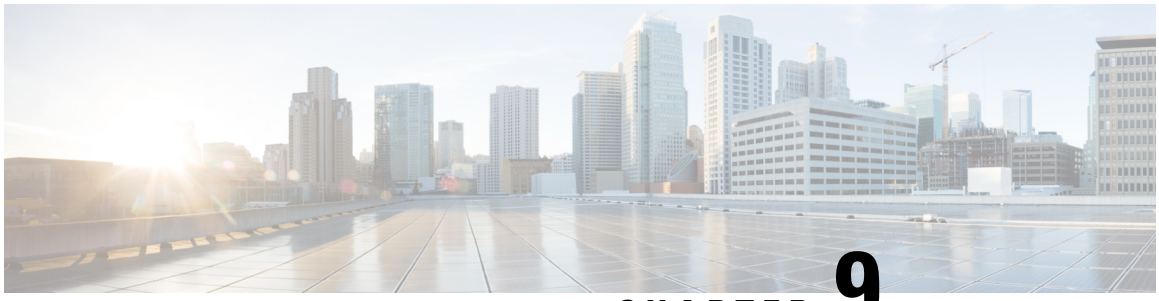
Example:

```
Device# show ap config general
```

Step 3 Display the configuration of a particular AP.

Example:

```
Device# show ap name ap-name AP44d3.ca52.48b5 config general
```



CHAPTER 9

802.11 Parameters for Cisco Access Points

- 2.4-GHz radio support, on page 69
- 5-GHz radio support, on page 71
- Dual-band radios in Cisco AP models, on page 73
- Configure default XOR radio support (CLI), on page 74
- Configure XOR radio support for the specified slot number (GUI), on page 76
- Configure XOR radio support for the specified slot number (CLI), on page 77
- Verify XOR radio support, on page 79
- Receiver only Dual-Band radio support, on page 79
- Configure client steering (CLI), on page 81
- Verify Cisco APs with dual-band radios, on page 82

2.4-GHz radio support

Configure 2.4-GHz radio support for the specified slot number (CLI)

Enable and configure 2.4-GHz radio features for a specified AP slot using commands.

Note The term **802.11b radio** or **2.4-GHz radio** are used interchangeably.

Procedure

Step 1 Enter the privileged EXEC mode.

Example:

```
Device# enable
```

Step 2 Enable Spectrum Intelligence (SI) for the dedicated 2.4-GHz radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 24ghz slot 0 SI
```

For more information, see the *Spectrum Intelligence* section in this guide. In this context, ***0*** refers to the Slot ID.

Step 3 Configure 802.11b antenna hosted on slot 0 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 24ghz slot 0 antenna {ext-ant-gain antenna_gain_value |
selection [ internal | external ]}
```

- **ext-ant-gain** : configures the 802.11b external antenna gain. *antenna_gain_value* : the external antenna gain value, specified in multiples of 0.5 dBi units. The valid range is from zero to 40, with a maximum gain of 20 dBi.
- **selection** : configures the 802.11b antenna to use either the internal or external option.

Note

- For APs that support self-identifying antennas (SIA), the gain depends on the antenna and not the AP model. The AP automatically learns the gain, so no controller configuration is necessary.
- For APs that do not support SIA, the AP sends the antenna gain in the configuration payload. The default antenna gain depends on the AP model.
- Cisco Catalyst 9120E and 9130E APs support self-identifying antennas (SIA). Cisco Catalyst 9115E APs do not support SIA antennas. Although Cisco Catalyst 9115E APs work with SIA antennas, they do not automatically detect SIA antennas or apply the correct external gain.

Step 4 Configure beamforming for the 2.4-GHz radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 24ghz slot 0 beamforming
```

Step 5 Configure advanced 802.11 channel assignment parameters for the 2.4-GHz radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 24ghz slot 0 channel {channel_number | auto}
```

Step 6 Enable CleanAir for 802.11b radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 24ghz slot 0 cleanair
```

Step 7 Configure 802.11n antenna for 2.4-GHz radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 24ghz slot 0 dot11n antenna {A | B | C | D}
```

Here, are the descriptions of various options:

A : A is the antenna port A.

B : B is the antenna port B.

C : C is the antenna port C.

D : D is the antenna port D.

Step 8 Disable 802.11b radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 24ghz slot 0 shutdown
```

Step 9 Configure transmit power level for 802.11b radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 24ghz slot 0 txpower {tx_power_level | auto}
```

- *tx_power_level* : is the transmit power level in dBm. The valid range is from one to eight.
- **auto** : enables auto-RF.

5-GHz radio support

Configure 5-GHz radio support for the specified slot number (CLI)

Enable and configure 5-GHz radio features on a selected AP slot.

Note The term **802.11a radio** or **5-GHz radio** are used interchangeably in this document.

Procedure

Step 1 Enable Spectrum Intelligence (SI) for the dedicated 5-GHz radio hosted on slot 1 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 SI
```

Here, ***1*** refers to the Slot ID.

Step 2 Configure external antenna gain for 802.11a radios for a specific AP hosted on slot 1.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 antenna ext-ant-gain antenna_gain_value
```

antenna_gain_value : refers to the external antenna gain value in multiples of .5 dBi units. The valid range is from zero to 40, with the maximum gain of 20 dBi.

Note

- For APs supporting self-identifying antennas (SIA), the gain depends on the antenna, not on the AP model. The AP learns the gain, so controller configuration is not required.
- For APs that do not support SIA, the AP sends the antenna gain in the configuration payload. The default antenna gain depends on the AP model.
- Cisco Catalyst 9120E and 9130E APs support self-identifying antennas (SIA). Cisco Catalyst 9115E APs do not support SIA antennas. Although Cisco Catalyst 9115E APs work with SIA antennas, these APs do not automatically detect SIA antennas or add the correct external gain.

Step 3 Configure the antenna mode for 802.11a radios for a specific AP hosted on slot 1.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 antenna mode {omni | sectorA | sectorB}
```

Step 4 Configure the antenna selection for 802.11a radios for a specific AP hosted on slot 1.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 antenna selection {internal | external}
```

Step 5 Configure beamforming for the 5-GHz radio hosted on slot 1 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 beamforming
```

Step 6 Configure advanced 802.11 channel assignment parameters for the 5-GHz radio hosted on slot 1 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 channel {channel_number | auto | width [20 |
 40 | 80 | 160]}
```

Here,

channel_number : refers to the channel number. The valid range is from one to 173.

Step 7 Enable CleanAir for 802.11a radio hosted on slot 1 for a given or specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 cleanair
```

Step 8 Configure 802.11n for 5-GHz radio hosted on slot 1 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 dot11n antenna {A | B | C | D}
```

Here, are the descriptions of various options:

A : A is the antenna port A.

B : B is the antenna port B.

C : C is the antenna port C.

D : D is the antenna port D.

Change the channel hosted on slot 1 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 rrm channel 2
```

Here, *channel*: refers to the new channel created using 802.11h channel announcement. The valid range is from one to 173, provided 173 is a valid channel in the country where the AP is deployed.

Step 9 Disable 802.11a radio hosted on slot 1 for a specific AP and configure 802.11a radio hosted on slot 1 for a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 shutdown
Device# ap name AP-SIDD-A06 dot11 5ghz slot 1 txpower {tx_power_level | auto}
```

- *tx_power_level* : is the transmit power level in dBm. The valid range is from one to eight.
- **auto** : enables auto-RF.

Dual-band radios in Cisco AP models

A dual-band radio is a device category that

- offers connectivity on more than one frequency band (such as 2.4 GHz and 5 GHz)
- provides flexibility in network configuration, and
- is used in multiple Cisco AP models like the 2800, 3800, 4800, and 9120 series.

Feature history table

Table 3: Feature history table for dual-band radios in Cisco AP models

Feature name	Release information	Feature description
Dual-band (XOR) radio support	Cisco IOS XE 16.10.1	The Dual-band (XOR) radio support offers the ability to serve 2.4 GHz or 5 GHz bands or passively monitor both the bands on the same AP. These APs can be configured to serve clients in 2.4 GHz and 5 GHz bands, or serially scan both 2.4 GHz and 5 GHz bands on the flexible radio while the main 5 GHz radio serves clients.

Key features of dual-band radios in Cisco APs

The XOR radio support can be steered manually or automatically.

- Manual steering of a band on a radio: The band on the XOR radio can only be changed manually.
- Automatic client and band steering on radios: This is managed by the Flexible Radio Assignment (FRA) feature that monitors and changes the band configurations as per site requirements.

Client steering

When a radio moves between bands (from 2.4 GHz to 5 GHz and vice versa), clients need to be steered to get an optimal distribution across radios. When an AP has two radios in the 5 GHz band, client steering algorithms contained in the FRA algorithms are used to steer a client between the same band co-resident radios

Cisco APs and dual-band radios

Cisco 2800, 3800, 4800, and 9120 series AP models are equipped with dual-band (XOR) radios. These models have

- radios that operate on either 2.4 GHz or 5 GHz bands, or
- the ability to passively monitor both the bands on the same AP.

These APs can be configured to serve clients in 2.4 GHz and 5 GHz bands, or serially scan both 2.4 GHz and 5 GHz bands on the flexible radio while the main 5 GHz radio serves clients.

Cisco AP models up to the Cisco 9120 APs are designed to support dual 5 GHz band operations with the *i* model supporting a dedicated Macro or Micro architecture and the *e* and *p* models supporting Macro or Macro. The Cisco 9130AXI APs support dual 5 GHz operations as Macro or Micro cell.

Limitations

These are the limitations for XOR radio support:

- RF measurement is disabled when a static channel is configured on slot 1. As a result, the dual-band radio slot 0 operates only with 5 GHz radios and not in the monitor mode. When slot 1 radio is disabled, RF measurement will not run, and the dual band radio slot 0 will be only on 2.4 GHz radio.
- Only one of the 5 GHz radios can operate in the UNII band (100 to 144), due to an AP limitation to maintain the power budget within the regulatory limit.

Configure default XOR radio support (CLI)

Complete this task to configure the basic settings for XOR radio support.

Before you begin

Note The default radio points to the XOR radio hosted on slot 0.

Procedure

Step 1 Enable the priviledged EXEC mode.

Example:

```
Device> enable
```

Step 2 Configure the 802.11 dual-band external antenna gain on the AP.

Example:

```
Device# ap name ap-name  dot11 dual-band antenna ext-ant-gain antenna_gain_value
```

Enter external antenna gain value in multiple of .5 dBi units (that is, an integer value 4 means 4 x 0.5 = 2 dBi of gain).

Step 3 Shut down the default dual-band radio.

Example:

```
Device# ap name ap-name  dot11 dual-band shutdown
```

Use the **no** form of the command to enable the radio.

Step 4 Switch to the client-serving mode of the AP.

Example:

```
Device# ap name ap-name  dot11 dual-band role manual client-serving
```

Step 5 Switch to the 2.4 GHz radio band.

Example:

```
Device# ap name ap-name  dot11 dual-band band 24ghz
```

The basic configuration of the XOR radio is completed.

Example

```
Device> enable
Device# ap name ap-name  dot11 dual-band antenna ext-ant-gain 2
Device# ap name ap-name  dot11 dual-band shutdown
Device# Device# ap name ap-name  dot11 dual-band role manual client-serving
Device# Device# ap name ap-name  dot11 dual-band band 24ghz
```

What to do next

Continue with the configuration steps listed in the "Configure advanced settings" to complete the configuration.

Configure advanced settings (CLI)

Complete this task to configure the advanced settings for XOR radio support, such as, transmit power, channel, channel width, CleanAir settings and so on.

Procedure

Step 1 Configure the transmit power for the radio on the AP.

Example:

```
Device# ap name ap-name  dot11 dual-band txpower {transmit_power_level | auto}
```

Note
When an FRA-capable radio (slot 0 on 9120 AP[for instance]) is set to Auto, you cannot configure static channel and Txpower on this radio.

If you want to configure static channel and Txpower on this radio, you will need to change the radio role to Manual Client-Serving mode.

Step 2 Configure the channel number for the dual band.

Example:

```
Device# ap name ap-name  dot11 dual-band channel 40
```

The range of the *channel-number* is from 1 to 173.

Step 3 (Optional) Enable the auto channel assignment for the dual-band.

Example:

```
Device# ap name ap-name  dot11 dual-band channel auto
```

Step 4 Configure the channel width for the dual band.

Example:

```
Device# ap name ap-name  dot11 dual-band channel width {20 MHz | 40 MHz | 80 MHz | 160 MHz}
```

Step 5 Enable the Cisco CleanAir management on the dual-band radio.

Example:

```
Device# ap name ap-name  dot11 dual-band cleanair
```

Step 6 Configure a band for the Cisco CleanAir feature.

Example:

```
Device# ap name ap-name [no] dot11 dual-band cleanair band 5 GHz
```

Selects a band for the Cisco CleanAir feature.

Use the **no** form of this command to disable the Cisco CleanAir feature.

Step 7 Configure the 802.11n dual-band antenna and antenna ports selection for a specific AP.

Example:

```
Device# ap name ap-name  dot11 dual-band dot11n antenna {A | B | C | D}
```

Here, A, B, C, and D are the antenna ports.

The configuration of the additional features for dual-band (XOR) radios are completed.

Example

```
Device# ap name ap-name  dot11 dual-band txpower auto
Device# ap name ap-name  dot11 dual-band channel 40
Device# ap name ap-name  dot11 dual-band channel width 40 MHz
Device# ap name ap-name  dot11 dual-band cleanair
Device# ap name ap-name [no] dot11 dual-band cleanair band 5 GHz
Device# ap name ap-name  dot11 dual-band dot11n antenna A
```

Configure XOR radio support for the specified slot number (GUI)

Complete this task to configure XOR radio for the specified slot number.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 In the **Dual-Band Radios** section, select the AP for which you want to configure dual-band radios.

The AP name, MAC address, CleanAir capability and slot information for the AP are displayed. If the Hyperlocation method is HALO, it displays the antenna PID and antenna design specifics.

Step 3 Click **Configure**.

Step 4 In the **General** tab, set the **Admin Status** as required.

Step 5 Set the **CleanAir Admin Status** field to Enable or Disable.

Step 6 Click **Update & Apply to Device**.

The XOR radio support for the specified slot number has been configured.

Configure XOR radio support for the specified slot number (CLI)

Complete this task to configure XOR radio for a specified slot number.

Procedure

Step 1 Enable the priviledged EXEC mode.

Example:

```
Device> enable
```

Step 2 Configure dual-band antenna for the XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 antenna ext-ant-gain
external_antenna_gain_value
```

Here, *external_antenna_gain_value* is the external antenna gain value in multiples of .5 dBi unit. The range is from 0 to 40.

Note

- For APs supporting self-identifying antennas (SIA), the gain depends on the antenna, and not on the AP model. The gain is learned by the AP and there is no need for controller configuration.
- For APs that do not support SIA, the APs send the antenna gain in the configuration payload, where the default antenna gain depends on the AP model.

Step 3 Configure the current band for XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 band {24ghz | 5ghz}
```

Step 4 Configures dual-band channel for the XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 channel {channel-number | auto | width [160
 | 20 | 40 | 80]}
```

The range of the *channel_number* is from 1 to 165.

Step 5 Enable the Cisco CleanAir feature for dual-band radios hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 cleanair band {24Ghz | 5ghz}
```

Step 6 Configure 802.11n dual-band parameters hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 dot11n antenna {A | B | C | D}
```

Here are the antenna configurations.

A : Enables antenna port A.

B : Enables antenna port B.

C : Enables antenna port C.

D : Enables antenna port D.

Step 7 Configure dual-band role for the XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 role {auto | manual [client-serving | monitor]}
```

Here are the dual-band roles.

- **auto** : refers to the automatic radio role selection.
- **manual** : refers to the manual radio role selection.

Step 8 Disable dual-band radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name [no] dot11 dual-band slot 0 shutdown
```

Use the **no** form of this command to enable the dual-band radio.

Step 9 Configure dual-band transmit power for XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 txpower {tx-power-level | auto}
```

Here,

- *tx_power_level* : is the transmit power level in dBm. The range is from 1 to 8.
- **auto** : enables auto-RF.

The XOR radio for the specified slot number is configured.

Example

```
Device> enable
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 antenna ext-ant-gain 2
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 band 24ghz
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 channel 3
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 cleanair band 24Ghz
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 dot11n antenna A
Device# ap name AP-SIDD-A06 [no] dot11 dual-band slot 0 shutdown
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 txpower 2
```

Verify XOR radio support

To verify the XOR radio support parameters, use these **show** commands:

Verify auto-RF information

To display the auto-RF information for a Cisco AP, use the **show ap name** *ap-name* **auto-rf dot11 dual-band** command.

```
Device# show ap name cisco-ap-name auto-rf dot11 dual-band
```

Verify the list of BSSIDs

To display the list of BSSIDs for a Cisco AP, use the **show ap name** *ap-name* **wlan dot11 dual-band** command.

Receiver only Dual-Band radio support

Receiver only dual-band radio support

A receiver only dual-band radio is a WLAN radio type that

- configures the dual-band Rx-only radio features for an AP with dual-band radios
- serves dedicated functions such as analytics, hyperlocation, wireless security monitoring, and BLE Angle of Arrival (AoA), and
- continually remains in monitor mode, preventing any *tx-rx* configuration for client or data traffic.

Configure receiver only Dual-Band parameters for APs

Enable CleanAir with receiver Only dual-band radio on a Cisco AP (GUI)

Enable CleanAir functionality on a Cisco AP that is configured with a receiver only dual-band radio through the GUI.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 In the **Dual-Band Radios** settings, click the AP for which you want to configure the dual-band radios.

Step 3 In the **General** tab, enable the **CleanAir** toggle button.

Step 4 Click **Update & Apply to Device**.

Enabling CleanAir with receiver only dual-band radio on a Cisco AP (CLI)

Enable CleanAir spectrum analysis for a dual-band receiver-only radio on a specified Cisco AP.

Procedure

Step 1 Enter the privileged EXEC mode.

Example:

```
Device# enable
```

Step 2 Enable CleanAir with receiver only (Rx-only) dual-band radio on a specific AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 rx-dual-band slot 2 cleanair band 24Ghz
Device# ap name AP-SIDD-A06 [no] dot11 rx-dual-band slot 2 cleanair band 24Ghz
```

Here, 2 refers to the slot ID. Use the ***no*** form of this command to disable CleanAir.

Disable receiver only dual-band radio on a Cisco AP (GUI)

Prevent the AP from operating a receiver-only dual-band radio by using the GUI.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 In the **Dual-Band Radios** settings, click the AP for which you want to configure the dual-band radios.

Step 3 In the **General** tab, disable the **CleanAir Status** toggle button.

Step 4 Click **Update & Apply to Device**.

Disable receiver only dual-band radio on a Cisco AP (CLI)

Disable the receiver only dual-band radio function on a specific Cisco AP using commands.

Procedure

Step 1 Enter the privileged EXEC mode.

Example:

```
Device# enable
```

Step 2 Disable receiver only dual-band radio on a specific Cisco AP.

Example:

```
Device# ap name AP-SIDD-A06 dot11 rx-dual-band slot 2 shutdown
Device# ap name AP-SIDD-A06 [no] dot11 rx-dual-band slot 2 shutdown
```

Here, 2 refers to the slot ID. Use the ***no*** form of this command to enable receiver only dual-band radio.

Configure client steering (CLI)

Enable and customize client steering on a wireless device to optimize client distribution between macro (5 GHz) and micro (2.4 GHz) radios, improving wireless network performance and load balancing.

Before you begin

Enable Cisco CleanAir on the corresponding dual-band radio.

Procedure

Step 1 Configure the macro-micro client load–balancing window for a set number of clients.

Example:

```
Device(config)# wireless macro-micro steering transition-threshold balancing-window
number-of-clients(0-65535) 10
```

Step 2 Configure the macro-micro client parameters for a minimum client count for transition.

Example:

```
Device(config)# wireless macro-micro steering transition-threshold client count
number-of-clients(0-65535) 10
```

Step 3 Configure the macro-to-micro transition RSSI.

Example:

```
Device(config)# wireless macro-micro steering transition-threshold macro-to-micro RSSI-in-dBm(
 -128—0) -100
```

Step 4 Configure the micro–to–macro transition RSSI.

Example:

```
Device(config)# wireless macro-micro steering transition-threshold micro-to-macro
RSSI-in-dBm(-128—0) -110
```

Step 5 Configure the number of probe cycles to be suppressed.

Example:

```
Device(config)# wireless macro-micro steering probe-suppression aggressiveness
number-of-cycles(-128—0) -110
```

Step 6 Configure the macro-to-micro probe in RSSI.

Example:

```
Device(config)# wireless macro-micro steering probe-suppression hysteresis RSSI-in-dBm -5
```

The range is between –6 to –3.

Step 7 Enable probe suppression mode.

Example:

```
Device(config)# wireless macro-micro steering probe-suppression probe-only
```

Step 8 Enable probe and single authentication suppression mode.

Example:

```
Device(config)# wireless macro-micro steering probe-suppression probe-auth
```

Step 9 Display the wireless client steering information.

Example:

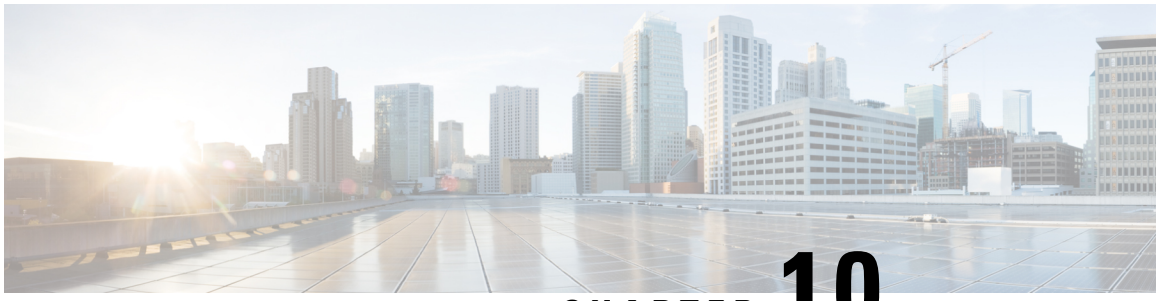
```
Device# show wireless client steering
```

Verify Cisco APs with dual-band radios

To verify the APs with dual-band radios, use the command:

```
Device# show ap dot11 dual-band summary


AP Name Subband Radio      Mac   Status Channel Power Level Slot ID Mode
------------------------------------------------------------------------------
4800   All 3890.a5e6.f360 Enabled (40)* *1/8     (22 dBm)      0   Sensor
4800   All 3890.a5e6.f360 Enabled N/A    N/A       2              Monitor
```



CHAPTER 10

802.1x Support

- 802.1X authentication, on page 83
- 802.1X authentication limitations, on page 84
- Topology, on page 85
- Configuring 802.1X authentication type and LSC AP authentication type (GUI), on page 85
- Configure 802.1X authentication type and LSC AP authentication type (CLI), on page 86
- Enable 802.1X on the switch port (CLI), on page 88
- Verify 802.1X on the switch port, on page 90
- Verify the authentication type, on page 90

802.1X authentication

IEEE 802.1X port-based authentication is a network security protocol that

- prevents unauthorized devices from accessing the network
- utilizes EAP authentication models to ensure secure communication, and
- integrates with devices like routers, switches, and access points based on configuration.

Feature history

Table 4: Feature history for 802.1X authentication

Feature name	Release information	Feature description
802.1X authentication	Cisco IOS XE 16.9.1	IEEE 802.1X port-based authentication is a network security protocol that utilizes EAP authentication models to ensure secure communication, and integrates with devices like routers, switches, and access points based on configuration.
Access ports with dual port authentication	Cisco IOS XE 17.17.1	The access ports with dual port authentication feature supports dual Ethernet ports on Cisco Catalyst 9136 APs and Cisco Wireless 9178I APs.

Currently, Cisco Wave 2 and Wi-Fi 6 (802.11AX) APs support 802.1X authentication with switch ports for EAP-FAST, EAP-TLS, and EAP-PEAP methods. Configuration and credential provision to APs can be done through the controller.



Note If the AP is dot1x EAP-FAST, upon reboot, it should perform an anonymous PAC provision using ADH cipher suites to establish an authenticated tunnel. Authentication will fail if RADIUS servers do not support ADH cipher suites.

EAP-FAST protocol

In the EAP-FAST protocol developed by Cisco, to establish a secured TLS tunnel with RADIUS, the AP requires a strong shared key (PAC), provided via in-band or manual out-band provisioning.

- The EAP-FAST type configuration requires 802.1x credentials configuration for AP, since AP will use EAP-FAST with MSCHAP Version 2 method.
- Cisco 7925 phones do not support Local EAP.
- In Cisco Wave 2 APs, for 802.1x authentication using EAP-FAST after PAC provisioning (caused by the initial connection or after AP reload), ensure that you configure the switch port to trigger re-authentication using **authentication timer restart** *num* or **authentication timer reauthenticate** *num*.

EAP-TLS/EAP-PEAP Protocol

The EAP-TLS protocol or EAP-PEAP protocol provides certificate based mutual EAP authentication.

In EAP-TLS, both the server and the client side certificates are required, where the secured shared key is derived for the particular session to encrypt or decrypt data. In EAP-PEAP, only the server-side certificate is required, and the client authenticates using a password-based protocol in a secured channel.

The EAP-PEAP type configuration requires Dot1x credentials configuration for the AP, and the AP also needs to go through LSC provisioning. AP uses the PEAP protocol with MSCHAP Version 2 method.

802.1X authentication limitations

The 802.1X authentication limitations are:

- 802.1X is not supported on dynamic ports or Ethernet Channel ports.
- 802.1X is not supported in a mesh AP scenario.
- There is no recovery from the embedded controller on credential mismatch or the expiry/invalidity of the certificate on AP. The 802.1X authentication has to be disabled on the switch port to connect the AP back to fix the configurations.
- There are no certificate revocation checks implemented on the certificates installed in AP.
- You can provision only one Locally Significant Certificate (LSC) for the AP. Use the same certificate for both CAPWAP DTLS session establishment and 802.1X authentication with the switch. If you disable the global LSC configuration on the controller, the AP deletes the already provisioned LSC.

- If the AP has clear configurations applied, it will lose the 802.1X EAP Type configuration and the LSC Certificates. The AP should undergo the staging process again if 802.1X is required.
- 802.1X for trunk port APs on multi-host authentication mode is supported. Network Edge Authentication Topology (NEAT) is not supported on COS APs.

Topology

This topic explains how an AP acts as an 802.1X supplicant and how a switch uses a RADIUS server that supports EAP-FAST, EAP-TLS, and EAP-PEAP to authenticate it.

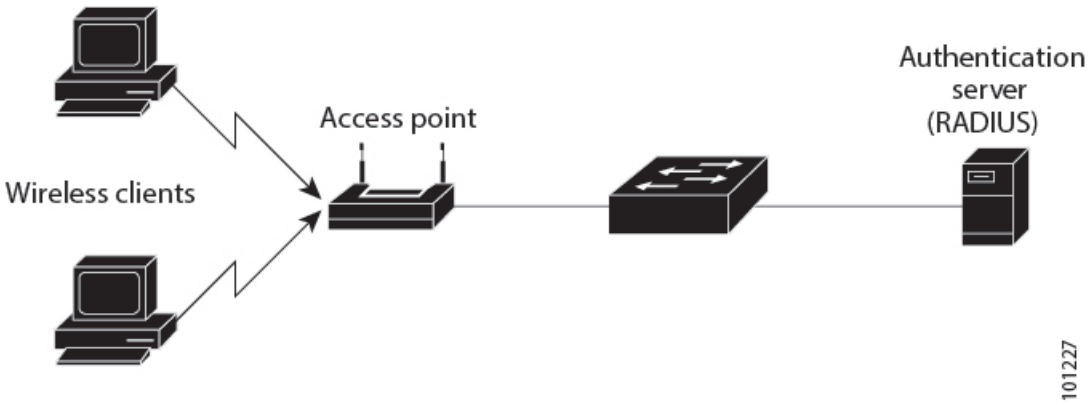
Summary

When dot1x authentication is enabled on a switch port, the connected device must authenticate itself to send and receive data other than 802.1X traffic.

- For EAP-FAST authentication, configure the RADIUS server's credentials at the controller and pass them to the AP through a configuration update request.
- For EAP-TLS or EAP-PEAP, the APs use certificates provided by the local CA server.

Workflow

Figure 2: Topology for 802.1X authentication



Configuring 802.1X authentication type and LSC AP authentication type (GUI)

Complete this task to configure 802.1X authentication type and LSC AP authentication type.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **AP Join**.

Step 2 On the **AP Join Profile** page, click **Add**.

The **Add AP Join Profile** page is displayed.

Step 3 In the **AP** > **General** tab, navigate to **AP EAP Auth Configuration**.

Step 4 From the **EAP Type** drop-down list, choose the EAP type as **EAP-FAST**, **EAP-TLS**, or **EAP-PEAP** to configure the dot1x authentication type.

Step 5 From the **AP Authorization Type** drop-down list, choose either **CAPWAP DTLS +** or **CAPWAP DTLS**.

Step 6 Click **Save & Apply to Device**.

The 802.1X authentication type and LSC AP authentication type are configured.

Configure 802.1X authentication type and LSC AP authentication type (CLI)

Complete this task to configure 802.1X authentication type and LSC AP authentication type.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify a profile name.

Example:

```
Device(config)# ap profile ap-profile-name
```

Step 3 Configure the dot1x authentication type.

Example:

```
Device(config-ap-profile)# dot1x {max-sessions | username | eap-type | lsc-ap-auth-state}
```

Here

- **max-sessions**: Configures the maximum 802.1X sessions initiated per AP.
- **username**: Configures the 802.1X username for all APs.
- **eap-type:**: Configures the dot1x authentication type with the switch port.
- **lsc-ap-auth-state**: Configures the LSC authentication state on the AP.

Step 4 Configure the dot1x authentication type as EAP-FAST, EAP-TLS, or EAP-PEAP.

Example:

```
Device(config-ap-profile)# dot1x eap-type {EAP-FAST | EAP-TLS | EAP-PEAP}
```

Step 5 Configure the LSC authentication state on the AP.

Example:

```
Device(config-ap-profile)# dot1x lsc-ap-auth-state {CAPWAP-DTLS | Dot1x-port-auth | Both}
```

Here

- **CAPWAP-DTLS**: Uses LSC only for CAPWAP DTLS.
- **Dot1x-port-auth**: Uses LSC only for dot1x authentication with port.
- **Both**: Uses LSC for both CAPWAP-DTLS and Dot1x authentication with port.

Step 6 Exit the AP profile configuration mode and enter the privileged EXEC mode.

Example:

```
Device(config-ap-profile)# end
```

The 802.1X authentication type and LSC AP authentication type have been configured.

```
Device# configure terminal
Device(config)# ap profile ap-profile-name
Device(config-ap-profile)# dot1x eap-type
Device(config-ap-profile)# dot1x eap-type EAP-TLS
Device(config-ap-profile)# dot1x lsc-ap-auth-state Dot1x-port-auth
Device(config-ap-profile)# end
```

Configure the 802.1X username and password (CLI)

Complete these steps to configure the 802.1X username and password.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **AP Join**.

Step 2 On the **AP Join** page, click the name of the AP Join profile or click **Add** to create a new one.

Step 3 Click the **Management** tab and then click **Credentials**.

Step 4 Enter the local username, password details, and choose the appropriate local password type.

Step 5 Enter 802.1X username and password details.

Step 6 Choose the appropriate 802.1X password type.

Step 7 Enter the time in seconds after which the session should expire.

Step 8 Enable local credentials or 802.1X credentials, or both, as required.

Step 9 Click **Update & Apply to Device**.

The configuration of the 802.1X username and password is complete.

Configure the 802.1X username and password (CLI)

Complete these steps to configure the 802.1X username and password.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify a profile name for the AP.

Example:

```
Device(config)# ap profile ap-profile-name
```

Step 3 Configure the dot1x authentication type.

Example:

```
Device(config-ap-profile)# dot1x {max-sessions | username | eap-type | lsc-ap-auth-state}
```

Here

- **max-sessions**: Configures the maximum 802.1X sessions initiated per AP.
- **username**: Configures the 802.1X username for all APs
- **eap-type:**: Configures the dot1x authentication type with the switch port.
- **lsc-ap-auth-state**: Configures the LSC authentication state on the AP.

Step 4 Configure the dot1x password for all the APs.

Example:

```
Device(config-ap-profile)# dot1x username username password {0 | 8} password
```

Here

- **0**: Specifies an unencrypted password will follow.
- **8**: Specifies an AES encrypted password will follow.

The configuration of the 802.1X username and password is complete.

```
Device# configure terminal
Device(config)# ap profile ap-profile-name
Device(config-ap-profile)# dot1x eap-type
Device(config-ap-profile)# dot1x username username password 0 password
```

Enable 802.1X on the switch port (CLI)

Complete these steps to enable 802.1X on the switch port.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable AAA.

Example:

```
Device(config)# aaa new-model
```

Step 3 Create authentication methods to determine user privilege for accessing the privileged command level, enabling the device to communicate with the AAA server.

Example:

```
Device(config)# aaa authentication dot1x {default | listname} method1[method2...]
```

Step 4 Enable AAA authorization for network services on 802.1X.

Example:

```
Device(config)# aaa authorization network group
```

Step 5 Enable 802.1X port-based authentication, globally.

Example:

```
Device(config)# dot1x system-auth-control
```

Step 6 Enter the interface configuration mode and specify the interface to be enabled for 802.1X authentication.

Example:

```
Device(config)# interface type slot/port
```

Step 7 Enable 802.1X port-based authentication on the interface.

Example:

```
Device(config-if)# authentication port-control {auto | force-authorized | force-unauthorized}
```

Here are the options:

- **auto**: Enables IEEE 802.1X authentication and causes the port to begin in the unauthorized state, allowing only EAPOL frames to be sent and received through the port. The authentication process begins when the link state of the port changes from down to up or when an EAPOL-start frame is received. The Device requests the identity of the supplicant and begins relaying authentication messages between the supplicant and the authentication server. Each supplicant attempting to access the network is uniquely identified by the Device by using the supplicant MAC address.
- **force-authorized**: Disables IEEE 802.1X authentication and causes the port to change to the authorized state without any authentication exchange required. The port sends and receives normal traffic without IEEE 802.1X-based authentication of the client. This is the default setting.
- **force-unauthorized**: Causes the port to remain in the unauthorized state, ignoring all attempts by the supplicant to authenticate. The Device cannot provide authentication services to the supplicant through the port.

Step 8 Enable 802.1X authentication on the port with default parameters.

Example:

```
Device(config-if)# dot1x pae [supplicant | authenticator | both]
```

Step 9 Enter the privileged EXEC mode.

Example:

```
Device(config-if)# end
```

802.1X is enabled on the switch port.

```
Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa authentication dot1x default group radius
Device(config)# aaa authorization network group
Device(config)# dot1x system-auth-control
Device(config)# interface fastethernet2/1
Device(config-if)# authentication port-control auto
Device(config-if)# dot1x pae authenticator
Device(config-if)# end
```

Verify 802.1X on the switch port

To display the authentication state of 802.1X on the switch port, use the following command:

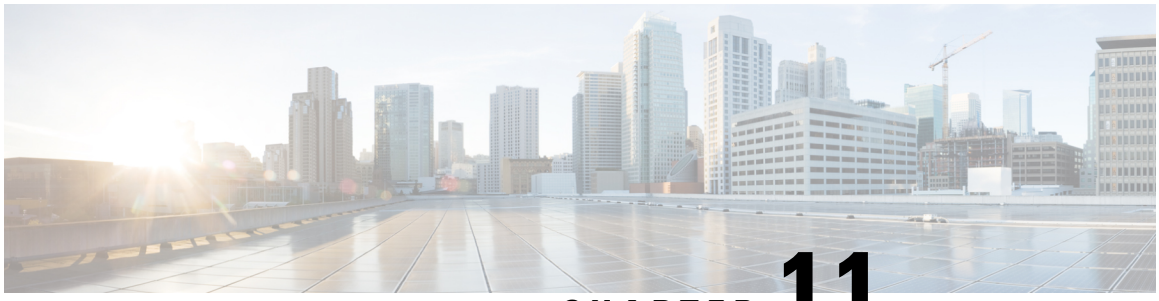
```
Device# show dot1x all
Sysauthcontrol              Enabled
Dot1x Protocol Version      2
Dot1x Info for FastEthernet1
-----------------------------------
PAE                         = AUTHENTICATOR
PortControl                 = AUTO
ControlDirection            = Both
HostMode                    = MULTI_HOST
ReAuthentication            = Disabled
QuietPeriod                 = 60
ServerTimeout               = 30
SuppTimeout                 = 30
ReAuthPeriod                = 3600 (Locally configured)
ReAuthMax                   = 2
MaxReq                      = 2
TxPeriod                    = 30
RateLimitPeriod             = 0
```

Verify the authentication type

To display the authentication state of an AP profile, use the following command:

```
Device#show ap profile default-ap-profile detailed
        AP Profile Name        : default-ap-profile
        Description            : default ap profile
        …
        Dot1x EAP Method       : [EAP-FAST/EAP-TLS/EAP-PEAP/Not-Configured]
        LSC AP AUTH STATE      : [CAPWAP DTLS / DOT1x port auth / CAPWAP DTLS + DOT1x port
```

```
auth
```



CHAPTER 11

Real-Time Access Points Statistics

•
• Access point real-time statistics, on page 93
• SNMP traps and intervals for APs, on page 94
• Restrictions for AP radio monitoring statistics, on page 94
• Configure access point real time statistics (GUI), on page 94
• Configure access point real-time statistics (CLI), on page 95
• Configure the access point radio monitoring statistics (CLI), on page 97
• Monitor access point real-time statistics (GUI), on page 98
• Verify access point real-time statistics, on page 99

Access point real-time statistics

An access point real-time statistic is a tool that

- allows tracking of CPU utilization and memory usage of an AP,
- monitors the health of an AP, and
- generates real-time statistics from an AP.

Feature history

Release	Feature	Feature information
Cisco IOS XE 17.7.1	Real time access point statistics	The system implements this feature with AP threshold values between 0 and 50. From Cisco IOS XE Cupertino 17.7.1 onwards, you can reset radios based on the AP's real-time statistics. If Tx or Rx counters do not increment during a sampling period, a radio reset is triggered. The following commands are introduced: • **show wireless stats ap join summary** • **show wireless stats ap history**

Release	Feature	Feature information
Cisco IOS XE 17.5.1	Real time access point statistics	Starting from Cisco IOS XE 17.5.1, you can monitor both CPU utilization and memory usage to assess the health of an AP through generated real-time statistics.

Supporting reference information

SNMP traps are sent out when the threshold is crossed. The sampling period and statistics interval can be configured using SNMP, YANG, and CLI.

From Cisco IOS XE 17.7.1 release onwards, for radio monitoring, you can reset the radios based on the statistics sent by the AP for a sampling period. When you configure the radios in the controller, if there is no increment in the Tx or Rx statistics when the radio is up, then the radio reset is triggered.

SNMP traps and intervals for APs

AP real-time statistics support these capabilities:

- SNMP Traps: Triggers notifications when CPU or memory usage crosses configured thresholds for APs and controllers.
- Sampling Period and Statistics Interval: Can be configured using SNMP, YANG, and CLI to control how often statistics are collected and reported.

Restrictions for AP radio monitoring statistics

You cannot reset the radio firmware from the controller. The controller will shut and then restart the radio if the Rx or Tx count does not increase for a radio slot within a specified period.

Configure access point real time statistics (GUI)

This task helps you configure real-time statistics for access points using a graphical user interface, allowing you to effectively monitor and manage AP behavior.

Procedure

Step 1 Choose **Configuration > Tags & Profiles > AP Join**.

Step 2 Click **Add**. The **Add AP Join Profile** page is displayed.

Step 3 Under the **AP** tab, click the **AP Statistics** tab.

Step 4 In the **System Monitoring** section:

- Enable **Monitor Real Time Statistics** to get calculated statistics and alarms of the AP.
- To receive an alarm when the upper threshold is surpassed for parameters such as CPU utilization and memory, enable **Trigger Alarm for AP**.

- Enter the threshold percentage for CPU and memory usage in the **CPU Threshold to Trigger Alarm** field and **Memory Threshold to Trigger Alarm** fields, respectively. The valid range is between 0 and 50. An SNMP trap is sent out when this threshold is crossed.
- In the **Interval to Hold Alarm** field, enter the time for which the alarm is held before it gets triggered. The range is between 0 and 3600 seconds.
- In the **Trap Retransmission Time** field, enter the time between retransmissions of the alarm. The range is between 0 and 65,535 seconds.
- To define how often data should be collected from the AP, enter a value in the **Sampling Interval** field. The range is between 720 and 3600 seconds.
- To define the interval at which AP statistics are to be calculated, enter a value in the **Statistics Interval** field. The range is between 2 and 900 seconds.
- To automatically reload the AP when there is high CPU and memory usage in the defined sampling interval, select the **Reload the AP** check box.

Step 5 Under the **Radio Monitoring** section:

- Select the **Monitoring of AP Radio stuck** check box to verify that the Tx and Rx statistics of the AP are updated each time the payloads are coming in from the AP to the controller.
- To generate an alarm for the radio of the AP when there is no increment in the Tx and RX statistics for the payloads, select the **Alarms for AP Radio stuck** check box.
- Select the **Reset the stuck AP Radio** check box to recover the radio from the bad state. A radio admin state payload will be sent from the controller to toggle the radio and the radio will be shut when there is no increment in the Tx and Rx statistics.
- To define how often data should be collected from the radio, enter a value in the **Sampling Interval** field. The valid range is between 720 and 3600 seconds.

Step 6 Click **Apply to Device** to save the configuration.

The AP monitors real-time statistics and triggers alarms based on defined thresholds to aid you in efficiently managing AP resources.

Configure access point real-time statistics (CLI)

This task provides instructions on how to configure real-time statistics for an access point using CLI commands.

This task is intended for network administrators who need to monitor and configure various system parameters on a Cisco access point, particularly real-time statistics related to performance monitoring.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the AP profile. The default AP join profile name is *default-ap-profile*.

Example:

```
Device(config)# ap profile doc-test
```

Step 3 (Optional) Configure the statistics timer.

Example:

```
Device(config-ap-profile)# stats-timer 60
```

This step configures the interval for the statistics reports coming from the AP, with values ranging from 0 to 65535 seconds.

Step 4 (Optional) Enable monitoring for AP system.

Example:

```
Device(config-ap-profile)# statistics ap-system-monitoring enable
```

Step 5 Enable alarms for AP system monitoring.

Example:

```
Device(config-ap-profile)# statistics ap-system-monitoring alarm-enable
```

Step 6 Define the hold time for system monitoring alarms on the AP.

Example:

```
Device(config-ap-profile)# statistics ap-system-monitoring alarm-hold-time 400
```

The values range from 0 to 3600 seconds.

Step 7 Define the retransmission interval for the trap alarms.

Example:

```
Device(config-ap-profile)# statistics ap-system-monitoring alarm-retransmit-time 100
```

Set the interval, with values from 0 to 65535 seconds, for retransmitting trap alarms when conditions persist.

Step 8 Define the CPU usage threshold for the AP to trigger alarms.

Example:

```
Device(config-ap-profile)# statistics ap-system-monitoring cpu-threshold 90
```

Note
From Cisco IOS XE 17.7.1 release onwards, the threshold value for triggering alarms is from 0 to 100%.

Step 9 Define the memory usage threshold on the AP to trigger alarms.

Example:

```
Device(config-ap-profile)# statistics ap-system-monitoring mem-threshold 90
```

The percentage threshold for memory usage on the AP to trigger is from 0 to 100%.

Note
From Cisco IOS XE 17.7.1 release onwards, the memory usage threshold to trigger alarms ranges from 0 to 100%.

Step 10 (Optional) Configure the statistics sampling interval.

Example:

```
Device(config-ap-profile)# statistics ap-system-monitoring sampling-interval 600
```

The interval can range from 2 to 65535 seconds.

Step 11 Exit from AP profile configuration mode and return to global configuration mode.

Example:

```
Device(config-ap-profile)# exit
```

Step 12 Enable sending AP-related trap flags for statistics that exceed set thresholds.

Example:

```
Device(config)# trapflags ap ap-stats
```

Traps are sent when statistics exceed the configured thresholds, enabling alerts and automated responses.

The statistics of the access point have been configured, enabling real-time monitoring and alarm triggering for system performance parameters.

```
                Device(config)# ap profile default-policy-profile
                Device(config-ap-profile)# statistics ap-system-monitoring enable
               Device(config-ap-profile)#statistics ap-system-monitoring sampling-interval
 600
                Device(config-ap-profile)#statistics ap-system-monitoring alarm-enable
                Device(config-ap-profile)#statistics ap-system-monitoring alarm-hold-time
3
                Device(config-ap-profile)#statistics ap-system-monitoring
alarm-retransmit-time 10
                Device(config-ap-profile)#statistics ap-system-monitoring cpu-threshold 90
                Device(config-ap-profile)#statistics ap-system-monitoring mem-threshold 90
                Device(config)# trapflags ap ap-stats
```

Configure the access point radio monitoring statistics (CLI)

Learn how to configure monitoring statistics for AP radios to enable stuck radio statistics, alarms, and actions for optimal performance.

These steps help configure AP radio monitoring statistics:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an AP profile and enter the AP profile configuration mode.

Example:

```
Device(config)# ap profile test1
```

Step 3 Enable the monitoring of AP radio stuck statistics.

Example:

```
(config-ap-profile)#statistic ap-radio-monitoring enable
```

Step 4 Enable the alarm for AP radio stuck statistics.

Example:

```
(config-ap-profile)#statistic ap-radio-monitoring alarm-enable
```

Step 5 Specify the sampling interval in seconds.

Example:

```
(config-ap-profile)# statistic ap-radio-monitoring action reload-ap interval850
```

The values range from 720 to 3,600 seconds.

Step 6 Generate an alarm and reset the radio if the radio is stuck.

Example:

```
(config-ap-profile)# statistic ap-radio-monitoring action radio-reset
```

Step 7 Reload the AP.

Example:

```
(config-ap-profile)# statistic ap-system-monitoring action reload-ap
```

The AP radio monitoring statistics help identify stuck radios and automatically take corrective actions to ensure optimal performance.

```
Device(config)# ap profile test1
Device(config-ap-profile)# statistics ap-radio-monitoring enable
Device(config-ap-profile)#statistic ap-radio-monitoring alarm-enable
Device(config-ap-profile)#statistic ap-radio-monitoring sampling-interval 750
Device(config-ap-profile)# statistic ap-radio-monitoring action radio-reset
Device(config-ap-profile)#statistic ap-system-monitoring action reload-ap
```

Monitor access point real-time statistics (GUI)

This task enables network administrators to monitor access point performance and diagnose potential issues by viewing real-time statistics.

Procedure

Step 1 Choose **Monitoring** > **Wireless** > **AP Statistics**.

Step 2 Click the **General** tab.

Step 3 Click an AP name. The **General** window is displayed.

Step 4 To view the AP Statistics data, click the **AP Statistics** tab.

These types of information are displayed:

- **Memory alarm last send time**: Displays the time of the last memory trap sent.
- **Memory Alarm Status**: Displays the state of the memory alarm. An alarm can be **ACTIVE**, **INACTIVE**, **INACTIVE_SOAKING**, **ACTIVE_SOAKING**. An alarm is soaked until the configured hold time has passed.
- **Memory alarm raise time**: Displays the last time the memory alarm was active.
- **Memory alarm clear time**: Displays the last time the memory alarm was inactive.
- **Last statistics received**: Displays the time of the last statistics report received from the AP.
- **Current CPU Usage**: Displays the latest percentage of CPU usage reported.
- **Average CPU Usage**: Displays the average CPU usage calculated.
- **Current Memory Usage**: Displays the latest percentage of memory usage reported.
- **Average Memory Usage**: Displays the average memory usage calculated.
- **Current window size**: Displays the window size. The window size is calculated by dividing the statistics interval by the sampling interval. The average CPU and memory usage is calculated by the window size.
- **CPU alarm last send time**: Displays the time of the last CPU trap sent.
- **CPU Alarm Status**: Displays the state of the CPU alarm. An alarm can be **ACTIVE**, **INACTIVE**, **INACTIVE_SOAKING**, **ACTIVE_SOAKING**. An alarm is soaked until the configured hold time has passed.
- **CPU alarm raise time**: Displays the last time the CPU alarm was active.
- **CPU alarm clear time**: Displays the last time the CPU alarm was inactive.

Step 5 Click **OK**.

The current statistics for the selected access point are displayed, allowing for comprehensive monitoring and analysis of AP performance metrics.

Verify access point real-time statistics

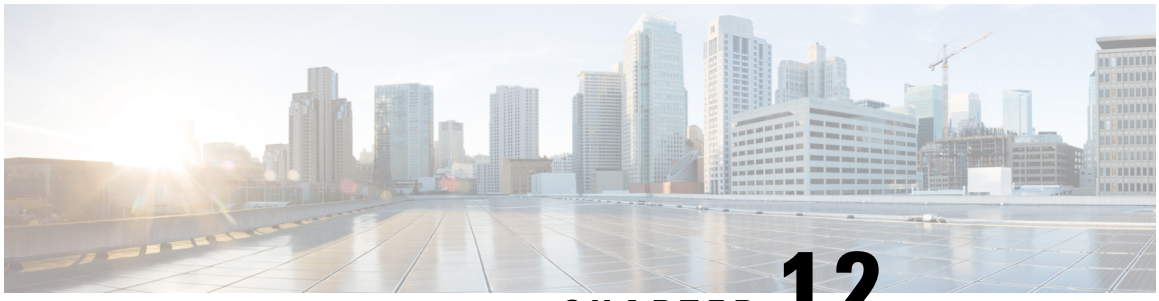
To verify AP real-time statistics, run this command:

```
Device# show ap config general | section AP statistics
!Last Statistics
AP statistics : Enabled
Current CPU usage : 4
Average CPU usage : 49
Current memory usage : 35
Average memory usage : 35
Last statistics received : 03/09/2021 15:25:08
!Statistics Configuration
Current window size : 1
Sampling interval : 30
Statistics interval : 300
AP statistics alarms : Enabled
!Alarm State - Active, Inactive, Inactive_Soaking, Inactive_Soaking
Memory alarm status : Active
```

```
Memory alarm raise time : 03/09/2021 15:24:29
Memory alarm clear time : NA
Memory alarm last send time : 03/09/2021 15:24:59
CPU alarm status : Inactive
CPU alarm raise time : 03/09/2021 15:24:25
CPU alarm clear time : 03/09/2021 15:25:05
CPU alarm last send time : 03/09/2021 15:25:05
!Alarm Configuration
Alarm hold time : 6
Alarm retransmission time : 30
Alarm threshold cpu : 30
Alarm threshold memory : 32
```

To verify that the statistics reporting period is accurate, run this command:

```
Device# show ap config general | i Stats Reporting Period
Stats Reporting Period : 10
```



CHAPTER 12

Access Point Tag Persistency

- AP tag persistency, on page 101
- Recommendation: Rejoin APs after enabling tag persistency, on page 102
- Requirement: Match tags across controllers, on page 102
- Tag persistency for redundancy scenarios, on page 102
- Configure access point tag persistency (GUI), on page 102
- Configure AP tag persistency (CLI), on page 104
- Verify AP tag persistency, on page 104

AP tag persistency

AP tag persistency is a configuration feature that

- allows mapped tags to be saved locally on APs
- enables APs to retain tag configurations when moving between controllers, and
- removes the need for reapplying tags individually on each AP.

Feature history for AP tag persistency

Table 5: Feature history for secure data wipe

Release	Feature	Feature Information
Cisco IOS XE 17.6.1	AP tag persistency	Global tag persistency configuration on the controller that automatically write tags on the APs.

Supporting reference information

- The feature is disabled by default and must be explicitly enabled on the controller.
- When enabled, any AP that joins a controller stores the mapped tags locally.

Recommendation: Rejoin APs after enabling tag persistency

After enabling AP tag persistency on a controller, ensure that all existing APs rejoin the controller for the configuration to take effect.

Requirement: Match tags across controllers

To retain tag configuration across different controllers:

- Ensure that the policy tag, site tag, and RF tag exist on all controllers an AP might connect to.
- If all three tags do not exist on a new controller, the AP will use default tags.
- Even if one or two tags exist, tag persistency can still apply using available tags.

Tag persistency for redundancy scenarios

Tag persistency helps in N+1 redundancy scenarios by ensuring that an AP retains its previously assigned tags when moving between controllers. This process assumes that the tags (policy, site, RF) exist on the secondary controller. If all required tags do not exist, the AP reverts to default tags. For more information, see "*New Configuration Model*" chapter in *Cisco Catalyst 9800 Series Wireless Controller Software Configuration Guide*.

Configure access point tag persistency (GUI)

The purpose of this task is to enable tag persistency on APs. It allows them to retain their tag mapping information without requiring individual configuration after reconnection.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags**.

Step 2 Click the **AP** tab.

Step 3 In the **Tag Source** tab, check the **Enable AP Tag Persistency** check box to configure AP Tag persistency globally.

When APs join a controller with the tag persistency enabled, the mapped tags are saved on the AP without having to write the tag configurations on each AP individually.

Step 4 Click **Apply to Device**.

The AP tag persistency is enabled, allowing access points to retain their tag configurations even after disconnections.

Save tags on an access point (GUI)

This task guides you on how to save tags, including policy, site, and RF tags, on an access point using the graphical user interface (GUI). Saving tags ensures the access point remembers its configuration across different controllers.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 Click an AP from the list.
The **Edit AP** page is displayed.

Step 3 Click the **General** tab.

Step 4 In the **Tags** section, specify the appropriate policy, site, and RF tags that you created in the **Configuration** > **Tags & Profiles** > **Tags** page.

Step 5 From the **Policy** drop-down list, select a value.

Step 6 From the **Site** drop-down list, select a value.

Step 7 From the **RF** drop-down list, select a value.

Step 8 Check the **Write Tag Config to AP** check box to push the tags to the AP so that the AP can save and remember this information even when the AP is moved from one controller to another.

Step 9 Click **Update & Apply to Device**.

The AP saves the specified tags and configurations, allowing seamless operation even if the AP is transferred between controllers.

Delete saved tags on an access point (GUI)

The purpose of this task is to guide you to delete saved tags on an access point through the GUI.

Use these steps to delete saved tags on an access point:

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 Click an AP from the list of APs.

The **Edit AP** window is displayed.

Step 3 In the **Edit AP** window, choose the **Advanced** tab.

Step 4 In the **Set to Factory Default** section, check the **Clear Resolved Tag Config** check box to clear the saved tags on an AP.

Step 5 Click **Update & Apply to Device**.

The access point is updated and all saved tags are cleared.

Configure AP tag persistency (CLI)

Configure AP tag persistency to ensure APs maintain their assigned tags when connecting to different controllers, which aids in redundancy scenarios.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure AP tag persistency

Example:

```
Device(config)# ap tag persistency enable
```

Step 3 Exit configuration mode and return to privileged EXEC mode.

Example:

```
Device(config)# end
```

After completing these steps, the AP tag persistency feature will be enabled on the controller, ensuring APs keep their tag assignments when moving to different controllers.

Verify AP tag persistency

To verify AP tag persistency in the primary controller, use this command:

```
Device# show ap tag summary
Number of APs: 1

AP Name         AP Mac           Site Tag Name         Policy Tag Name        RF Tag Name
           Misconfigured    Tag Source
-------------------------------------------------------------------------------------------
Cisco01_AP      xxxx.xxxx.xxxx   default-site-tag      OpenRoaming           default-rf-tag
          No               Static
```

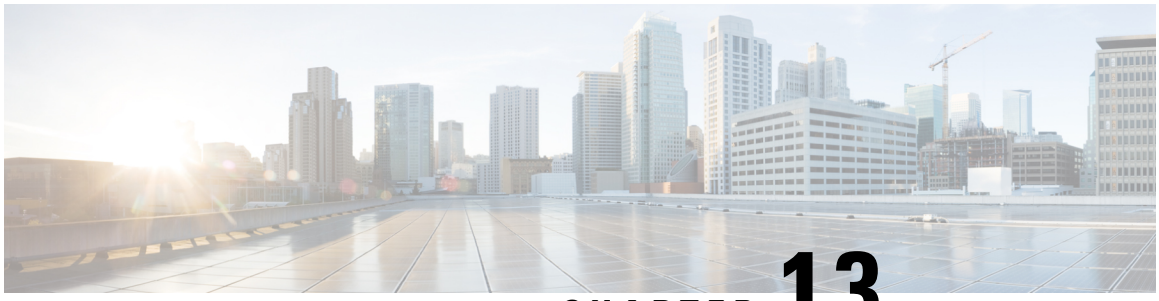
If the Tag Source displays **Static** or **Filter**, it means that the AP tag mappings were configured on the primary controller. If the source displays **Default**, it means that the AP received the default tags when joining the controller.

To verify the AP tag persistency in the secondary controller, use this command:

```
Device# show ap tag summary
Number of APs: 1

AP Name       AP Mac           Site Tag Name        Policy Tag Name     RF Tag Name
Misconfigured   Tag Source
-------------------------------------------------------------------------------------------
Cisco01_AP   xxxx.xxxx.xxxx    default-site-tag     OpenRoaming         default-rf-tag
 No              AP
```

If the Tag Source displays **AP**, it means that the policy tag, site tag, and RF tag match what was configured on the primary controller, indicating that the AP tags have persisted across controllers.



CHAPTER 13

LED States for Access Points

- LED states for APs, on page 107
- Configure the LED State on APs (GUI), on page 107
- Configure LED state for APs (CLI), on page 108
- Configure LED state in the AP profile, on page 109
- Verify LED state for APs, on page 109

LED states for APs

A LED state for access points is a configuration that

- allows the identification of specific access points in a LAN network
- can be configured globally or for individual APs, and
- prioritizes global configurations over individual AP settings.

Note When disabling the LED on an AP, the LED state that is controlled by the AP-Join profile.

To maintain the LED in a disabled state, it is recommended to create a separate AP-Join profile and Site Tag specifically for APs with the LED disabled.

Note For APs that have Ethernet LEDs in addition to the main system LED, the Ethernet LEDs are enabled or disabled (switched ON or OFF) as per the system LED. For example, if the system LED is ON, the Ethernet LED will also be ON.

Configure the LED State on APs (GUI)

Configure the LED state on access points to optimize visibility and performance using the GUI.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 Click an AP from the AP list.
The **Edit AP** window is displayed.

Step 3 In the **General** tab, under the General section, click the box adjacent to the **LED State** field to enable or disable the LED state.

Step 4 From the **LED Brightness Level** drop-down list, choose a value from 1 to 8.

Step 5 Click **Update & Apply to Device**.

The LED state and related settings on the access points are configured according to your selections, enhancing network device visibility or conserving energy.

Configure LED state for APs (CLI)

Configure the LED state for APs in the global configuration mode using commands.

Procedure

Step 1 Enable privileged EXEC mode.

Example:

```
Device> enable
```

Enter your password if prompted.

Step 2 Enable the LED state for APs, globally.

Example:

```
Device# ap name Cisco-AP-name led
```

Step 3 Configure the LED brightness level.

Example:

```
Device# ap name Cisco-AP-name led-brightness-level 4
```

The brightness value ranges from 1 to 8.

The LED state is successfully configured with adjusted brightness and flash settings according to commands executed.

Configure LED state in the AP profile

The task enables the LED state for all APs, ensuring active visual indicators across the network.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enter the AP profile configuration mode.

Example:

```
Device(config)#ap profile default-ap-profile
```

Step 3 Enable the LED-state for all APs.

Example:

```
Device(config-ap-profile)# led
```

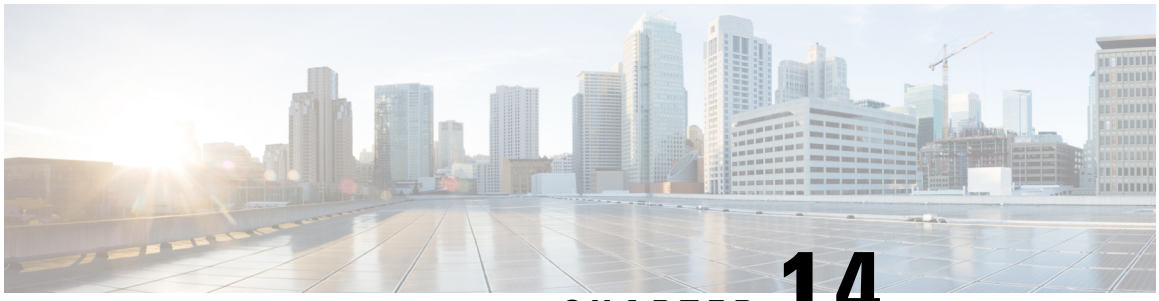
Verify that the LED status is visible on the access point, confirming successful configuration.

Verify LED state for APs

To verify the LED state of the APs, use this command

```
Device# show ap name AXXX-APXXXX.bdXX.f2XX config general
Cisco AP Name : AXXX-APXXXX.bdXX.f2XX
=====================================================
Cisco AP Identifier : 0cXX.bdXX.65XX
Country Code : Multiple Countries : FR,IN,US
Regulatory Domain Allowed by Country : 802.11bg:-AE 802.11a:-ABDEN
AP Country Code : US - United States
AP Regulatory Domain
802.11bg : -A
802.11a : -B
.
.
.
CAPWAP Preferred mode : IPv4
CAPWAP UDP-Lite : Not Configured
AP Submode : WIPS
Office Extend Mode : Disabled
Dhcp Server : Disabled
Remote AP Debug : Disabled
Logging Trap Severity Level : information
Logging Syslog facility : kern
Software Version : 17.X.0.XXX
Boot Version : 1.1.X.X
Mini IOS Version : 0.0.0.0
Stats Reporting Period : 180
```

```
LED State : Enabled
MDNS Group Id : 0
.
```



CHAPTER 14

Secure Data Wipe

- Feature history, on page 111
- Secure data wipe, on page 111
- Supported AP models and software versions, on page 112
- Verify data wipe, on page 113

Feature history

Table 6: Feature history for secure data wipe

Release	Feature	Feature Information
Cisco IOS XE Dublin 17.11.1	Secure data wipe	The Secure Data Wipe feature allows you to securely erase files from the file system of Cisco APs by using the **clear ap config** command.

Secure data wipe

Secure data wipe is a feature that

- securely erases files from the file system of Cisco APs using the **clear ap config** command
- stores basic information about the wipeout and its status, and
- helps verify and troubleshoot erased files.

Types of files securely erased

These files are securely erased, without possibility of recovery:

- Configuration and backup configuration files
- Crash files
- Log files
- Boot variables

- Package logs

Restrictions

Restriction for secure data wipe is as follows:

Data wipe for APs in Work Group Bridge mode can be done only through the mode button, which needs to be pressed for 20 to 60 seconds to remove storage content.

Supported AP models and software versions

Supported software versions

Cisco APs	Supported versions
Cisco Wave 1 APs	Cisco IOS XE 17.3, Cisco IOS XE 17.9.3 and its later versions, and Cisco IOS XE 17.12.
Cisco Wave 2 APs	Cisco IOS XE 17.11, Cisco IOS XE 17.12, and Cisco IOS XE 17.13.



Note Cisco Wave 1 APs are not supported in 17.4, 17.5, 17.6, 17.7, 17.8, 17.10 and later releases.

Supported AP models

Cisco IOS APs	Cisco COS APs	Cisco Catalyst APs
3700 (I/E/P)	3800 (I/E/P)	9162I 9164I 9166I 9166D1 9163E
2700 (I/E)	2800 (I/E)	9124AX (I/D/E)
1700I	1815 (I/W)	9136I
702W	1840 (I)	9130AX (I/E)
1532I/E	1850 (I/E)	9120AX (I/E)
1570	1830 (I/W)	9117AXI
—	1810	9115AX (I/E)
—	1800I	9105AX (I/W)

Cisco IOS APs	Cisco COS APs	Cisco Catalyst APs
—	1540	—
—	1560	—
—	4800	—

Verify data wipe

To verify the output of the data wipe, run the **show flash wipeout-log** AP command:

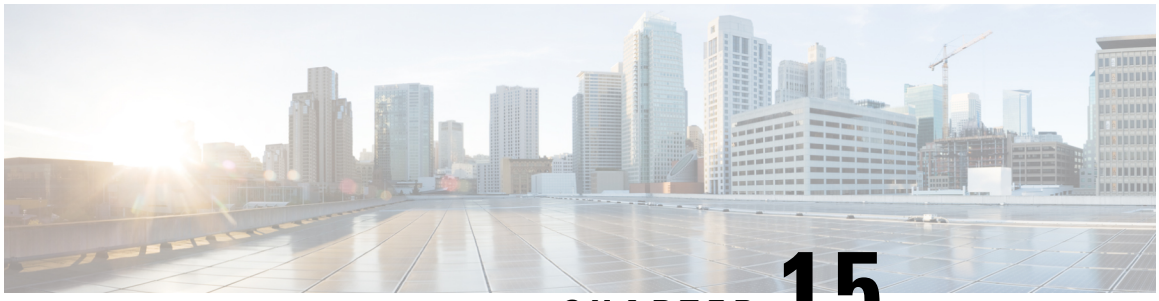
```
Cisco-AP# show flash wipeout-log
DATA SANITATION LOGS
Filesystem Name    :    Flash
Filesystem size    :    519 M (bytes)
Total Files        :    95
Data Wipe Time     :    Fri Mar  8 09:50:49 UTC 2024
Data Wipe method   :    CLEAR
Files cleared      :    92
Bytes cleared      :    5484544 (bytes)
Total Free byte    :    458846208 (bytes)
Device PID         :    C9130AXI-E
Serial number      :    KWC233202MN
Data Wipe Status   :    SUCCESS
```



PART III

Radio Resource Management

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CHAPTER 15

Radio Resource Management

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Radio resource management

A Radio Resource Management (RRM) is a system that

- consistently manages real-time RF parameters of a wireless network
- monitors associated APs for traffic load, interference, noise, coverage, and other metrics,
- performs critical functions like radio resource monitoring, power control transmission, dynamic channel assignment, and coverage hole detection and correction.

Feature history

Table 7: Feature history table for radio resource management

Feature name	Release information	Feature description
Radio resource management	Cisco IOS XE 16.10.1	Radio Resource Management (RRM) is a feature that automates and optimizes the management of radio frequencies in a wireless network. It enables continuous monitoring of access points (APs) for metrics such as traffic load, interference, noise, and coverage.

Functions of radio resource management

- Radio Resource Monitoring: Ensures optimal allocation of network resources.
- Power Control Transmission: Adjusts power levels to maintain network performance.
- Dynamic Channel Assignment: Allocates channels dynamically to reduce interference and optimize network performance.
- Coverage Hole Detection and Correction: Identifies and rectifies gaps in coverage to ensure consistent connectivity.
- RF Grouping: Groups RF resources effectively to manage interference and optimize performance.

Radio resource monitors

Radio resource monitor is a system that

- detects and configures new devices and APs automatically
- adjusts associated APs for optimal coverage and capacity, and
- supports noise and interference monitoring.
- APs scan all the valid channels for the country of operation as well as for channels available in other locations.
- The APs in local mode go *offchannel* for a period not greater than 70 ms to monitor these channels for noise and interference.
- Packets collected during this time are analyzed to detect rogue APs, rogue clients, ad-hoc clients, and interfering APs.
- In the presence of voice traffic or other critical traffic (in the last 100 ms), APs can defer off-channel measurements. The APs also defer off-channel measurements based on the WLAN scan priority configurations.
- Each AP spends only 0.2 percent of its time off channel. This activity is distributed across all the APs so that adjacent APs are not scanning at the same time, which could adversely affect wireless LAN performance.

Mobility controller and mobility agent

Transmit power control

A transmit power control is an automation algorithm that:

- increases and decreases an access point's power dynamically
- responds to changes in the RF coverage environment, and
- provides enough RF power to achieve the required coverage levels while avoiding channel interference.

This feature is different from coverage hole detection, which is primarily concerned with clients.

- TPC provides enough RF power to achieve the required coverage levels while avoiding channel interference between APs. We recommend that you select TPCv1; TPCv2 option is deprecated.
- With TPCv1, you can select the channel aware mode; we recommend that you select this option for 5 GHz, and leave it unchecked for 2.4 GHz.

Override the TPC algorithm with minimum and maximum transmit power settings

A Transmit Power Control (TPC) minimum and maximum transmit power setting is a wireless network configuration option that

- defines the allowed range of RF transmit powers for APs
- overrides the automatic power adjustment recommendations of the TPC algorithm, and
- applies settings globally to APs through RF profiles.

The TPC (Transmit Power Control) algorithm automatically balances RF power in various environments. Occasionally, site or architectural constraints require manually overriding TPC recommendations. With minimum and maximum power settings, you ensure APs do not exceed or fall below specific transmit powers, regardless of TPC or automatic adjustments or coverage hole detection.

Each AP model and each regulatory domain has its own allowed power levels. The increments vary: Cisco APs use 3 dB increments, but settings can be chosen in 1 dB increments and rounded.

To set the Maximum Power Level Assignment and Minimum Power Level Assignment, enter the maximum and minimum transmit power used by RRM in the fields in the **Tx Power Control** window. The range for these parameters is from –10 to 30 dBm. The minimum value cannot be greater than the maximum value; the maximum value cannot be less than the minimum value.

If you configure a maximum transmit power, RRM does not allow any access point attached to the controller, to exceed this transmit power level (whether the power is set by RRM TPC or by coverage hole detection). For example, if you configure a maximum transmit power of 11 dBm, no AP will transmit above 11 dBm unless the AP is configured manually.

Dynamic channel assignment

A dynamic channel assignment (DCA) is a wireless LAN management technique that

- automatically evaluates radio frequency (RF) conditions and network utilization
- dynamically allocates channels among APs to minimize interference and maximize performance, and
- continuously updates channel assignments based on system-wide RF analytics and policies.

Features of DCA

Features of DCA are:

- **Dynamic channel allocation**: DCA dynamically assigns channels to APs to avoid conflicts and interference, improving network capacity and performance. Two adjacent APs on the same channel can cause signal contention or collision. In a collision, data is not received by the AP. For example, reading an e-mail in a café can affect the performance of an AP in a neighboring business.

  Even though these are separate networks, someone sending traffic to the café on channel 1 can disrupt communication in an enterprise using the same channel. Devices can dynamically allocate AP channel assignments to avoid conflict and increase capacity and performance.

- **Channel reuse**: Efficiently reuses channels by assigning the same channel to APs that are physically far apart, maximizing scarce RF resources. In other words, channel 1 is allocated to a different AP far from the café, which is more effective than not using channel 1 altogether.

- **Adjacent channel separation**: The device's DCA capabilities are also useful in minimizing adjacent channel interference between APs.

  For example, two overlapping channels in the 802.11b/g band, such as 1 and 2, cannot simultaneously use 11 or 54 Mbps. By effectively reassigning channels, the device keeps adjacent channels separated.

Channel assignments

The device examines a variety of real-time RF characteristics to efficiently handle channel assignments.

- AP received energy: The received signal strength measured between each AP and its nearby neighboring AP. Channels are optimized to give you the highest network capacity.
- Noise: Noise can limit signal quality for your devices and APs. Increased noise reduces cell size and degrades user experience. By optimizing channels to avoid noise sources, the device helps you maintain coverage and system capacity. If a channel is unusable due to excessive noise, that channel can be avoided.
- 802.11 interference: Interference is any 802.11 traffic that is not a part of your wireless LAN, including rogue APs and neighboring wireless networks. Lightweight APs automatically scan all channels to detect interference sources. If the amount of 802.11 interference exceeds a predefined configurable threshold (the default is 10 percent), the AP sends an alert to the device. Using the RRM algorithms, the device may then dynamically rearrange channel assignments to increase system performance in the presence of the interference. Such an adjustment could result in adjacent lightweight APs being on the same channel, but this setup provides better performance than keeping APs on a channel made unusable by interference.

  In addition, if other wireless networks are present, the device shifts the usage of channels to complement the other networks. For example, if one network is on channel 6, an adjacent wireless LAN is assigned to channel 1 or 11. This arrangement increases the capacity of the network by limiting the sharing of frequencies. If a channel has virtually no capacity remaining, the device may choose to avoid this channel. In huge deployments in which all nonoverlapping channels are occupied, the device does its best, but you must consider RF density when setting expectations.

- Load and utilization: When utilization monitoring is enabled, capacity calculations can consider that some APs are deployed in ways that carry more traffic than other APs, for example, a lobby versus an engineering area. The device can then assign channels to improve the AP that has performed the worst. The load is taken into account when changing the channel structure to minimize the impact on the clients that are currently in the wireless LAN. This metric keeps track of every AP's transmitted and received packet counts to determine how busy the APs are. New clients avoid an overloaded AP and associate to a new AP. This *Load and utilization* parameter is disabled by default.

The device combines this RF characteristic information with RRM algorithms to make system-wide decisions. Conflicting demands are resolved using soft-decision metrics that guarantee the best choice for minimizing network interference. The result is optimal channel configuration across three dimensions. APs located on different floors play an important role in your wireless LAN configuration.

RRM startup mode

The RRM startup mode is invoked under these conditions:

- In a single- device environment, the RRM startup mode is invoked after the device is upgraded and rebooted.
- In a multiple- device environment, the RRM startup mode is invoked after an RF Group leader is elected.
- You can trigger the RRM startup mode using the **ap dot11 {24ghz | 5ghz | 6ghz} rrm dca restart** command.

The RRM startup mode runs for 100 minutes (ten iterations at ten-minute intervals). The duration of the RRM startup mode is independent of the DCA interval, sensitivity, and network size. The startup mode consists of ten DCA runs with high sensitivity (making channel changes easy and sensitive to the environment) to converge to a steady-state channel plan. DCA continues to run at the specified interval and sensitivity after the startup mode is finished.

Coverage hole detection and correction

A coverage hole detection and correction algorithm is a wireless LAN management mechanism that

- identifies areas with insufficient radio coverage for reliable performance
- alerts administrators when access points fail to provide adequate coverage, and
- adjusts AP transmit power to mitigate correctable coverage holes.

If clients on a lightweight AP are detected at threshold levels such as RSSI, failed client count, percentage of failed packets, and number of failed packets that are lower than those specified in the RRM configuration, the AP sends a “coverage hole” alert to the device. The alert indicates that clients cannot connect to a usable AP because of poor signal coverage.

The device discriminates between coverage holes that can and cannot be corrected. For coverage holes that can be corrected, the device mitigates the coverage hole by increasing the transmit power level for that specific AP.

The device does not mitigate coverage holes caused by clients that are unable to increase their transmit power or are statically set to a power level. Increasing downstream transmit power could increase interference in the network.

Restrictions

The restrictions for RRM are:

- If an AP tries to join the RF-group that already holds the maximum number of APs it can support, the device rejects the application and throws an error.
- RRM grouping does not occur when an AP operates in a static channel that is not in the DCA channel list. The Neighbor Discovery Protocol (NDP) is sent only on DCA channels; therefore, when a radio operates on a non-DCA channel, it does not receive NDP on the channel.

How to Configure RRM

Configure neighbor discovery type (CLI)

Specify how neighbor discovery packets are handled on each radio band.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the neighbor discovery type for the desired radio band.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm ndp-type {protected | transparent}
```

The NDP types are:

- **protected**: Use **protected** to encrypt discovery packets.
- **transparent**: Use **transparent** to send packets as is (default).

Step 3 Return to privileged EXEC mode by ending the configuration mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

The neighbor discovery type for the specified band is set.

Configuring Transmit Power Control

Configure Tx-power control threshold (CLI)

Set the Tx-power control threshold to define the minimum received signal strength at which the device adjusts its transmit power.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the Tx-power control threshold used by RRM for auto power assignment.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz | 6ghz} rrm tpc-threshold threshold_value
```

The range is from –80 dBm to –50 dBm.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

You can also press **Ctrl-Z** to exit global configuration mode.

The Tx-power control threshold is updated, enabling the device to adjust its transmit power according to the specified threshold.

```
Device# configure terminal
Device(config)# ap dot11 24ghz rrm tpc-threshold -60
Device(config)# end
```

Configure the Tx-power level (CLI)

Set the transmit power level of the wireless AP to improve wireless coverage and signal strength.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the 802.11 Tx-power level.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm txpower {trans_power_level | auto | max | min
| once}
```

The Tx-power parameters are:

- **trans_power_level**: Sets the transmit power level.
- **auto**: Enables auto-RF.
- **max**: Configures the maximum auto-RF Tx-power.
- **min**: Configures the minimum auto-RF Tx-power.
- **once**: Enables one-time auto-RF.

Step 3 **end**

Example:

```
Device(config)# end
```

Return to privileged EXEC mode.

Configuring 802.11 RRM Parameters

Configure 802.11 channel assignment parameters (CLI)

Configure DCA and related parameters on 802.11 radios.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure CleanAir event-driven RRM parameters.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm channel cleanair-event sensitivity {high | low
 | medium}
```

The types of sensitivity are:

- **High** : Specifies the most sensitivity to non-Wi-Fi interference as indicated by the air quality (AQ) value.
- **Low** : Specifies the least sensitivity to non-Wi-Fi interference as indicated by the AQ value.
- **Medium** : Specifies medium sensitivity to non-Wi-Fi interference as indicated by the AQ value.

Step 3 Configure DCA algorithm parameters for the 802.11 band.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm channel dca {add channel-number | anchor-time
| global {auto | once} | interval | min-metric | remove channel-number | sensitivity {high
 | low | medium}}
```

The DCA algorithm parameters include:

- : Enter a channel number to be added to the DCA list.
- **anchor-time**: Configures the anchor time for DCA. The range is from 0 to 23 hours.
- **global**: Configures the DCA mode for all 802.11 Cisco APs.
  - **auto**: Enables auto-RF.
  - **once**: Enables auto-RF only once.
- **interval**: Configures the DCA interval value. The values are 1, 2, 3, 4, 6, 8, 12 and 24 hours, and the default value 0 denotes 10 minutes.
- **min-metric**: Configures the DCA minimum RSSI energy metric. The range is from -100 to -60.
- **sensitivity**: Configures the DCA sensitivity level to changes in the environment.
  - **high**: Specifies the most sensitivity.
  - **low**: Specifies the least sensitivity.
  - **medium**: Specifies medium sensitivity.

Step 4 Configure the DCA channel bandwidth for all 802.11 radios in the 5-GHz band.

Example:

```
Device(config)# ap dot11 5ghz rrm channel dca chan-width {20 | 40 | 80}
```

The channel bandwidth can be set to 20 MHz, 40 MHz, or 80 MHz, . The default value for channel bandwidth is 20 MHz (80 MHz is the default value for Best). Set the channel bandwidth to Best before configuring the constraints.

The 802.11 channel assignment parameters are configured.

What to do next

Configure the advanced channel assignment parameters.

Configure the advanced channel assignment parameters (CLI)

Procedure

Step 1 Configure the persistent non-Wi-Fi device avoidance in the 802.11 channel assignment.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm channel device
```

Step 2 Configure the foreign AP 802.11 interference avoidance in the channel assignment.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm channel foreign
```

Step 3 Configure the Cisco AP 802.11 load avoidance in the channel assignment.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm channel load
```

Step 4 Configure noise avoidance in 802.11 channel assignment.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm channel noise
```

Step 5 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

You can also press **Ctrl-Z** to exit global configuration mode.

The 802.11 advanced channel assignment parameters are configured.

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm channel noise
  Device(config)# end
```

Configure 802.11 coverage hole detection (CLI)

Set up coverage hole detection for your wireless network.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the 802.11 coverage hole detection for data packets.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm coverage data {fail-percentage | packet-count
| rssi-percentage} value
```

The attributes for the data packets are:

- **fail-percentage**: Configures the 802.11 coverage failure rate threshold for uplink data packets as a percentage that ranges from 1 to 100 percent.
- **packet-count**: Configures the 802.11 coverage minimum failure count threshold for uplink data packets that ranges from 1 to 255.
- **rssi-threshold**: Configures the 802.11 minimum receive coverage level for data packets that range from –90 dBm to –60 dBm.

Step 3 Configure the 802.11 AP coverage exception level as a percentage that ranges from 0 to 100 percent.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm coverage exception global exception-level
```

Step 4 Set the minimum exception level for AP clients.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm coverage level global cli_min exception level
```

The value range is from 1 to 75 clients.

Step 5 Configure the 802.11 coverage hole detection for voice packets.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm coverage voice { fail-percentage |  packet-count
 | rssi-threshold} value
```

The attributes for voice packets are:

- **fail-percentage**: Configures the 802.11 coverage failure rate threshold for uplink voice packets as a percentage that ranges from 1 to 100 percent.
- **packet-count**: Configures the 802.11 coverage minimum failure count threshold for uplink voice packets that ranges from 1 to 255.
- **rssi-threshold**: Configures the 802.11 minimum receive coverage level for voice packets that range from –90 dBm to –60 dBm.

Step 6 Return to privileged EXEC mode to complete configuration.

Example:

```
Device(config)# end
```

ress **Ctrl-Z** to exit global configuration mode.

After you configure coverage hole detection thresholds, the wireless APs monitor your network and send alerts about coverage gaps.

```
Device# configure terminal
Device(config)# ap dot11 24ghz rrm coverage data fail-percentage 60
Device(config)# ap dot11 6ghz rrm coverage data fail-percentage 60
Device(config)# ap dot11 24ghz rrm coverage exception global 50
Device(config)# ap dot11 24ghz rrm coverage level global 10
Device(config)# ap dot11 24ghz rrm coverage voice packet-count 10

Device(config)# end
```

Configure 802.11 event logging (CLI)

Enable and customize event logging for 802.11 wireless network parameters.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure event logging for various parameters.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm logging {channel | coverage | foreign | load |
 noise | performance | txpower}
```

The event logging parameters include:

- **channel**: Configures the 802.11 channel change logging mode.
- **coverage**: Configures the 802.11 coverage profile logging mode.
- **foreign**: Configures the 802.11 foreign interference profile logging mode.
- **load**: Configures the 802.11 load profile logging mode.
- **noise**: Configures the 802.11 noise profile logging mode.
- **performance**: Configures the 802.11 performance profile logging mode.
- **txpower**: Configures the 802.11 transmit power change logging mode.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

You can also press **Ctrl-Z** to exit global configuration mode.

You have enabled 802.11 event logging for the specified parameters.

```
Device# configure terminal
Device(config)# ap dot11 {24ghz | 5ghz} rrm logging {channel | coverage | foreign | load |
 noise | performance | txpower}

Device(config)# end
```

Configure 802.11 statistics monitoring (CLI)

Enable or customize the monitoring of 802.11 statistics on wireless APs.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Set the 802.11 monitoring channel-list for parameters such as noise/interference/rogue.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm monitor channel-list {all | country | dca}
```

The channel list parameters include:

- **all**: Monitors all channels.
- **country**: Monitor channels used in configured country code.
- **dca**: Monitor channels used by dynamic channel assignment.

Step 3 Configure the 802.11 coverage measurement interval in seconds, which ranges from 60 to 3,600.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm monitor coverage interval
```

Step 4 Configure the 802.11 load measurement interval in seconds, which ranges from 60 to 3,600.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm monitor load interval
```

Step 5 Configure the 802.11 noise measurement interval (channel scan interval) in seconds, which ranges from 60 to 3,600.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm monitor noise interval
```

Step 6 Configure the 802.11 signal measurement interval (neighbor packet frequency) in seconds, which ranges from 60 to 3,600.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm monitor signal interval
```

Step 7 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

You can also press **Ctrl-Z** to exit global configuration mode.

The system applies your 802.11 statistics monitoring settings to the APs.

```
Device# configure terminal
Device(config)# ap dot11 24ghz rrm monitor channel-list all
Device(config)# ap dot11 24ghz rrm monitor coverage 600
Device(config)# ap dot11 24ghz rrm monitor load 180
Device(config)# ap dot11 24ghz rrm monitor noise 360
Device(config)# ap dot11 24ghz rrm monitor signal 480
Device(config)# end
```

Configure the 802.11 performance profile (CLI)

Configure threshold values for 802.11 performance parameters, including clients, interference, noise, throughput, and RF utilization, on Cisco APs.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Set the threshold value for 802.11 Cisco AP clients, which ranges from 1 to 75 clients.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm profile clients cli_threshold_value
```

Step 3 Set the threshold value for 802.11 foreign interference, which ranges from 0 to 100 percent.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm profile foreign int_threshold_value
```

Step 4 Set the threshold value for 802.11 foreign noise, which ranges from –127 to 0 dBm.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm profile noise for_noise_threshold_value
```

Step 5 Set the threshold value for 802.11 Cisco AP throughput, which ranges from 1000 to 10000000 bytes per second.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm profile throughput throughput_threshold_value
```

Step 6 Set the threshold value for 802.11 RF utilization, which ranges from 0 to 100 percent.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} rrm profile utilization rf_util_threshold_value
```

Step 7 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The AP's performance profile is updated with your specified threshold values, enabling automated monitoring and adjustment of wireless network conditions according to configured criteria.

```
Device# configure terminal
Device(config)# ap dot11 24ghz rrm profile clients 20
Device(config)# ap dot11 24ghz rrm profile foreign 50
Device(config)# ap dot11 24ghz rrm profile noise -65
Device(config)# ap dot11 24ghz rrm profile throughput 10000

Device(config)# ap dot11 24ghz rrm profile throughput 10000
```

```
Device(config)# ap dot11 24ghz rrm profile utilization 75
Device(config)# end
```

Configuring Advanced 802.11 RRM

Enable channel assignment (CLI)

To optimize radio resource allocation, assign wireless channels to 802.11 APs.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device# enable
```

Step 2 Enable the 802.11 channel selection update for each AP.

Example:

```
Device# ap dot11 {24ghz | 5ghz} rrm channel-update
```

Note
After enabling the feature, the DCA algorithm assigns a token for channel assignment.

The system applies the DCA algorithm to update wireless channel assignments on all APs for the specified frequency.

```
Device# enable
Device# ap dot11 24ghz rrm channel-update
```

Restart DCA operation

To restore optimal channel allocation for wireless radios, restart the Dynamic Channel Assignment (DCA).

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device# enable
```

Step 2 Restart the DCA cycle for the 802.11 radio.

Example:

```
Device# ap dot11 {24ghz | 5ghz } rrm dca restart
```

The DCA process restarts on the wireless device.

```
Device# enable
Device# ap dot11 24ghz rrm dca restart
```

Update power assignment parameters (CLI)

Adjust the wireless transmit power settings for APs to optimize coverage and performance.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device# enable
```

Step 2 Update the 802.11 transmit power for each of the APs.

Example:

```
Device# ap dot11 {24ghz | 5ghz} rrm txpower update
```

The system updates the transmit power configuration for the specified APs.

```
Device# enable
Device# ap dot11 24ghz rrm txpower update
Device# ap dot11 6ghz rrm txpower update
```

Configuring Rogue Access Point Detection in RF Groups

Configure rogue AP detection in RF groups (CLI)

Enable detection of rogue APs within RF groups on the controllers.

Before you begin

Ensure that you configure each controller in the RF group with the same RF group name.

Note The name is used to verify the authentication IE in all beacon frames. If the controllers have different names, it results in false alarms.

Procedure

Step 1 Perform this step for each AP connected to the controller.

Example:

Step 2 Return to privileged EXEC mode to continue configuration.

Example:

```
Device(config)# end
```

Press **Ctrl-Z** to exit global configuration mode as an alternative.

Step 3 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 4 Enable rogue AP detection.

Example:

```
Device(config)# wireless wps ap-authentication
```

Step 5 Set a threshold value for rogue AP alarms.

Example:

```
Device(config)# wireless wps ap-authentication threshold value
```

The system generates an alarm when the threshold value (the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.

The threshold ranges from 1 to 255. The default value is 1. Set a higher threshold value to avoid false alarms.

Note
Enable rogue AP detection and set the threshold value on every controller in the RF group.

APs on any controller with rogue detection disabled are reported as rogues.

The system enables rogue AP detection on all APs in the RF group. Alarms are triggered when the configured threshold for invalid authentication frames is met or exceeded within the detection period.

```
Device(config)# end
Device# configure terminal
Device(config)# wireless wps ap-authentication
Device(config)# wireless wps ap-authentication threshold 50
```

Monitoring RRM Parameters and RF Group Status

Monitor RRM parameters

Provide a quick reference to the commands used for monitoring Radio Resource Management (RRM) parameters, enabling users to efficiently assess and troubleshoot wireless network performance.

Table 8: Commands for monitoring Radio Resource Management

Commands	Description
show ap dot11 24ghz channel	Displays the configuration and statistics of the 802.11b monitoring.
show ap dot11 24ghz coverage	Displays the configuration and statistics of the 802.11b coverage.
show ap dot11 24ghz group	Displays the configuration and statistics of the 802.11b grouping.
show ap dot11 24ghz logging	Displays the configuration and statistics of the 802.11b event logging.
show ap dot11 24ghz monitor	Displays the configuration and statistics of the 802.11b monitoring. nnn
show ap dot11 24ghz profile	Displays 802.11b profiling information for all APs.
show ap dot11 24ghz summary	Displays the configuration and statistics of the 802.11a APs.
show ap dot11 24ghz txpower	Displays the configuration and statistics of the 802.11b transmit power control.
show ap dot11 5ghz channel	Displays the configuration and statistics of the 802.11a channel assignment.
show ap dot11 5ghz coverage	Displays the configuration and statistics of the 802.11a coverage.
show ap dot11 5ghz group	Displays the configuration and statistics of the 802.11a grouping.
show ap dot11 5ghz logging	Displays the configuration and statistics of the 802.11a event logging.
show ap dot11 5ghz monitor	Displays the configuration and statistics of the 802.11a monitoring.
show ap dot11 5ghz profile	Displays 802.11a profiling information for all APs.
show ap dot11 5ghz summary	Displays the configuration and statistics of the 802.11a APs.
show ap dot11 5ghz txpower	Displays the configuration and statistics of the 802.11a transmit power control.

Verify RF group status

This section describes the new commands for RF group status.

These commands are used to verify RF group status on the .

This table lists the commands for verifying aggressive load balancing.

Table 9: Aggressive load balancing verification commands

Command	Purpose
show ap dot11 5ghz group	Displays the controller name that is the group leader for the 802.11a RF network.
show ap dot11 24ghz group	Displays the controller name that is the group leader for the 802.11b/g RF network.

Examples: RF group configuration

These are examples of RF group name configuration.

```
Device# configure terminal
Device(config)# wireless rf-network test1
Device(config)# ap dot11 24ghz shutdown
Device(config)# end
Device# show network profile 5
```

This example demonstrates how to configure rogue AP sdetection within RF groups.

```
Device#
Device# end
Device# configure terminal
Device(config)# wireless wps ap-authentication
Device(config)# wireless wps ap-authentication threshold 50
Device(config)# end
```

Event-Driven Radio Resource Management

A Event-Driven Radio Resource Management (ED-RRM) feature is a radio frequency management solution that

- continuously monitors air quality metrics
- automatically triggers channel changes when interference exceeds a set threshold, and
- blocks affected channels for a specified duration to prevent immediate reselection.

Spontaneous interference is interference that appears suddenly on a network, perhaps jamming a channel or a range of channels completely. The Cisco CleanAir spectrum event-driven RRM feature allows you to set a threshold for air quality (AQ) that, if exceeded, triggers an immediate channel change for the affected AP.

Most RF management systems can avoid interference, but this information takes time to propagate through the system. Cisco CleanAir relies on AQ measurements to continuously evaluate the spectrum and can trigger a move within 30 seconds. For example, if an AP detects interference from a video camera, it can recover by changing channels within 30 seconds of the camera becoming active.

Configure ED-RRM on the controller (CLI)

Configure Event-Driven Radio Resource Management (ED-RRM) on the controller using CLI commands.

Trigger spectrum event-driven RRM to run when a Cisco CleanAir-enabled AP detects a significant level of interference by entering these commands.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure CleanAir driven RRM parameters for the 802.11 APs.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz | 6ghz} rrm channel cleanair-event
```

Step 3 Configure CleanAir driven RRM sensitivity for the 802.11 APs.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz | 6ghz} rrm channel cleanair-event sensitivity {low
 | medium | high | custom}
```

Default selection is Medium.

Step 4 Trigger the ED-RRM event at the set threshold value.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz | 6ghz} rrm channel cleanair-event custom-threshold
 custom-threshold-value
```

The custom threshold range is from 1 to 99.

Step 5 Enable rogue contribution.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz | 6ghz} rrm channel cleanair-event rogue-contribution
```

Step 6 Configure threshold value for rogue contribution.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz | 6ghz} rrm channel cleanair-event rogue-contribution
 duty-cycle thresholdvalue
```

The range is from 1 to 99, with 80 as the default.

Step 7 Save your changes.

Example:

```
Device# write memory
```

Step 8 (Optional) Verify the CleanAir configuration for the 802.11a/n/ac or 802.11b/g/n network.

Example:

```
Device# show ap dot11 {24ghz | 5ghz | 6ghz}cleanair config
```

The output is displayed.

The Event-Driven Radio Resource Management (ED-RRM) on the controller is configured.

Rogue PMF containment

Rogue PMF containment is a wireless security feature that

- uses 802.11w Protected Management Frames (PMF) to contain rogue APs and clients

- operates on centrally switched WLANs when the radio channel of the detecting AP matches the rogue AP's channel, and
- activates only when certain mode and channel conditions are met to secure the network against unauthorized devices.

Feature history

Table 10: Feature history table for rogue PMF containment

Feature name	Release information	Feature description
Rogue PMF containment	Cisco IOS XE 17.12.1	Starting with Cisco IOS XE Dublin 17.12.1, the controller contains a rogue AP with 802.11w Protected Management Frame (PMF) on centrally switched wireless LANs. Containment occurs if the client-serving radio channel of a rogue-detecting AP matches the channel of the corresponding rogue AP.

Operational scenarios

PMF containment occurs in these scenarios:

- You can use PMF containment only in the local mode.
- You can perform PMF containment only for rogue clients that have not joined a rogue AP.
- You can use PMF containment only if a rogue-detecting AP shares the same primary channel with a rogue client.
- You cannot use PMF containment on DFS channels, even if a DFS channel serves as the client-serving channel.
- PMF containment works only if at least one WLAN operates on the serving radio.

For information about APs that support the Rogue PMF Containment feature, see Cisco AP Feature Matrix.

Enable rogue PMF containment

Enable PMF containment to protect your wireless network from rogue APs.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an AP profile and enter AP profile configuration mode.

Example:

```
Device(config)# ap profile ap-profile
```

Step 3 Enable PMF-denial rogue AP containment.

Example:

```
Device(config-ap-profile)# rogue detection containment pmf-denial
```

Step 4 Enable PMF-denial type deauthentication rogue AP containment.

Example:

```
Device(config-pmf-denial)# pmf-deauth
```

Step 5 Return to privileged EXEC mode.

Example:

```
Device(config-ap-profile)# end
```

Rogue AP PMF containment is enabled for the specified AP profile.

```
Device# configure terminal
Device(config)# ap profile pmf-ap-profile
Device(config-ap-profile)# rogue detection containment pmf-denial
Device(config-pmf-denial)# pmf-deauth
Device(config-ap-profile)# end
```

Verify PMF containment

To verify PMF containment and the relevant statistics, use these commands.

To view the summary of containment details for all AP radios, use this command

```
Device# show wireless wps rogue containment summary

Rogue Containment activities for each managed AP

AP: 687d.b45f.2ae0  Slot: 1
  Active Containments   : 3
   Containment Mode     : DEAUTH_PMF
   Rogue AP MAC         : 687d.b45f.2a2d
   Containment Channels : 40
```

To verify the rogue statistics, use this command:

```
Device# show wireless wps rogue stats
.
.
.
 States
  Alert                         : 256
  Internal                      : 0
  External                      : 0
```

```
  Contained                     : 1
  Containment-pending           : 0
  Threat                        : 0
  Pending                       : 0
Rogue Clients
  Total/Max Scale               : 20/16000
  Contained                     : 0
  Containment-pending           : 0
.
.
.
```

Rogue detection - rogue channel width

A rogue detection configuration is a security measure that

- allows specifying channel width and band for detecting unauthorized APs, and
- filters rogue APs based on matching channel width criteria and band.

The **condition chan-width** command is introduced in Cisco IOS XE Dublin 17.12.1 allows you to set the minimum or maximum channel width for rogue detection.

Configure rogue channel width (CLI)

Complete this task to configure rogue channel width.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create or enable a rule.

Example:

```
Device(config)# wireless wps rogue rule rule-name priority priority
```

Step 3 Configure channel width and band for rogue detection.

Example:

```
Device(config-rule)# condition chan-width {160MHz | 20MHz | 40MHz | 80MHz} band {24ghz |
5ghz | 6ghz}
```

If the classification is **Friendly**, this is the minimum channel width.

If the classification is **Custom**, **Malicious**, or **Delete**, this is the maximum channel width.

Step 4 Use Step 4, 5, 6, or 7.

Note

Use only one of the Steps: 4, 5, 6, or 7 as required to classify rogue devices. Do not use all of them.

Step 5 (Optional) Classify devices matching this rule as friendly.

Example:

```
Device(config-rule)# classify friendly state {alert | external | internal}
```

The options are:

- **alert**: Sets the malicious rogue access point to alert mode.
- **external**: Acknowledges the presence of a rogue access point.
- **internal**: Trusts a foreign access point.

Step 6 (Optional) Classify devices matching this rule as malicious.

Example:

```
Device(config-rule)# classify malicious state {alert | contained}
```

The options are:

- **alert**: Sets the malicious rogue AP to alert mode.
- **contained**: Contains the rogue AP.

Step 7 (Optional) Classify devices matching this rule as custom.

Example:

```
Device(config-rule)# classify custom severity-score severity-score [name name] state {alert
 | contained}
```

Here the options are:

- *severity-score* : Custom classification severity score. The range is from 1 to 100.
- **name**: Defines the name for custom classification.
- *name* : Specifies the custom classification name.
- **state**: Defines the final state if rule is matched.
- **alert**: Sets the rogue AP to alert mode.
- **contained**: Contains the rogue AP.

Step 8 Ignore the devices matching this rule.

Example:

```
Device(config-rule)# classify delete
```

Step 9 Return to privileged EXEC mode.

Example:

```
Device(config-rule)# end
```

The rogue channel width is configured.

```
Device# configure terminal
                Device(config)# wireless wps rogue rule 1 priority 1
                Device(config-rule)# condition chan-width 20MHz band 5ghz
                Device(config-rule)# classify friendly state internal
                Device(config-rule)# classify malicious state alert
                Device(config-rule)# classify custom severity-score 12 name rule1 state
alert
                Device(config-rule)# classify delete
                Device(config-rule)# end
```

Configure rogue classification rules (GUI)

Complete this task to configure rogue classification rules.

Procedure

Step 1 Choose **Configuration** > **Security** > **Wireless Protection Policies** > **Rogue AP Rules** to open the **Rogue Rules** window.

Rules that have already been created are listed in priority order. The name, type, status, state, match, and hit count of each rule is provided.

Note
To delete a rule, select the rule and click **Delete**.

Step 2 Create a new rule with these steps:

a) Click **Add**.

b) In the **Add Rogue AP Rule** window, enter a name for the new rule, in the **Rule Name** field. Ensure that the name does not contain any spaces.

c) From the **Rule Type** drop-down list, choose one of these options to classify rogue APs matching this rule:

- **Friendly**
- **Malicious**
- **Unclassified**
- **Custom**

d) From the **State** drop-down list, configure the state of the rogue AP. This is the state when the rule matches the conditions for the rogue APs.

- **Alert**: A trap is generated when an ad hoc rogue is detected.
- **Internal**: A foreign ad hoc rogue is trusted.
- **External**: The presence of an ad hoc rogue is acknowledged.
- **Contain**: The ad hoc rogue is contained.
- **Delete**: The ad hoc rogue is removed.

Note

The **State** field is not displayed if you select **Unclassified** as the **Rule Type**.

e) If you chose the **Rule Type** as **Custom**, enter the **Severity Score** and the **Custom Name**.
f) Click **Apply to Device** to add this rule to the list of existing rules, or click **Cancel** to discard this new rule.

Step 3 (Optional) Edit a rule using these steps:

a) Click the name of the rule that you want to edit.
b) In the **Edit Rogue AP Rule** page that is displayed, from the **Type** drop-down list, choose one of these options to classify rogue APs matching this rule:

- **Friendly**
- **Malicious**
- **Custom**

c) Configure the notification from the **Notify** drop-down list to **All**, **Global**, **Local**, or **None** after the rule is matched.
d) Configure the state of the rogue AP from the **State** drop-down list after the rule is matched.
e) From the **Match Operation** field, choose one of these options:

- **Match All**: The detected rogue AP must meet all of the conditions specified by the rule for the rule to be matched and the rogue AP to adopt the classification type of the rule.
- **Match Any**: The detected rogue AP must meet any of the conditions specified by the rule for the rule to be matched and the rogue AP to adopt the classification type of the rule. This is the default value.

f) To enable this rule, check the **Enable Rule** check box. The default is unchecked.
g) If you chose the **Rule Type** as **Custom**, enter the **Severity Score** and the **Classification Name**.
h) From the **Add Condition** drop-down list, choose one or more of the conditions that the rogue AP must meet:

- **None**: No condition is set for rogue AP detection.
- **client-count**: Condition requires that a minimum number of clients be associated to the rogue AP. For example, if the number of clients associated to the rogue AP is greater than or equal to the configured value, then the AP can be classified as malicious. If you choose this option, enter the minimum number of clients to be associated with the rogue AP in the **Minimum Number of Rogue Clients** field. The valid range is 1 to 10 (inclusive), and the default value is 0.
- **duration**: Condition requires that the rogue AP be detected for a minimum period of time. If you choose this option, enter a value for the minimum detection period in the **Time Duration** field. The valid range is 0 to 86400 seconds (inclusive), and the default value is 0 seconds.
- **encryption**: Condition requires that the advertised WLAN have specified encryption. Requires that the rogue AP's advertised WLAN does not have encryption enabled. If a rogue AP has encryption disabled, it is likely that more clients will try to associate with it. No further configuration is required for this option.
- **infrastructure**: Condition requires that the rogue AP's SSID (the SSID configured for the WLAN) be known to the controller. Select the **Manage SSID** check box to enable this configuration.

- **rssi**: Condition requires that the rogue AP have a minimum received signal strength indication (RSSI) value. For example, if the rogue AP has an RSSI that is greater than the configured value, then the AP could be classified as malicious. If you choose this option, enter the minimum RSSI value in the **Maximum RSSI** field. The valid range is 0 to –128 dBm (inclusive).
- **channel-width**: Condition requires that the rogue AP use the specified radio spectrum channel width for the specified radio band, as defined. The valid channel widths are 20, 40, 80, and 160MHz.
  - For APs to be classified as **Malicious**, **Custom** or **Delete**, it must match the value (equal or more) set in the **Minimum Channel Width** drop-down list.
  - For APs to be classified as **Friendly**, it must match the value (equal or less) set using an option from the **Maximum Channel Width** drop-down list.
- **ssid**: Condition requires that the rogue AP have a specific user-configured SSID. If you choose this option, enter the SSID in the **User Configured SSID** text field, and click **+** to add the SSID.
- **substring-ssid**: Condition requires that the rogue AP have a substring of the specific user-configured SSID. The controller searches the substring in the same occurrence pattern and returns a match if the substring is found in the SSID string.

Step 4 Click **Apply to Device** to save the configuration.

Step 5 Click **OK**.

The rogue classification rules are configured.

Verify rogue channel width

To view channel width and band information of a classification rule, use these commands.

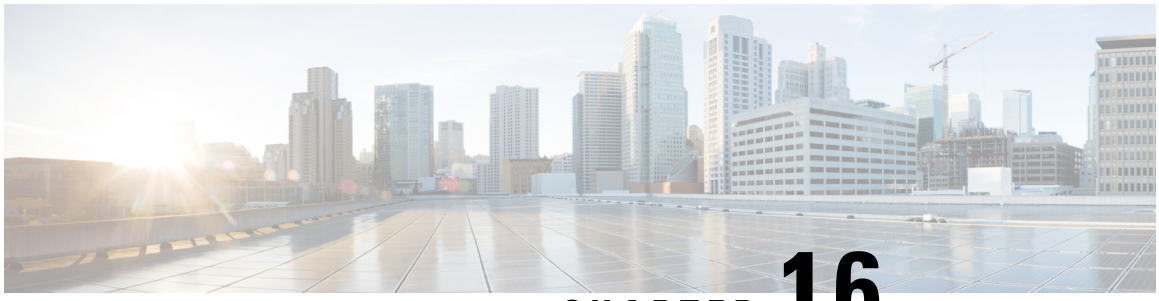


Note When the same BSSID is beaconing on multiple bands (2.4 GHz, 5 GHz, 6 GHz), the **show wireless wps rogue ap summary** command output displays information for the band with the highest RSSI.

```
Device# show wireless wps rogue rule detailed 1
Priority                                          : 1
Rule Name                                         : 1
Status                                            : Enabled
Type                                              : Friendly
State                                             : Alert
Match Operation                                   : Any
Notification                                      : Enabled
Hit Count                                         : 117
Condition :
  type                                            : chan-width
  Max value (MHz)                                 : 40
  Band (GHz)                                      : 5GHz


Device# wireless wps rogue ap summary
.
.
.
```

```
MAC Address     Classification  State  #APs  #Clients  Last Heard
Highest-RSSI-Det-AP  RSSI  Channel  Ch.Width  GHz
-------------------------------------------------------------------------------------------------
002c.c849.9f00  Unclassified    Alert  2     0         10/18/2022 16:50:18  0cd0.f895.efc0
       -31        11        20  2.4
0062.ecf3.e73f  Unclassified    Alert  1     0         10/18/2022 16:50:16  0cd0.f895.efc0
       -46        36        80  5
4ca6.4d22.cbaf  Unclassified    Alert  3     0         10/18/2022 16:50:46  0cd0.f895.efc0
       -62        36       160  5
```



CHAPTER 16

Coverage Hole Detection

- Coverage hole detection and correction, on page 145
- Configure coverage hole detection (GUI), on page 145
- Configure coverage hole detection (CLI), on page 146
- Configure CHD for RF tag profile (GUI), on page 147
- Configuring CHD for RF profile (CLI), on page 148

Coverage hole detection and correction

A coverage hole detection and correction algorithm is a wireless LAN management mechanism that

- identifies areas with insufficient radio coverage for reliable performance
- alerts administrators when access points fail to provide adequate coverage, and
- adjusts AP transmit power to mitigate correctable coverage holes.

If clients on a lightweight AP are detected at threshold levels such as RSSI, failed client count, percentage of failed packets, and number of failed packets that are lower than those specified in the RRM configuration, the AP sends a “coverage hole” alert to the device. The alert indicates that clients cannot connect to a usable AP because of poor signal coverage.

The device discriminates between coverage holes that can and cannot be corrected. For coverage holes that can be corrected, the device mitigates the coverage hole by increasing the transmit power level for that specific AP.

The device does not mitigate coverage holes caused by clients that are unable to increase their transmit power or are statically set to a power level. Increasing downstream transmit power could increase interference in the network.

Configure coverage hole detection (GUI)

Enable Coverage hole detection (CHD) to configure client accounting using the GUI.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **RRM**.

Step 2 Configure the Radio Resource Management parameters for 802.11a/n/ac (5 GHz) and 802.11b/g/n (2.4 GHz) radios, and flexible radio assignment parameters.

Step 3 Check the **Enable Coverage Hole Detection** check box to activate the feature.

CHD is enabled. The system identifies and reports wireless coverage gaps.

Configure coverage hole detection (CLI)

CHD is based on upstream RSSI metrics observed by the AP. Enable CHD on your wireless device using CLI commands.

Note To revert back radios from 5-GHz to 24-GHz for CHD, ensure that the 5-GHz radio is UP and client network preference value is other than the default.

Before you begin

Disable the 802.11 network before applying the configuration.

Procedure

Step 1 Configure the 802.11 coverage level for data packets.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz | 6ghz} rrm coverage data {fail-percentage |
packet-count | rssi-threshold} 60
```

The options are:

- **fail-percentage**: Configures 802.11b coverage failure rate threshold for uplink data packets.
- **packet-count**: Configures 802.11b coverage minimum failure count threshold for uplinkvoice packets.
- **rssi-threshold**: Configures 802.11b minimum receive coverage level for voice packets.

Step 2 Configure the 802.11 Cisco AP coverage exception level as a percentage that ranges from zero to 100%.

Example:

```
Device(config)# ap dot11 24ghz rrm coverage exception global 50
```

Step 3 Configure the 802.11 Cisco AP client minimum exception level that ranges from one to 75 clients.

Example:

```
Device(config)# ap dot11 24ghz rrm coverage level global 10
```

Step 4 Configure the 802.11 coverage hole detection for voice packets.

Example:

```
Device(config)# ap dot11 24ghz rrm coverage voice {fail-percentage | packet-count |
rssi-threshold} 10
```

The options are:

- **fail-percentage**: Configures 802.11b coverage failure rate threshold for uplink data packets.
- **packet-count**: Configures 802.11b coverage minimum failure count threshold for uplinkvoice packets.
- **rssi-threshold**: Configures 802.11b minimum receive coverage level for voice packets.

Step 5 Save the configuration and return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Step 6 Verify the CHD details.

Example:

```
Device# show ap dot11 {24ghz | 5ghz | 6ghz} coverage
```

This displays CHD status and statistics.

Note If both the number and percentage of failed packets exceed the values entered in the **packet-count** and **fail-percentage** commands for a five-second period, the client enters a pre-alarm condition. The controller uses this information to distinguish between real and false coverage holes. False positives typically result from poor roaming logic implemented on most clients.

A coverage hole is detected if both the number and percentage of failed clients meet or exceed the values entered in the coverage level global and coverage exception global commands over a 90-second period. The controller determines if the coverage hole can be corrected and, if appropriate, increases the transmit power level for that specific AP.

Configure CHD for RF tag profile (GUI)

Enable and configure CHD parameters for an RF tag profile using the GUI to ensure optimal wireless coverage.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **RRM**.

Step 2 On the **Coverage** tab, select the **Enable Coverage Hole Detection** check box.

Step 3 In the **Data RSSI Threshold** field, enter the actual value in dBm. The valid value ranges from -60 dBm to -90 dBm; the default value is –80 dBm.

Step 4 In the **Voice RSSI Threshold** field, enter the actual value in dBm. The valid value ranges from -60 dBm to -90 dBm; the default value is –80 dBm.

Step 5 In the **Minimum Failed Client per AP** field, enter the minimum number of clients on an AP with a signal-to-noise ratio (SNR) below the coverage threshold. The valid value ranges from one to 75 and the default value is three.

Step 6 In the **Percent Coverage Exception Level per AP** field, enter the maximum desired percentage of clients on an AP's radio operating below the desired coverage threshold and click Apply. The valid value ranges from zero to 100% and the default value is 25%.

Step 7 In the **Voice Packet Count** and **Voice Packet Percentage** fields, enter the number and percentage of voice data packets.

Step 8 In the **Data Packet Count** and **Data Packet Percentage** fields, enter the number and percentage of data packets.

Step 9 Click **Apply**.

Configuring CHD for RF profile (CLI)

Enable CHD for a specified RF profile on your wireless device using CLI commands.

Before you begin

Ensure that the RF profile is already created.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the 802.11 coverage hole detection for data packets.

Example:

```
Device(config)# ap dot11 24ghz rf-profile alpha-rfprofile-24ghz
```

Step 3 Configure the minimum RSSI value for data packets received by the AP. The valid values range is from -90 to -60 in dBm.

Example:

```
Device(config-rf-profile)# coverage data rssi threshold -80
```

Step 4 Save the configuration and return to privileged EXEC mode.

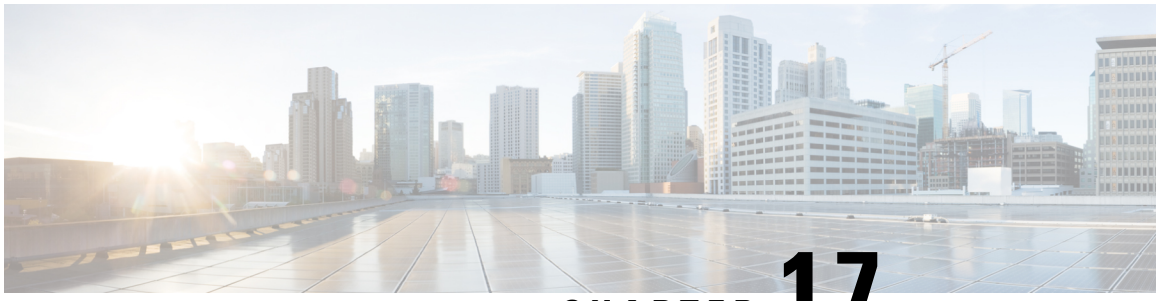
Example:

```
Device(config-rf-profile)# end
```

Step 5 Verify the summary of the available RF profiles.

Example:

```
Device# show ap dot11 24ghz rf-profile summary
```



CHAPTER 17

Cisco Flexible Radio Assignment

- Flexible radio assignments, on page 151
- XOR support in 2.4-GHz or 5-GHz bands, on page 152
- Flexible radio assignments, on page 153
- FRA role selection by AP model and client capability, on page 153
- Configure FRA Radio (CLI), on page 155
- Configure FRA radio (GUI), on page 157
- Flexible Radio Assignment (FRA) Action, on page 158

Flexible radio assignments

A Flexible Radio Assignment (FRA) is a configuration management feature that

- adapts AP radio hardware for multiple roles
- manages various Cisco AP models like Cisco Aironet 2800 Series Access Points, Cisco Aironet 3800 Series Access Points, and other APs in Catalyst series, and
- optimizes client experience by adapting radio roles based on client capabilities

FRA takes advantage of the dual-band radios included in APs. The FRA is a new feature added to the RRM to analyze the Neighbor Discovery Protocol (NDP) measurements, which manages the hardware used to determine the role of the new flexible radio (2.4 GHz, 5 GHz, or monitor) in your network.

Traditional legacy dual–band APs always had 2 radio slots, (1 slot per band) and were organized by the band they were serving, that is slot 0= 802.11b,g,n and slot 1=802.11a,n,ac.

Benefits of the FRA

- Solves the problem of 2.4–GHz over coverage.
- Creates two distinct 5–GHz cells to double available airtime.
- Permits one AP with one Ethernet drop to function like two 5–GHz APs.
- Introduces the concept of macro and micro cells for airtime efficiency.
- Allows more bandwidth to be applied to an area within a larger coverage cell.
- Addresses nonlinear traffic distribution.

- Enhances the High-Density Experience (HDX) with one AP.
- Allows XOR radios to serve client or monitor roles based on configuration.

XOR support in 2.4-GHz or 5-GHz bands

XOR support increases flexibility in AP operations by offering capabilities to serve various frequency bands and monitor radio signals, thereby optimizing network coverage and efficiency.

The flexible radio (XOR) offers the ability to serve the 2.4-GHz or the 5-GHz bands, or passively monitor both bands on the same AP.

- AP models supporting dual 5-GHz band operations:
  - *i* model supports a dedicated Macro/Micro architecture.
  - *e* and *p* models support Macro/Macro architecture.
- FRA with internal antenna (*i* series models) allows two 5-GHz radios in Micro/Macro cell mode.
- FRA with external antenna (*e* and *p* models) enables creation of two separate macro or micro cells for HDX.
- FRA calculates redundancy for 2.4-GHz radios with a metric called COF (Coverage Overlap Factor).
- Feature integration in RRM for mixed environments and AP **AP MODE** selections include:
  - Local Mode
  - Monitor Mode
  - FlexConnect Mode
  - Sniffer Mode
  - Spectrum Connect Mode

Before XOR was introduced, mode changes affected the entire AP (both radio slot 0 and slot 1). The XOR addition allows operation of a single radio interface independently, known as *roles*:

- Client Serving
- Either 2.4 GHz(1) or 5 GHz(2)
- Monitor-Monitor mode (3)

Note

- Mode: Assigned to a whole AP (slot 0 and slot 1)
- Role: Assigned to a single radio interface (slot 0)

Flexible radio assignments

A flexible radio assignment is a configuration management feature that

- adapts AP radio hardware for multiple roles
- manages various Cisco AP models such as Cisco Aironet 2800 series, Cisco Aironet 3800 series, and Catalyst series, and
- optimizes client experience by adapting radio roles based on client capabilities.

Feature history

Release	Feature	Feature Information
Cisco IOS XE 17.11.1	Convert Redundant 2.4-GHz Radios to Monitor Mode	From this release, you can select the redundant dual-band radios in a network to operate in monitor only mode.
Cisco IOS XE 17.9.1	Support for Cisco Catalyst 9166I Series Wi-Fi 6E Access Points	From this release onwards, the dual-band radio in Cisco Catalyst 9166I Series Wi-Fi 6E Access Points offers the ability to serve either in 5-GHz or 6-GHz band, as monitor or sniffer on the same AP.
Cisco IOS XE 16.10.1	Flexible Radio Assignment	This feature was introduced.

FRA role selection by AP model and client capability

FRA performs multiple roles depending on the AP model and capabilities. FRA dynamically adjusts radio roles to optimize client performance and network coverage.

FRA configuration modes

All FRA-capable models support these configuration options:

- Automatic: Allows FRA to manage role selection automatically.
- Client Serving: Manual role selection of 2.4-GHz, 5-GHz, or 6-GHz. FRA is not engaged.
- Monitor: Manual role selection. FRA is not engaged.
- Sniffer: Manual role selection. FRA is not engaged.

2.4-GHz and 5-GHz XOR models

FRA establishes the required 2.4-GHz coverage, identifies redundant radios, and converts them to either 5-GHz or a monitor role.

Tri-radio and 5/6-GHz XOR models

FRA determines the 2.4-GHz coverage, and the redundant radios are converted to a monitor role.

Role selection based on client capabilities

5-GHz Tri-Radio: FRA determines the best operating role for the 5-GHz tri-radio (as either a single 8x8 or a dual 4x4), based on connected client capabilities.

5/6-GHz XOR Radios: For the 5/6-GHz XOR radio, the band that the radios should operate on is based on the availability of 6-GHz client presence in the regulatory domain.

FRA client steering and load balancing

FRA works with client steering to optimize how clients connect across available radios.

FRA also manages the resulting configurations of the radios to optimize client experience across flexible roles. Client Steering is responsible for load balancing client connections. For instance, from Cisco Aironet 2800 APs through Cisco Catalyst 9120 Series APs, all the internal antenna AP models perform dual 5-GHz roles as a Macro-Micro cell (a cell within a cell). The antennas on these models are built to support the directionality needed for the micro cell. FRA client steering helps to steer clients to the appropriate radio based on their position within the cell (closer clients are put on the micro cell).

Macro-macro radio layouts

The FRA APs that support external antennas operate as Macro-Macro, which allows full control over power and channels.

FRA on Cisco Catalyst 9130

In Cisco Catalyst 9130 APs , FRA also manages the operating mode of the band-locked 8x8 5-GHz tri-radio by monitoring client capabilities of connected clients. Mode selection depends on the client types.

Wi-Fi 5 clients: For instance, if the attached clients are largely Wi-Fi 5-capable clients, then, beam forming should be multi-user MIMO (MU-MIMO), ensuring better capacity with dual 4x4 5-GHz cells.

Wi-Fi 6 clients:

FRA on CW9166 AP

AP models and types of hardware managed by FRA

To provide comprehensive details on the AP models and types of hardware managed by Flexible Radio Assignment (FRA) technology, enabling users to identify the appropriate access points for their specific wireless network needs and configurations.

AP Model	FRA Radios	Functions
Cisco Aironet 2800 Series Access Points	2.4/5 XOR	2.4-GHz and 5-GHz or dual 5-GHz operations
Cisco Aironet 3800 Series Access Points	2.4/5 XOR	2.4-GHz and 5-GHz or dual 5-GHz operations

AP Model	FRA Radios	Functions
Cisco Aironet 4800 Series Access Points	2.4/5 XOR	2.4-GHz and 5-GHz or dual 5-GHz operations
Cisco Catalyst 9120 Series Access Points	2.4/5 XOR	2.4-GHz and 5-GHz or dual 5-GHz operations
Cisco Catalyst 9130AX Series Access Points	5-GHz Tri-Radio	2.4-GHz 4x4 and single 5-GHz 8x8, or 2.4-GHz 4x4 and dual 5-GHz 4x4

Configure FRA Radio (CLI)

Procedure

Step 1 Enable privileged EXEC mode

Example:

```
Device# enable
```

Enters privileged EXEC mode.

Step 2 Enter configuration mode

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 3 Enable or disable FRA

Example:

```
Device(config)# [no] ap fra
```

Enables or disables FRA on the AP.

Step 4 Configure FRA interval

Example:

```
Device(config)# ap fra interval 3
```

Configures the FRA interval in hours. The range is 1 to 24 hours.

Note
The FRA interval has to be more than the configured RRM interval.

Step 5 Configure the FRA sensitivity

Example:

```
Device(config)# ap fra sensitivity high
```

Configures the FRA sensitivity.

- **high**: Sets the FRA Coverage Overlap Sensitivity to **high**.
- **medium**: Sets the FRA Coverage Overlap Sensitivity to **medium**.
- **low**: Sets the FRA Coverage Overlap Sensitivity to **low**.

Step 6 Exit global configuration mode

Example:

```
Device(config)# end
```

Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Step 7 Reverts to XOR radio state

Example:

```
Device# ap fra revert all auto
```

Rolls back the XOR Radio state.

- **all**: Reverts all XOR Radios
- **auto-only**: Revert only XOR radios currently in automatic band selection.
- **auto**: Sets the XOR radios in automatic band selection.
- **static**: Sets the XOR radio in static 2.4-GHz band.

Step 8 View the configuration and statistics of 802.11 APs

```
Device# show ap dot11 5ghz summary
```

Shows the configuration and statistics of 802.11 Cisco APs

Step 9 View the current FRA configuration

Example:

```
Device# show ap fra

FRA State                                          : Disabled
FRA Sensitivity                                    : medium (95%)
FRA Interval                                       : 1 Hour(s)

AP Name              MAC Address       Slot ID  Current-Band      COF %      Suggested Mode
-----------------------------------------------------------------------------------------
AP00A6.CA36.295A     006b.f09c.8290    0        2.4GHz            None       2.4GHz

COF : Coverage Overlap Factor

test_machine#
```

Shows the current FRA configuration.

Step 10 View the current 802.11 dual-band parameters

Example:

```
Device# show ap name config dot11 dual-band
```

Shows the current 802.11 dual-band parameters in a given AP.

Configure FRA radio (GUI)

The purpose of configuring the FRA radio is to optimize the radio assignment for overlapping coverage areas, improving network efficiency and performance. This includes enabling the Flexible Radio Assignment (FRA) status, setting intervals, and adjusting sensitivity levels to ensure optimal coverage.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **RRM** > **FRA**.

Step 2 In the **Flexible Radio Assignment** window, enable FRA status and determine the overlapping 2.4 GHz or 5 GHz coverage for each AP, choose **Enabled** in the **FRA Status** field. By default, the FRA status is disabled.

Step 3 Under the From the **FRA Interval** drop-down list, choose the FRA run interval. The interval values range from 1 hour to 24 hours. Choose the FRA run interval value only after you enable the FRA status.

Step 4 From the **FRA Sensitivity** drop-down list, choose the percentage of Coverage Overlap Factor (COF) required to consider a radio as redundant. You can select the supported value only after you enable the FRA status.

The supported values are as follows:

- Low: 100 percent
- Medium (default): 95 percent
- High: 90 percent

The **Last Run** and **Last Run Time** fields will show the time FRA was run last and the time it was run.

Step 5 Check the **Client Aware** check box to take decisions on redundancy.

When enabled, the **Client Aware** feature monitors the dedicated 5-GHz radio and when the client load passes a pre-set threshold, automatically changes the Flexible Radio assignment from a monitor role into a 5-GHz role, effectively doubling the capacity of the cell on demand. Once the capacity crisis is over and Wi-Fi load returns to normal, the radios resume their previous roles.

Step 6 In the **Client Select** field, enter a value for client selection. The valid values range between 0 and 100 percent. The default value is 50 percent.

This means that if the dedicated 5-GHz interface reaches 50% channel utilization, this will trigger the monitor role dual-band interface to transition to a 5-GHz client-serving role.

Step 7 In the **Client Reset** field, enter a reset value for the client. The valid values range between 0 and 100 percent. The default value is 5 percent.

Once the AP is operating as a dual 5-GHz AP, this setting indicates the reduction in the combined radios' overall channel utilization required to reset the dual-band radio to monitor role.

Step 8 Click **Apply** to save the configuration.

After completing the configuration, the FRA system will be active, improving the radio coverage efficiency by managing overlapping frequencies and enhancing redundancy decisions. This results in better utilization of network resources and coverage optimization.

Flexible Radio Assignment (FRA) Action

Flexible radio assignment actions

Flexible Radio Assignment (FRA) evaluates 2.4-GHz radio coverage to identify overlapping coverage causing radio interference. If there is an overlapping coverage, the dual-band radio moves to either 5-GHz client serving or monitor role.

Feature history for flexible radio assignment action

Table 11: Feature history for FRA Action

Release	Feature	Feature information
Cisco IOS XE Dublin 17.10.1	Flexible Radio Assignment (FRA) Action	In Cisco IOS-XE 17.10.1 and earlier releases, the FRA moves the redundant dual-band radios to either 5-GHz client-serving role or monitor role.
Cisco IOS XE Dublin17.11.1	Flexible Radio Assignment (FRA) Action	From Cisco IOS-XE 17.11.1 onwards, you can select the redundant dual-band radios in a network to operate in monitor only mode.

Release Information

In Cisco IOS-XE 17.10.1 and earlier releases, the FRA moves the redundant dual-band radios to either 5-GHz client-serving role or monitor role. From Cisco IOS-XE 17.11.1 onwards, you can set redundant dual-band radios in a network to operate in monitor-only mode.

Note The FRA action feature is disabled by default.

Configure FRA action in default RF profile (CLI)

Configure the FRA action in the default RF profile to optimize radio frequency management.

Procedure

Step 1 Configure terminal

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 2 Configure the FRA action

Example:

```
Device(config)# ap dot11 24ghz fra action monitor
```

Configures the FRA action to monitor mode, moving all redundant dual-band APs solely to the monitor role.

Step 3 Exit configuration mode

Example:

```
Device(config)# end
```

Exits configuration mode and returns to privileged EXEC mode.

Upon completion, the FRA action is set, redundancy in dual-band radios is handled efficiently, and the system returns to privileged EXEC mode.

Configure FRA action in 2.4-GHz RF profile (CLI)

Procedure

Step 1 Configure terminal

Example:

```
Device# configure terminal
```

Enters global configuration mode

Step 2 Configure the RF profile name

Example:

```
Device(config)# ap dot11 24ghz rf-profile alpha-rfprofile-24ghz
```

Configures the RF profile name and enters RF profile configuration mode.

Step 3 Configure the FRA action as monitor

Example:

```
Device(config-rf-profile)# fra action monitor
```

Configures the FRA action as monitor, and moves all redundant dual-band radios to monitor role only.

Step 4 Exit configuration mode

Example:

```
Device(config-rf-profile)# end
```

Exits configuration mode and returns to privileged EXEC mode.

Verify FRA action configuration

To view the selected FRA action, use the following command:

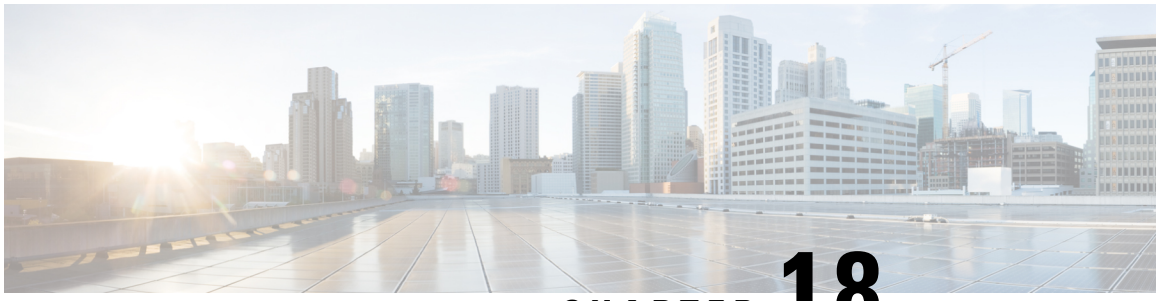
```
Device# show ap fra
FRA State              : Enabled
FRA Freeze             : Disabled
FRA Operation State    : Up
FRA Sensitivity        : higher (85%)
FRA Interval           : 1 Hour(s)
Service Priority       : Coverage
Client Aware FRA       : Enabled
  Client Select        : 25%
  Client Reset         : 5%
FRA Action             : 2.4GHz/Monitor
  Last Run             : 3069 seconds ago
```

To view the FRA action details in an AP RF profile, use the following command:

```
Device# show ap rf-profile name madhu-rf-profile-24 detail | sec FRA
Client Aware FRA                 : Disabled
FRA Action                       : 2.4GHz/Monitor
```

To view the radio mode and role in an AP, use the following command:

```
Device# show ap name AP7872.5DED.CB74 config slot 0 | sec Attribute
Attributes for Slot 0
  Radio Type                                    : 802.11n - 2.4/5 GHz
  Radio Mode                                    : Monitor
  Radio Role                                    : Monitor
    Assignment Method                           : Auto
    Monitor Mode Reason                         : Automatically Switched by FRA
```



CHAPTER 18

XOR Radio Support

- Dual-band radios in Cisco AP models, on page 161
- Configure default XOR radio support (CLI), on page 162
- Configure XOR radio support for the specified slot number (GUI), on page 165
- Configure XOR radio support for the specified slot number (CLI), on page 165
- Verify XOR radio support, on page 167

Dual-band radios in Cisco AP models

A dual-band radio is a device category that

- offers connectivity on more than one frequency band (such as 2.4 GHz and 5 GHz)
- provides flexibility in network configuration, and
- is used in multiple Cisco AP models like the 2800, 3800, 4800, and 9120 series.

Feature history table

Table 12: Feature history table for dual-band radios in Cisco AP models

Feature name	Release information	Feature description
Dual-band (XOR) radio support	Cisco IOS XE 16.10.1	The Dual-band (XOR) radio support offers the ability to serve 2.4 GHz or 5 GHz bands or passively monitor both the bands on the same AP. These APs can be configured to serve clients in 2.4 GHz and 5 GHz bands, or serially scan both 2.4 GHz and 5 GHz bands on the flexible radio while the main 5 GHz radio serves clients.

Key features of dual-band radios in Cisco APs

The XOR radio support can be steered manually or automatically.

- Manual steering of a band on a radio: The band on the XOR radio can only be changed manually.
- Automatic client and band steering on radios: This is managed by the Flexible Radio Assignment (FRA) feature that monitors and changes the band configurations as per site requirements.

Client steering

When a radio moves between bands (from 2.4 GHz to 5 GHz and vice versa), clients need to be steered to get an optimal distribution across radios. When an AP has two radios in the 5 GHz band, client steering algorithms contained in the FRA algorithms are used to steer a client between the same band co-resident radios

Cisco APs and dual-band radios

Cisco 2800, 3800, 4800, and 9120 series AP models are equipped with dual-band (XOR) radios. These models have

- radios that operate on either 2.4 GHz or 5 GHz bands, or
- the ability to passively monitor both the bands on the same AP.

These APs can be configured to serve clients in 2.4 GHz and 5 GHz bands, or serially scan both 2.4 GHz and 5 GHz bands on the flexible radio while the main 5 GHz radio serves clients.

Cisco AP models up to the Cisco 9120 APs are designed to support dual 5 GHz band operations with the *i* model supporting a dedicated Macro or Micro architecture and the *e* and *p* models supporting Macro or Macro. The Cisco 9130AXI APs support dual 5 GHz operations as Macro or Micro cell.

Limitations

These are the limitations for XOR radio support:

- RF measurement is disabled when a static channel is configured on slot 1. As a result, the dual-band radio slot 0 operates only with 5 GHz radios and not in the monitor mode. When slot 1 radio is disabled, RF measurement will not run, and the dual band radio slot 0 will be only on 2.4 GHz radio.
- Only one of the 5 GHz radios can operate in the UNII band (100 to 144), due to an AP limitation to maintain the power budget within the regulatory limit.

Configure default XOR radio support (CLI)

Complete this task to configure the basic settings for XOR radio support.

Before you begin

Note The default radio points to the XOR radio hosted on slot 0.

Procedure

Step 1 Enable the priviledged EXEC mode.

Example:

```
Device> enable
```

Step 2 Configure the 802.11 dual-band external antenna gain on the AP.

Example:

```
Device# ap name ap-name  dot11 dual-band antenna ext-ant-gain antenna_gain_value
```

Enter external antenna gain value in multiple of .5 dBi units (that is, an integer value 4 means 4 x 0.5 = 2 dBi of gain).

Step 3 Shut down the default dual-band radio.

Example:

```
Device# ap name ap-name  dot11 dual-band shutdown
```

Use the **no** form of the command to enable the radio.

Step 4 Switch to the client-serving mode of the AP.

Example:

```
Device# ap name ap-name  dot11 dual-band role manual client-serving
```

Step 5 Switch to the 2.4 GHz radio band.

Example:

```
Device# ap name ap-name  dot11 dual-band band 24ghz
```

The basic configuration of the XOR radio is completed.

Example

```
Device> enable
Device# ap name ap-name  dot11 dual-band antenna ext-ant-gain 2
Device# ap name ap-name  dot11 dual-band shutdown
Device# Device# ap name ap-name  dot11 dual-band role manual client-serving
Device# Device# ap name ap-name  dot11 dual-band band 24ghz
```

What to do next

Continue with the configuration steps listed in the "Configure advanced settings" to complete the configuration.

Configure advanced settings (CLI)

Complete this task to configure the advanced settings for XOR radio support, such as, transmit power, channel, channel width, CleanAir settings and so on.

Procedure

Step 1 Configure the transmit power for the radio on the AP.

Example:

```
Device# ap name ap-name  dot11 dual-band txpower {transmit_power_level | auto}
```

Note

When an FRA-capable radio (slot 0 on 9120 AP[for instance]) is set to Auto, you cannot configure static channel and Txpower on this radio.

If you want to configure static channel and Txpower on this radio, you will need to change the radio role to Manual Client-Serving mode.

Step 2 Configure the channel number for the dual band.

Example:

```
Device# ap name ap-name  dot11 dual-band channel 40
```

The range of the *channel-number* is from 1 to 173.

Step 3 (Optional) Enable the auto channel assignment for the dual-band.

Example:

```
Device# ap name ap-name  dot11 dual-band channel auto
```

Step 4 Configure the channel width for the dual band.

Example:

```
Device# ap name ap-name  dot11 dual-band channel width {20 MHz | 40 MHz | 80 MHz | 160 MHz}
```

Step 5 Enable the Cisco CleanAir management on the dual-band radio.

Example:

```
Device# ap name ap-name  dot11 dual-band cleanair
```

Step 6 Configure a band for the Cisco CleanAir feature.

Example:

```
Device# ap name ap-name [no] dot11 dual-band cleanair band 5 GHz
```

Selects a band for the Cisco CleanAir feature.

Use the **no** form of this command to disable the Cisco CleanAir feature.

Step 7 Configure the 802.11n dual-band antenna and antenna ports selection for a specific AP.

Example:

```
Device# ap name ap-name  dot11 dual-band dot11n antenna {A | B | C | D}
```

Here, A, B, C, and D are the antenna ports.

The configuration of the additional features for dual-band (XOR) radios are completed.

Example

```
Device# ap name ap-name  dot11 dual-band txpower auto
Device# ap name ap-name  dot11 dual-band channel 40
Device# ap name ap-name  dot11 dual-band channel width 40 MHz
Device# ap name ap-name  dot11 dual-band cleanair
Device# ap name ap-name [no] dot11 dual-band cleanair band 5 GHz
Device# ap name ap-name  dot11 dual-band dot11n antenna A
```

Configure XOR radio support for the specified slot number (GUI)

Complete this task to configure XOR radio for the specified slot number.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 In the **Dual-Band Radios** section, select the AP for which you want to configure dual-band radios.

The AP name, MAC address, CleanAir capability and slot information for the AP are displayed. If the Hyperlocation method is HALO, it displays the antenna PID and antenna design specifics.

Step 3 Click **Configure**.

Step 4 In the **General** tab, set the **Admin Status** as required.

Step 5 Set the **CleanAir Admin Status** field to Enable or Disable.

Step 6 Click **Update & Apply to Device**.

The XOR radio support for the specified slot number has been configured.

Configure XOR radio support for the specified slot number (CLI)

Complete this task to configure XOR radio for a specified slot number.

Procedure

Step 1 Enable the priviledged EXEC mode.

Example:

```
Device> enable
```

Step 2 Configure dual-band antenna for the XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 antenna ext-ant-gain
external_antenna_gain_value
```

Here, *external_antenna_gain_value* is the external antenna gain value in multiples of .5 dBi unit. The range is from 0 to 40.

Note

- For APs supporting self-identifying antennas (SIA), the gain depends on the antenna, and not on the AP model. The gain is learned by the AP and there is no need for controller configuration.
- For APs that do not support SIA, the APs send the antenna gain in the configuration payload, where the default antenna gain depends on the AP model.

Step 3 Configure the current band for XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 band {24ghz | 5ghz}
```

Step 4 Configures dual-band channel for the XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 channel {channel-number | auto | width [160
 | 20 | 40 | 80]}
```

The range of the *channel_number* is from 1 to 165.

Step 5 Enable the Cisco CleanAir feature for dual-band radios hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 cleanair band {24Ghz | 5ghz}
```

Step 6 Configure 802.11n dual-band parameters hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 dot11n antenna {A | B | C | D}
```

Here are the antenna configurations.

A : Enables antenna port A.

B : Enables antenna port B.

C : Enables antenna port C.

D : Enables antenna port D.

Step 7 Configure dual-band role for the XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 role {auto | manual [client-serving | monitor]}
```

Here are the dual-band roles.

- **auto** : refers to the automatic radio role selection.
- **manual** : refers to the manual radio role selection.

Step 8 Disable dual-band radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name [no] dot11 dual-band slot 0 shutdown
```

Use the **no** form of this command to enable the dual-band radio.

Step 9 Configure dual-band transmit power for XOR radio hosted on slot 0 for a specific AP.

Example:

```
Device# ap name ap-name dot11 dual-band slot 0 txpower {tx-power-level | auto}
```

Here,

- *tx_power_level* : is the transmit power level in dBm. The range is from 1 to 8.

- **auto** : enables auto-RF.

The XOR radio for the specified slot number is configured.

Example

```
Device> enable
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 antenna ext-ant-gain 2
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 band 24ghz
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 channel 3
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 cleanair band 24Ghz
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 dot11n antenna A
Device# ap name AP-SIDD-A06 [no] dot11 dual-band slot 0 shutdown
Device# ap name AP-SIDD-A06 dot11 dual-band slot 0 txpower 2
```

Verify XOR radio support

To verify the XOR radio support parameters, use these **show** commands:

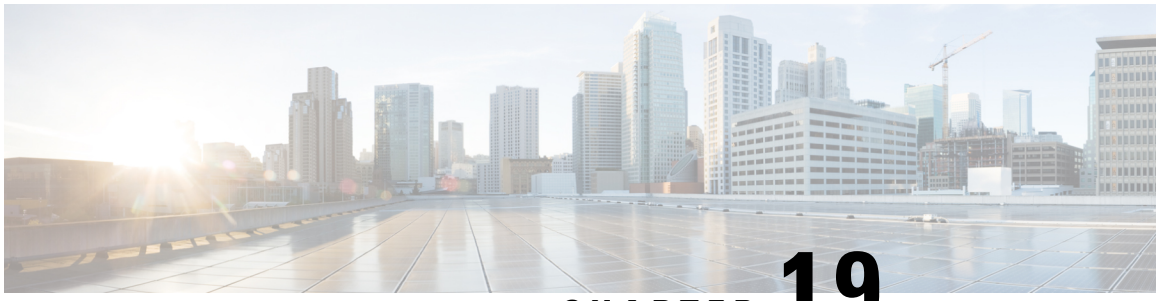
Verify auto-RF information

To display the auto-RF information for a Cisco AP, use the **show ap name** *ap-name* **auto-rf dot11 dual-band** command.

```
Device# show ap name cisco-ap-name auto-rf dot11 dual-band
```

Verify the list of BSSIDs

To display the list of BSSIDs for a Cisco AP, use the **show ap name** *ap-name* **wlan dot11 dual-band** command.



CHAPTER 19

Cisco Receiver Start of Packet

- Receiver start of packet detection threshold, on page 169
- Restrictions for Rx SOP, on page 169
- Permitted range for the Rx SOP threshold, on page 169
- Known behavior, on page 170
- Configure Rx SOP (CLI), on page 170
- Customize RF profile (CLI), on page 171

Receiver start of packet detection threshold

A receiver start of packet (Rx SOP) detection threshold is a wireless radio configuration setting that

- determines the Wi-Fi signal level (measured in dBm) at which an APs radio demodulates and decodes a received packet
- affects radio sensitivity and the effective size of the receiver cell, and
- influences how clients are distributed across APs within a wireless network.

Rx SOP is used to address clients with weak RF links, sticky clients, and to support client load balancing across APs. Rx SOP helps optimize network performance in high-density deployments, such as stadiums and auditoriums. In these environments, APs need to prioritize the nearest and strongest clients.

Restrictions for Rx SOP

- Rx SOP configuration does not apply to the third radio module pluggable on Cisco Aironet Series APs.
- Rx SOP configurations are supported only in Local, FlexConnect, Bridge, and Flex+Bridge modes.
- Rx SOP configurations are not supported in the FlexConnect+PPPoE, FlexConnect+PPPoE-wIPS, and FlexConnect+OEAP submodes.

Permitted range for the Rx SOP threshold

This table shows the allowed Rx SOP (Receiver Start of Packet) threshold settings.

- It is for different radio bands and threshold levels.

Table 13: Rx SOP Threshold

Radio Band	Threshold High	Threshold Medium	Threshold Low
2.4 GHz	-79 dBm	-82 dBm	-85 dBm
5 GHz	-76 dBm	-78 dBm	-80 dBm

Known behavior

Regardless of the radio mode, the controller sets the radio with the specified RX-SOP value. The AP then decides whether to use this value.

- For the XOR radio (Slot 0), when the AP is in monitor mode, the RX-SOP value sent to the AP depends on the frequency band used before switching to monitor mode. If the radio operated in the 2.4 GHz band, the RX-SOP parameters are selected from the 2.4 GHz RF profile or the default RF profile. If it operated in the 5 GHz band, the RX-SOP parameters are chosen from the 5 GHz RF profile or the default RF profile configured for the AP.

Configure Rx SOP (CLI)

Adjust the Rx SOP threshold for high-density Wi-Fi environments.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
DeviceDevice# configure terminal
```

Step 2 Configure the 802.11bg or 802.11a radio Rx SOP threshold.

Example:

```
DeviceDevice(config)# ap dot11 {24ghz | 5ghz} rx-sop threshold {auto | custom | high | low
 | medium}
```

Step 3 Return to the privileged EXEC mode.

Example:

```
Device# end
```

Step 4 Display the 802.11bg or 802.11a high-density parameters.

Example:

```
DeviceDevice# show ap dot11 {24ghz | 5ghz} high-density
```

Step 5 Display the summary of all the connected Cisco APs.

Example:

```
DeviceDevice# show ap summary
```

Customize RF profile (CLI)

Customize 802.11 RF profile parameters.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
DeviceDevice# configure terminal
```

Step 2 Configure the 802.11a and 11b parameters.

Example:

```
DeviceDevice(config)# ap dot11 {24ghz | 5ghz | 6ghz} rf-profile profile-name AHS_2.4ghz
```

Step 3 **Example:**

```
DeviceDevice(config)# ap dot11 {24ghz | 5ghz | 6ghz} rf-profile profile-name AHS_2.4ghz
```

Step 4 Configure the 802.11bg, 802.11a high-density parameters.

Example:

```
DeviceDevice(config-rf-profile)# high-density rx-sop threshold {auto | custom | high | low
 | medium}
```

Step 5 Display the summary of all the connected Cisco APs.

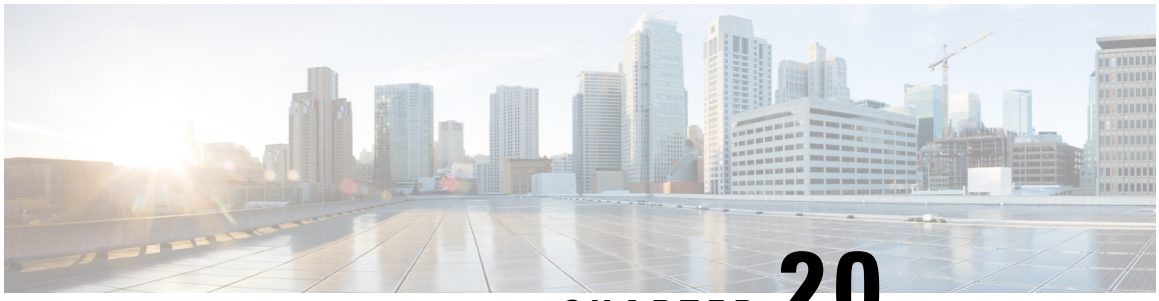
Example:

```
DeviceDevice# show ap summary
```

Step 6 Return to the privileged EXEC mode.

Example:

```
Device# end
```



CHAPTER 20

Client Limit

- Client limits, on page 173
- Configure client limit per WLAN (GUI), on page 174
- Configure client limit per WLAN (CLI), on page 174

Client limits

A client limit is a wireless network feature that

- enforces a maximum number of client devices that can connect to an AP, and
- allows you to configure the client cap per AP radio or per WLAN.

Feature history

This table provides release and related information about the feature explained in this section.

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 14: Feature history for client limits

Feature Name	Release Information	Feature Description
Client Limit and Delete	Cisco IOS XE Dublin 17.8.x	From this release, client limiting is supported per AP, per radio, and per AP-radio per WLAN. Client limiting is supported on the Cisco Catalyst 9136 Series APs in FlexConnect mode. The following commands are introduced: • association-limit • high-density clients count
Client limits	Cisco IOS XE Gibraltar 16.10.x	This feature enforces a maximum number of client devices per AP, supporting per-AP, per-radio, and per-WLAN configurations.

Configure client limit per WLAN (GUI)

Restrict the number of client devices that can connect to a specific WLAN.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Click a WLAN from the list of WLANs.

Step 3 Click the **Advanced** tab.

Step 4 Under the **Max Client Connections** settings, enter the client limit for **Per WLAN**, **Per AP Per WLAN**, and **Per AP Radio Per WLAN**.

Step 5 Click **Update & Apply to Device**.

Configure client limit per WLAN (CLI)

Set the maximum number of clients permitted to associate with a specific WLAN, AP, or AP radio using CLI commands.

Procedure

Step 1 Enter the privileged EXEC and the global configuration mode.

Example:

```
Device# enable
Device# configure terminal
```

Step 2 Specify the WLAN name.

Example:

```
Device(config)# wlan <wlan-profile-name>
```

WLAN needs to be shut down in order to change the client limit parameters.

Step 3 Configure the maximum number of clients that is associated to the given WLAN.

Example:

```
Device(config-wlan)# client association limit <maximum-client-per-WLAN>
```

Note
Depending on the primary AP in the Cisco Embedded Wireless Controller network, the maximum number of clients supported varies.

Table 15: Scale Supported in a Cisco Embedded Wireless Controller Network

Step 4 Return to the privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

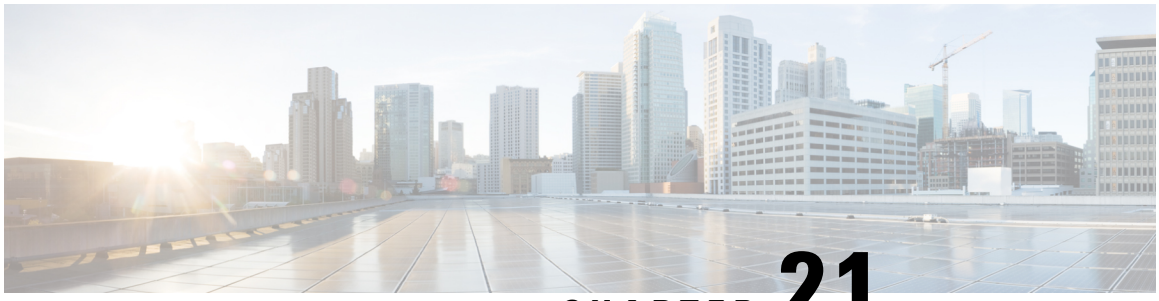
Example:

```
Device(config)# end
```

Step 5 Verify the current configuration of the WLAN and the corresponding client association limits.

Example:

```
Device# show wlan id wlan-id 2
```



CHAPTER 21

IP Theft

- IP theft, on page 177
- Lower the idle timeout to prevent false IP theft, on page 177
- IP preference levels for IP theft detection, on page 178
- Configure IP theft (GUI), on page 178
- Configure IP theft (CLI), on page 178
- Configure the IP theft exclusion timer (CLI), on page 179
- Verify IP theft configuration, on page 179

IP theft

An IP Theft feature is a wireless controller security mechanism that

- detects duplicate IP address usage among connected clients
- assigns precedence to clients based on a defined preference order, and
- blocks or excludes clients attempting to use IP addresses already assigned to others.

The IP Theft feature is enabled by default on the controller. If a wireless client tries to use an IP address assigned to a wired client, the controller marks it as a theft attempt.

Lower the idle timeout to prevent false IP theft

Lower the idle timeout for devices that may switch WLANs while out of range to prevent incorrect IP theft events.

When a device moves between WLANs while out of range of APs, it may retain the same IPv6 link-local address but present a different MAC address. Because the controller cannot immediately detect the move, it may interpret the reuse of the same IP address as an IP theft event.

To avoid this, lower the idle timeout value so the controller can promptly remove stale client entries from the original WLAN. This helps ensure that address reuse by legitimate roaming devices is not mistakenly treated as a theft attempt.

IP preference levels for IP theft detection

The controller uses IP preference levels to resolve conflicts when multiple clients claim the same IP address. These levels determine which client has priority based on the method used to learn the IP address. Preference order for IPv4 clients:

- DHCPv4
- ARP
- Data packets

Preference order for IPv6 clients:

- DHCPv6
- NDP (Neighbor Discovery Protocol)
- Data packets

Additional rules:

- Static wired clients always receive higher preference than dynamically assigned clients.
- Wired clients are prioritized over wireless clients when IP conflicts occur.

Configure IP theft (GUI)

Prevent unauthorized use or reuse of IP addresses by configuring IP theft protections.

Procedure

Step 1 Choose **Configuration** > **Security** > **Wireless Protection Policies** > **Client Exclusion Policies**.

Step 2 Check the **IP Theft or IP Reuse** check box.

Step 3 Click **Apply**.

Configure IP theft (CLI)

Enable IP theft detection and configure client exclusion policies using CLI.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the client exclusion policy.

Example:

```
Device(config)# wireless wps client-exclusion ip-theft
```

Configure the IP theft exclusion timer (CLI)

Set the exclusion timer to temporarily block IP addresses suspected of theft on a WLAN.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a WLAN policy profile and enter the wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy profile-policy default-policy-profile
```

Step 3 Specify the timeout, in seconds.

Example:

```
Device(config-wireless-policy)# exclusionlist timeout time-in-seconds
```

The valid range is from zero-2147483647. Enter zero for no timeout.

Verify IP theft configuration

Use the command to check if the IP theft feature is enabled or not:

```
Device# show wireless wps summary

Client Exclusion Policy
  Excessive 802.11-association failures   : Enabled
  Excessive 802.11-authentication failures: Enabled
  Excessive 802.1x-authentication         : Enabled
  IP-theft                                : Enabled
  Excessive Web authentication failure    : Enabled
  Cids Shun failure                       : Enabled
  Misconfiguration failure                : Enabled
  Failed Qos Policy                       : Enabled
  Failed Epm                              : Enabled
```

Use the commands to view additional details about the IP theft feature:

```
Device# show wireless client summary

Number of Local Clients: 1

MAC Address    AP Name                WLAN State              Protocol Method     Role
-------------------------------------------------------------------------------------------
000b.bbb1.0001 SimAP-1                2    Run                11a      None       Local


Number of Excluded Clients: 1

MAC Address    AP Name                WLAN State              Protocol Method
-------------------------------------------------------------------------------------------
10da.4320.cce9 charlie2               2    Excluded           11ac     None


Device# show wireless device-tracking database ip

IP                              VLAN  STATE       DISCOVERY   MAC
  ------------------------------------------------------------------------
  20.20.20.2                     20    Reachable   Local       001e.14cc.cbff
  20.20.20.6                     20    Reachable   IPv4 DHCP   000b.bbb1.0001

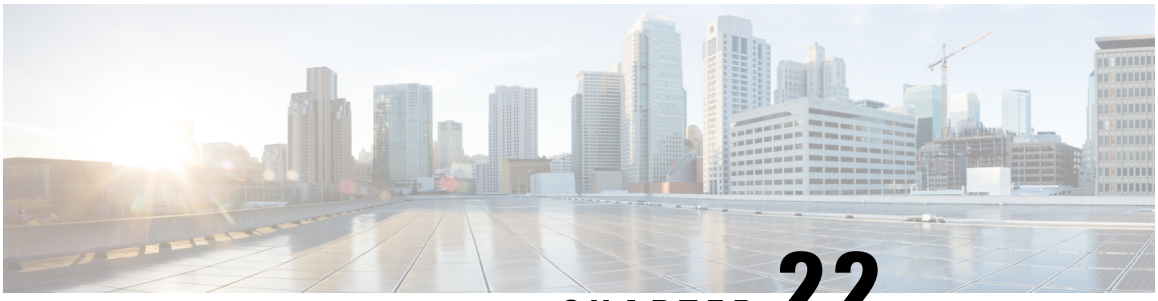

Device# show wireless exclusionlist

Excluded Clients

MAC Address       Description          Exclusion Reason               Time Remaining
-------------------------------------------------------------------------------------
10da.4320.cce9                         IP address theft                   59


Device# show wireless exclusionlist client mac 12da.4820.cce9 detail

Client State : Excluded
Client MAC Address : 12da.4820.cce9
Client IPv4 Address: 20.20.20.6
Client IPv6 Address: N/A
Client Username: N/A
Exclusion Reason : IP address theft
Authentication Method : None
Protocol: 802.11ac
AP MAC Address : 58ac.780e.08f0
AP Name: charlie2
AP slot : 1
Wireless LAN Id : 2
Wireless LAN Name: mhe-ewlc
VLAN Id : 20
```



CHAPTER 22

Unscheduled Automatic Power Save Delivery

- Unscheduled automatic power save delivery overview, on page 181
- View unscheduled automatic power save delivery, on page 181

Unscheduled automatic power save delivery overview

Unscheduled automatic power save delivery (U-APSD) is a power-saving mechanism that

- is defined as a QoS facility in IEEE 802.11e standards
- delivers multiple downlink packets in response to a single uplink trigger, and
- reduces wireless latency and extends mobile device battery life

Additional information

- U-APSD activates automatically when WMM (Wi-Fi Multimedia) is enabled.
- U-APSD eliminates the need for polling individual packets at the access point.

Possible sequence for U-APSD operation:

A client device sends a single uplink trigger packet. In response, the access point delivers multiple queued downlink packets based on that single trigger.

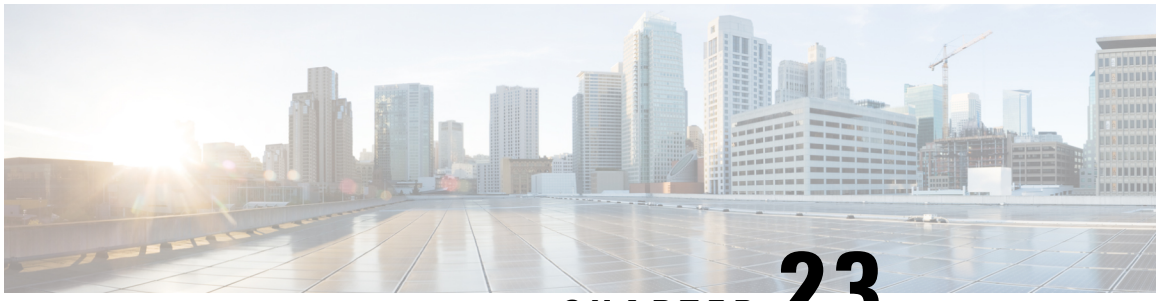
View unscheduled automatic power save delivery

Show detailed information of a client by MAC address.

```
Device# show wireless client mac-address 2B:5B:B3:18:56:E9 detail
Output Policy State : Unknown
Output Policy Source : Unknown
WMM Support : Enabled
U-APSD Support : Enabled
U-APSD value : 15
APSD ACs    : BK(T/D), BE, VI(T/D), VO(T/D)
Power Save : OFF
Current Rate :
```

```
--------------------------
BK : Background
BE : Best Effort
VI : Video
VO : Voice.

T: UAPSD Trigger Enabled
D: UAPSD Delivery Enabled
T/D : UAPSD Trigger and Delivery Enabled
```



CHAPTER 23

Target Wake Time

- Target wake time, on page 183
- Configure target wake time at radio level (CLI), on page 185
- Configuring target wake time on WLAN, on page 186
- Configure target wake time (GUI), on page 188
- Verify target wakeup time, on page 188

Target wake time

Target wakeup time (TWT) is a power-saving mechanism that

- allows an AP to schedule specific times for devices or stations (STAs) to wake up and communicate
- enables those devices to remain in a power-saving state for longer periods, and
- reduces overall network congestion.

Feature history

Table 16: Feature history for target wake time

Feature name	Release information	Feature description
Target wake time	Cisco IOS XE 17.2.1	Target wake time (TWT) allows an AP to manage activity in the Wi-Fi network, in order to minimize medium contention between Stations (STAs), and to reduce the required amount of time that an STA in the power-save mode needs to be awake. This is achieved by allocating STAs to operate at non-overlapping times, and/or frequencies, and concentrate the frame exchanges in predefined service periods.

With 802.11e, the new power-saving mechanism was introduced that helps voice-capable Wi-Fi devices, as voice packets are transmitted at short time intervals, typically 20 ms/sec.

The existing Wi-Fi client power-saving mechanisms have been in use since 802.11b, where the client devices sleep between AP beacons or multiple beacons, waking up only when they have data to transmit (they can transmit at any time, as AP does not sleep).

Delivery traffic indication map

A Delivery Traffic Indication Map (DTIM) is a bit-map that

- is contained within beacons
- indicates an AP has buffered downlink traffic, and
- specifies which particular clients are awaiting transmission.

If a client has a DTIM bit set, it can retrieve data from the AP by sending a Power-Save Poll (PS-Poll) frame to the AP. This power-save scheme is effective but only allows clients to doze for a small beacon interval. Clients still need to wake up several times per second to read DTIM from the beacon frame of the AP.

Unscheduled automatic power-save delivery

Unscheduled automatic power-save delivery (U-APSD) allows a power-save client to sleep at intervals within a beacon period. AP buffers the downlink traffic until the client wakes up and requests its delivery.

Note By default Target Wake Time (TWT) is disabled on the controller. To enable TWT, run the **ap dot11 {24ghz | 5ghz} dot11ax twt-broadcast** command.

Optimize power-saving with target wake time

TWT capable STA can either negotiate an individual TWT agreement with TWT-scheduling AP, or it can elect to be part or member of Broadcast TWT agreement existing on the AP. An STA does not need to be aware that a TWT service period can be used to exchange frames with other STAs.

Any frame exchanges that occur during a TWT service period can use any Physical Protocol Data Unit (PPDU) format that is supported by both the AP and STA involved in that TWT agreement. This includes formats such as High Efficiency Multi-User PPDU (HE MU PPDU) and High Efficiency Trigger-Based PPDU (HE TB PPDU).

The TWT agreement types are:

- **Individual TWT**: An individual TWT session is established through negotiation between the AP and a single STA. This arrangement provides a dedicated service period for both downlink and uplink communication between the AP and that specific STA. The expected traffic is highly concentrated within the negotiated service period, achieving up to 99% accuracy. Each service period begins at a defined offset from the Target Beacon Transmission Time (TBTT), lasts for the agreed-upon duration, and then repeats at regular intervals.
- **Solicited TWT**: In a solicited TWT agreement, the STA initiates the TWT session by sending a request to the AP.
- **Unsolicited TWT** : In an unsolicited TWT agreement, the AP initiates the TWT agreement with the STA. The AP sends a TWT response specifying the service period, which the STA then accepts.
- **Broadcast TWT**: In a broadcast TWT agreement, a High-Efficiency AP invites the STA to join a broadcast TWT operation, which may involve participating in an existing broadcast service period or a newly established service period.

TWT requesting STA communicates the wake scheduling information to its TWT responding AP, which then devises a schedule and delivers the TWT values to the TWT requesting STA when a TWT agreement has been established between them.

Configure target wake time at radio level (CLI)

Complete this task to configure target wake time at the radio level.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Disable the 802.11a or 802.11b network.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} shutdown
```

Step 3 Configure the 802.11ax parameters.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} dot11ax
```

Step 4 Configure the 802.11ax target wake-up time.

Example:

```
Device(config)# [no] ap dot11 {24ghz | 5ghz} dot11ax target-wakeup-time
```

Step 5 Configure the 802.11ax target waste-time.

Example:

```
Device(config)#ap dot11 {24ghz | 5gh} dot11ax target waste-time
```

Step 6 Enable the 802.11a or 802.11b network.

Example:

```
Device(config)# no ap dot11 {24ghz | 5ghz} shutdown
```

Step 7 Display and verify the 802.11ax network configuration details, which includes information about Target Wakeup Time and Target Wakeup Broadcast.

Example:

```
Device(config)# show ap dot11 {24ghz | 5ghz} network
```

The target wakeup time at the radio level is configured.

```
Device# configure terminal
Device(config)# ap dot11 24ghz shutdown
Device(config)# ap dot11 24ghz dot11ax
Device(config)# [no] ap dot11 24ghz dot11ax target-wakeup-time
```

```
Device(config)# [no] ap dot11 24ghz dot11ax twt-broadcast
Device(config)# no ap dot11 24ghz shutdown
```

Configuring target wake time on WLAN

Enable target wakeup time on WLAN (CLI)

Complete this task to enable target wakeup time on the WLAN.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enter the WLAN configuration submode.

Example:

```
Device(config)# wlan wlan-profile-name
```

The *wlan-profile-name* is the profile name of the configured WLAN.

Step 3 Disable the WLAN network.

Example:

```
Device(conf-wlan)# shutdown
```

Step 4 Configure target wake time mode on WLAN.

Example:

```
Device(conf-wlan)# dot11ax target-waketime
```

Step 5 Configure the TWT broadcast support on WLAN.

Example:

```
Device(conf-wlan)# dot11ax twt-broadcast-support
```

Step 6 Enable WLAN.

Example:

```
Device(conf-wlan)# no shutdown
```

Step 7 Display the details of the configured WLAN, including Target Wakeup Time and Target Wakeup Broadcast Time.

Example:

```
Device# show wlan {all | id | name | summary}
```

The target wakeup time is enabled on the WLAN.

```
Device# configure terminal
Device(config)# wlan wlan-profile-name
Device(conf-wlan)# shutdown
Device(conf-wlan)# dot11ax target-waketime
Device(conf-wlan)# dot11ax twt-broadcast-support
Device(conf-wlan)# no shutdown
```

Disable target wakeup time on WLAN (CLI)

Complete this task to disable target wakeup time on WLAN.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enter the WLAN configuration submode.

Example:

```
Device(config)# wlan wlan-profile-name
```

The *wlan-profile-name* is the profile name of the configured WLAN.

Step 3 Disable the WLAN.

Example:

```
Device(conf-wlan)# shutdown
```

Step 4 Disable the target wake time mode on WLAN.

Example:

```
Device(conf-wlan)# no dot11ax target-waketime
```

Step 5 Disable the TWT broadcast support on WLAN.

Example:

```
Device(conf-wlan)# no dot11ax twt-broadcast-support
```

Step 6 Enable WLAN.

Example:

```
Device(conf-wlan)# no shutdown
```

The target wakeup time is disabled on the WLAN.

```
Device# configure terminal
Device(config)# wlan wlan-profile-name
Device(conf-wlan)# shutdown
Device(conf-wlan)# no dot11ax target-waketime
```

```
Device(conf-wlan)# no dot11ax twt-broadcast-support
Device(conf-wlan)# no shutdown
```

Configure target wake time (GUI)

Complete this task to configure the target wakeup time and the broadcast for target wakeup time.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **Parameters**.

The parameters page is displayed where you can configure global parameters for 5 GHz band and 2.4 GHz band radios.

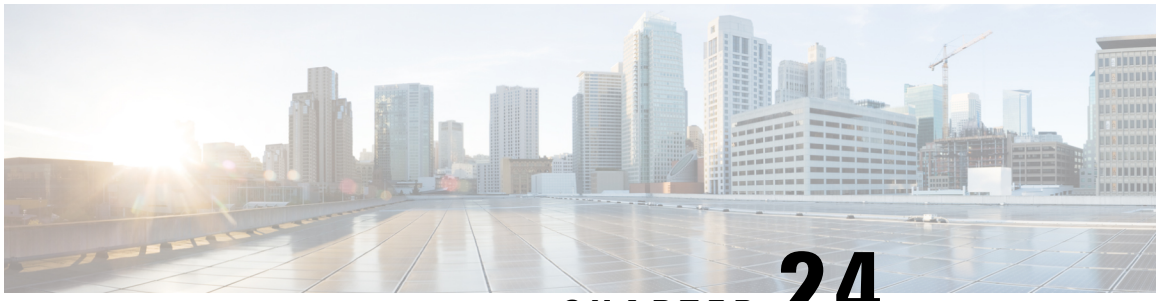
Step 2 In the **11ax Parameters** section, check the **Target Wakeup Time** check box and the **Target Wakeup Time Broadcast** check box to configure target wakeup time and broadcast target wakeup time.

The target wakeup time and the target wakeup time broadcast are configured.

Verify target wakeup time

To verify Target Wakeup Time and Target Wakeup Time Broadcast, use this command

```
Device#show ap dot11 24ghz network
.
.
.
802.11ax                                : Enabled
Target Wakeup Time                      : Enabled
Target Wakeup Time Broadcast            : Enabled
.
.
.
```



CHAPTER 24

Enabling USB Port on Access Points

- USB Port as Power Source for Access Points, on page 189
- Configuring an AP Profile (CLI), on page 190
- Configuring USB Settings for an Access Point (CLI), on page 190
- Monitoring USB Configurations for Access Points (CLI), on page 191

USB Port as Power Source for Access Points

Some Cisco APs have a USB port that can act as a source of power for some USB devices. The power can be up to 2.5W; if a USB device draws more than 2.5W of power, the USB port shuts down automatically. The port is enabled when the power draw is 2.5W and lower. Refer to the datasheet of your AP to check if the AP has a USB port that can act as a source of power.

Note The controller records the last five power-overdrawn incidents in its logs.

Caution When unsupported USB device is connected to the Cisco AP, the following message is displayed:

```
The inserted USB module is not a supported device. The behavior of this
USB device and the impact to the Access Point is not guaranteed. If Cisco
determines that a fault or defect can be isolated due to the use of
third-party USB modules installed by a customer or reseller, Cisco may
withhold support under warranty or support program under contract. In the
course of providing support for Cisco networking products, the end user
may be required to install Cisco-supported USB modules in the event Cisco
determines that removing third-party parts will assist Cisco in diagnosing
root cause for troubleshooting purposes. Cisco also reserves the right
to charge the customer per then-current time and material rates for
services provided to the customer when Cisco determines, after having
provided such services, that an unsupported device caused the root cause
of the defective product
```

Configuring an AP Profile (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**ap profile** *ap-profile* **Example:** `Device(config)# ap profile xyz-ap-profile`	Configures an AP profile and enters the AP profile configuration mode. **Note** When you delete a named profile, the APs associated with that profile will not revert to the default profile.
Step 3	**usb-enable** **Example:** `Device(config-ap-profile)# usb-enable`	Enables USB for each AP profile. **Note** By default, the USB for each AP profile is enabled. Use the **no usb-enable** command to disable USB for each AP profile.
Step 4	**end** **Example:** `Device(config-ap-profile)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring USB Settings for an Access Point (CLI)

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
Step 2	**ap name** *ap-name* **usb-module** **Example:** `Device# ap name AP44d3.xy45.69a1 usb-module`	Enables the USB port on the AP. Use the **ap name** *ap-name* **no usb-module** command to disable the USB port on the AP.

	Command or Action	Purpose
Step 3	**ap name** *ap-name* **usb-module override** **Example:** `Device# ap name AP44d3.xy45.69a1 usb-module override`	Overrides USB status of the AP profile and considers the local AP configuration. Use the **ap name** *ap-name* **no usb-module override** command to override USB status of the AP and consider the AP profile configuration. **Note** You can configure the USB status for an AP only if you enable USB override for it.

Monitoring USB Configurations for Access Points (CLI)

- To view the inventory details of APs, use the following command:

  show ap name *ap-name* **inventory**

  The following is a sample output:

```
Device# show ap name AP500F.8059.1620  inventory
NAME: AP2800    , DESCR: Cisco Aironet 2800 Series (IEEE 802.11ac) Access Point
PID: AIR-AP2802I-D-K9  ,  VID: 01,  SN: XXX1111Y2ZZZZ2800
NAME: SanDisk    , DESCR: Cruzer Blade
PID: SanDisk  ,  SN: XXXX1110010, MaxPower: 224
```

- To view the summary of an AP module, use the following command:

  show ap module summary

  The following is a sample output:

```
Device# show ap module summary
AP Name               External Module       External Module PID   External Module
Description
-------------------------------------------------------------------------------------------
AP500F.1111.2222      Enable                SanDisk               Cruzer Blade
```

- To view the USB configuration details for each AP, use the following command:

  show ap name *ap-name* **config general**

  The following is a sample output:

```
Device# show ap name AP500F.111.2222 config general

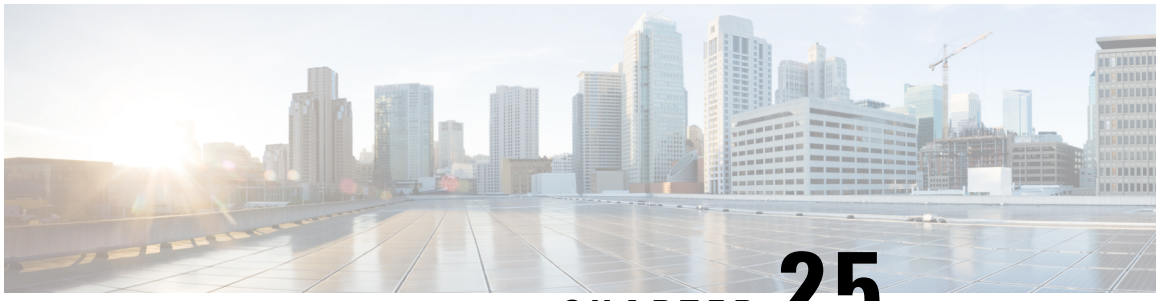
.
.
.
USB Module Type.................................. USB Module
USB Module Status................................ Disabled
USB Module Operational State..................... Enabled
USB Override ……..... Enabled
```

- To view status of the USB module, use the following command:

  show ap profile name *xyz* **detailed**

The following is a sample output:

```
Device# show ap profile name xyz detailed
USB Module                : ENABLED
```



CHAPTER 25

Zero Wait Dynamic Frequency Selection

- Information About Zero Wait Dynamic Frequency Selection, on page 193
- Configuring Zero Wait Dynamic Frequency Selection Globally (CLI), on page 193
- Configuring Zero Wait Dynamic Frequency Selection Globally (GUI), on page 194
- Enabling Zero Wait Dynamic Frequency Selection on a RF Profile (CLI), on page 194
- Enabling Zero Wait Dynamic Frequency Selection on a RF Profile (GUI), on page 195
- Verifying Zero Wait Dynamic Frequency Selection Configuration, on page 195

Information About Zero Wait Dynamic Frequency Selection

Access points (APs) monitor and perform Channel Availability Check (CAC) on a potential channel for 60 seconds when AP moves to Dynamic Frequency Selection (DFS) channels. Further, the AP ensures that there is no radar operating in the same frequency range before advertising beacons and serving clients. When the AP moves to a DFS, there is a service outage for a minute. This outage can be higher and extend up to 10 minutes. The Zero Wait Dynamic Frequency Selection feature helps to avoid the service outage in regulatory domains. As of now, U.S. and Europe are the only supported domains.

Configuring Zero Wait Dynamic Frequency Selection Globally (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**ap dot11 5ghz rrm channel zero-wait-dfs** **Example:** `Device(config)# ap dot11 5ghz rrm channel zero-wait-dfs`	Enables the Zero Wait Dynamic Frequency Selection feature. By default, the feature is disabled.

	Command or Action	Purpose
		Use the **no** form of this command to disable the feature. **Note** The Zero Wait Dynamic Frequency Selection feature is only available on a 5-GHz radio.

Configuring Zero Wait Dynamic Frequency Selection Globally (GUI)

Procedure

Step 1 Choose **Configuration > Radio Configurations > RRM**.

Step 2 In the **RRM** page, click the **5 GHz Band** tab.

Step 3 Click the **DCA** tab.

Step 4 Select the **Zero Wait DFS** check box to allow the AP to change to DFS without a service outage.

Step 5 Click **Apply**.

Enabling Zero Wait Dynamic Frequency Selection on a RF Profile (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**ap dot11 5ghz rf-profile** *profile-name* **Example:** `Device(config)# ap dot11 5ghz rf-profile test-dfs`	Configures a radio frequency (RF) profile and enters RF profile configuration mode.
Step 3	**channel zero-wait-dfs** **Example:** `Device(config-rf-profile)# channel zero-wait-dfs`	Enables the Zero Wait Dynamic Frequency Selection feature for the RF profile. Use the **no** form of this command to disable the feature.

Enabling Zero Wait Dynamic Frequency Selection on a RF Profile (GUI)

Procedure

Step 1 Choose **Configuration > Tags & Profiles > RF/Radio**.

Step 2 In the **RF** tab, click **Add**.

The **Add RF Profile** page is displayed.

Step 3 Enter the name for the RF profile.

Step 4 From the **Radio Band** drop-down, choose the **5 GHz** band.

Step 5 Click the **RRM** tab.

Step 6 Click the **DCA** tab.

Step 7 Select the **Zero Wait DFS** check box to allow the AP to change to DFS without a service outage.

Step 8 Click **Apply to Device**.

Verifying Zero Wait Dynamic Frequency Selection Configuration

Use the following commands to verify the DFS configuration.

To display the Zero Wait DFS configuration on an AP, use the following command:

```
Device# show ap name ap1 config slot 1 | inc Zero

  Zero Wait DFS Parameters
    Zero Wait DFS Capable                       : Yes
    CAC Domain                                  : None
```

To display the global configuration related to the Zero Wait Dynamic Frequency Selection feature, use the following command:

```
Device# show ap dot11 5ghz channel | inc Zero

  Zero Wait DFS Parameters
    Zero Wait DFS Capable                       : Yes
    CAC Domain                                  : None
```

To display the RF profile configuration related to the Zero Wait Dynamic Frequency Selection feature, use the following command:

```
Device# show ap rf-profile name test detail | sec Zero

Description                     :
RF Profile Name                 : test
Band                            : 5 GHz
Transmit Power Threshold v1     : -70 dBm
Min Transmit Power              : -10 dBm
Max Transmit Power              : 30 dBm
```

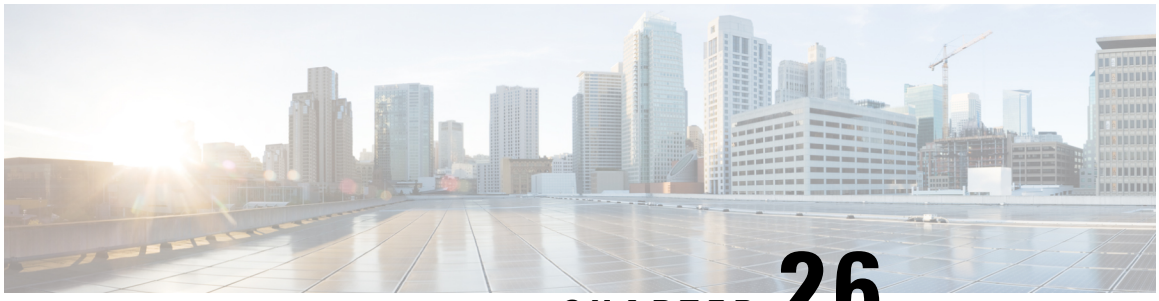
```
.
.
.
Guard Interval                    : default
Zero Wait DFS                     : Enabled
```



PART IV

Network Management

- DHCP Option82, on page 199
- RADIUS Realm, on page 211
- RADIUS Accounting, on page 219
- Persistent SSID Broadcast, on page 225
- Network Monitoring, on page 227



CHAPTER 26

DHCP Option82

- DHCP Option 82, on page 199
- Configure DHCP Option 82 global interface, on page 200
- Configure DHCP Option 82 format, on page 202
- Configure DHCP Option82 through a VLAN interface, on page 204

DHCP Option 82

DHCP Option 82 is a relay agent information option that

- carries information known by the relay agent
- increases DHCP security by enabling identification of request sources, and
- allows address allocation based on network topology or client device characteristics.

The controller can be configured to add Option 82 information to DHCP requests from clients before forwarding the requests to a DHCP server. The DHCP server can then be configured to allocate IP addresses to the wireless client based on the information present in DHCP Option 82.

DHCP provides a framework for passing configuration information to hosts on a TCP/IP network. Configuration parameters and other control information are carried in tagged data items stored in the Options field of the DHCP message. These data items are also called options. Option 82 includes information known by the relay agent.

The Relay Agent Information option is a single DHCP option containing one or more suboptions that convey information known by the Relay Agent. Option 82 enables a DHCP Relay Agent to insert circuit-specific information into a forwarded request to a DHCP server. This option uses two suboptions:

- Circuit ID: The Circuit ID suboption includes information that is specific to the circuit the request came in on. This suboption is an identifier that is specific to the relay agent. Thus, the circuit that is described will vary depending on the relay agent.
- Remote ID: The Remote ID suboption includes information on the remote host–end of the circuit. This suboption usually contains information that identifies the relay agent. In a wireless network, this is likely a unique identifier for the wireless AP.

Note

- IP MAC binding is required for DHCP Option 82 to work in some situations.

DHCP Option 82 configuration options

You can configure these DHCP Option 82 options in a controller:

- DHCP Enable
- DHCP Opt82 Enable
- DHCP Opt82 Ascii
- DHCP Opt82 RID
- DHCP Opt Format
- DHCP AP MAC
- DHCP SSID
- DHCP AP ETH MAC
- DHCP AP NAME
- DHCP Site Tag
- DHCP AP Location
- DHCP VLAN ID

The controller includes the SSID in ASCII format and the VLAN ID in hexadecimal format within the remote ID suboption of Option 82 in the outgoing DHCP packets to the server for this configuration.

```
ipv4 dhcp opt82 format ssid
ipv4 dhcp opt82 format vlan-id
```

However, if *ipv4 dhcp opt82 ascii* configuration is also present, the controller adds VLAN-ID and SSID in ASCII format.

For Cisco Catalyst 9800 Series Configuration Best Practices, see the following link: https://www.cisco.com/c/en/us/products/collateral/wireless/catalyst-9800-series-wireless-controllers/guide-c07-743627.html

Configure DHCP Option 82 global interface

Configure DHCP Option 82 globally through server override (CLI)

Set up DHCP Option 82 settings to override relay agent information in DHCP packets at the server.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Insert the global server override and link selection suboptions.

Example:

```
Device(config)# ip dhcp-relay information option server-override
```

The system processes DHCP Option 82 information globally based on server settings.

```
Device# configure terminal
Device(config)# ip dhcp-relay information option server-override
```

Configure DHCP Option 82 globally through different SVIs (GUI)

Enable DHCP Option 82 to insert relay information for clients across selected SVIs.

Procedure

Step 1 Choose **Configuration** > **VLAN**.

Step 2 Select a VLAN from the drop-down list.

The **Edit SVI** window appears.

Step 3 Click the **Advanced** tab.

Step 4 Select an option from the **IPv4 Inbound ACL** drop-down list.

Step 5 Select an option from the **IPv4 Outbound ACL** drop-down list.

Step 6 Select an option from the **IPv6 Inbound ACL** drop-down list.

Step 7 Select an option from the **IPv6 Outbound ACL** drop-down list.

Step 8 Enter an IP address in the **IPv4 Helper Address** field.

Step 9 Set the status to **Enabled** if you want to enable the **Relay Information Option** setting.

Step 10 Enter the **Subscriber ID**.

Step 11 Set the status to **Enabled** if you want to enable the **Server ID Override** setting.

Step 12 Set the status to **Enabled** if you want to enable the **Option Insert** setting.

Step 13 Select an option from the **Source-Interface Vlan** drop-down list.

Step 14 Click **Update & Apply to Device**.

DHCP Option 82 is enabled for the selected SVIs. This allows relay agent information to be included in DHCP requests.

Configure DHCP Option 82 globally through different SVIs (CLI)

Enable DHCP Option 82 globally so that DHCP relayed messages include option 82 information through the specified SVIs.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Set global source interface for relayed messages.

Example:

```
Device(config)# ip dhcp-relay source-interface vlan vlan-id
```

The device globally applies DHCP relay with Option 82 information using the specified SVI interface.

```
Device# configure terminal
Device(config)# ip dhcp-relay source-interface vlan 72
```

Configure DHCP Option 82 format

Configure the wireless controller to insert DHCP Option 82 information into DHCP requests from wireless clients.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable configuration for the specified profile policy.

Example:

```
Device(config)# wireless profile policy policy-name
```

Step 3 Shut down the profile policy.

Example:

```
Device(config-wireless-policy)# shutdown
```

Step 4 Assign the profile policy to a VLAN.

Example:

```
Device(config-wireless-policy)# vlan vlan-name
```

Step 5 (Optional) Set the session timeout value in seconds. The range is between 20 to 86,400 seconds.

Example:

```
Device(config-wireless-policy)# session-timeout value-btwn-20-86400
```

Step 6 (Optional) Set the idle timeout value in seconds. The range is between 15 to 100,000 seconds.

Example:

```
Device(config-wireless-policy)# idle-timeout 15
```

Step 7 Enable central switching.

Example:

```
Device(config-wireless-policy)# central switching
```

Step 8 Enable DHCP Option 82 for the wireless clients.

Example:

```
Device(config-wireless-policy)# ipv4 dhcp opt82
```

Step 9 (Optional) Enable ASCII on the DHCP Option 82 feature.

Example:

```
Device(config-wireless-policy)# ipv4 dhcp opt82 ascii
```

Step 10 (Optional) Add Cisco 2-byte Remote ID (RID) to the DHCP Option 82 feature.

Example:

```
Device(config-wireless-policy)# ipv4 dhcp opt82 rid
```

Step 11 Enable DHCP Option 82 on the corresponding AP.

Example:

```
Device(config-wireless-policy)# ipv4 dhcp opt82 format {ap_ethmac | ap_location | apmac |
apname | policy_tag | ssid | vlan_id}
```

For information on the various options available with the command, see Cisco Catalyst 9800 Series Wireless Controller Command Reference .

Step 12 Enable the profile policy.

Example:

```
Device(config-wireless-policy)# no shutdown
```

The wireless profile policy inserts DHCP Option 82 information in the specified format for wireless clients.

```
Device# configure terminal
Device(config)# wireless profile policy pp3
Device(config-wireless-policy)# shutdown
Device(config-wireless-policy)# vlan 72
Device(config-wireless-policy)# session-timeout 300
Device(config-wireless-policy)# idle-timeout 15
```

```
Device(config-wireless-policy)# central switching
Device(config-wireless-policy)# ipv4 dhcp opt82
Device(config-wireless-policy)# ipv4 dhcp opt82 ascii
Device(config-wireless-policy)# ipv4 dhcp opt82 rid
Device(config-wireless-policy)# ipv4 dhcp opt82 format apmac
Device(config-wireless-policy)# no shutdown
```

Configure DHCP Option82 through a VLAN interface

Configure DHCP Option 82 through option-insert command (CLI)

Enable DHCP Option 82 insertion on a VLAN interface to provide relay agent information in DHCP packets.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a VLAN ID.

Example:

```
Device(config)# interface vlan vlan-id
```

Step 3 Insert relay information in BOOTREQUEST.

Example:

```
Device(config-if)# ip dhcp relay information option-insert
```

Step 4 Configure the IP address for the interface.

Example:

```
Device(config-if)# ip address ip-address
```

Step 5 Configure the destination address for UDP broadcasts.

Example:

```
Device(config-if)# ip helper-address ip-address
```

Step 6 Disable the MOP for an interface.

Example:

```
Device(config-if)# no mop enabled
```

Step 7 Disable the task of sending MOP periodic system ID messages.

Example:

```
Device(config-apgroup)# no mop sysid
```

DHCP requests sent from this VLAN interface will contain Option 82 relay information to aid in DHCP server assignment and troubleshooting.

```
Device# configure terminal
Device(config)# interface vlan 72
Device(config-if)# ip dhcp relay information option-insert
Device(config-if)# ip address 9.3.72.38 255.255.255.0
Device(config-if)# ip helper-address 9.3.72.1
Device(config-if)# no mop enabled
Device(config-apgroup)# no mop sysid
```

Configure DHCP Option 82 through server-ID-override command (CLI)

Enable DHCP Option 82 with server-ID override to control how DHCP relay information is inserted on a Cisco device.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the server-id override suboption to use an RFC-specific or Cisco-specific value.

Example:

```
Device(config)# ip dhcp compatibility suboption server-override cisco
```

Step 3 Configure the link-selection suboption to use an RFC-specific or Cisco-specific value.

Example:

```
Device(config)# ip dhcp compatibility suboption link-selection cisco
```

Step 4 Configure a VLAN ID.

Example:

```
Device(config)# interface vlan vlan-id
```

Step 5 Insert the server-id override suboption and link-selection suboption.

Example:

```
Device(config-if)# ip dhcp relay information option server-id-override
```

Step 6 Configure the IP address for the interface.

Example:

```
Device(config-if)# ip address ip-address
```

Step 7 Configure the destination address for UDP broadcasts that your interfce will use.

Example:

```
Device(config-if)# ip helper-address ip-address
```

Step 8 Disable MOP for an interface.

Example:

```
Device(config-if)# no mop enabled
```

Step 9 Disable the task of sending MOP periodic system ID messages.

Example:

```
Device(config-if)# [no] mop sysid
```

The device uses the specified server-id override and link-selection options in DHCP Option 82 relay messages, which the device forwards through the configured VLAN interface.

```
Device# configure terminal
Device(config)# ip dhcp compatibility suboption server-override cisco
Device(config)# ip dhcp compatibility suboption link-selection cisco
Device(config)# interface vlan 72
Device(config-if)# ip dhcp relay information option server-id-override
Device(config-if)# ip address 9.3.72.38 255.255.255.0
Device(config-if)# ip helper-address 9.3.72.1
Device(config-if)# no mop enabled
Device(config-if)# no mop sysid
```

Configure DHCP Option 82 through a subscriber-ID (CLI)

Configure DHCP Option 82 through a subscriber-ID.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a VLAN ID.

Example:

```
Device(config)# interface vlan vlan-id
```

Step 3 Insert the subscriber identifier suboption to include the subscriber ID in DHCP messages.

Example:

```
Device(config-if)# ip dhcp relay information option subscriber-id subscriber-id
```

Step 4 Configure the IP address for the interface.

Example:

```
Device(config-if)# ip address ip-address
```

Step 5 Configure the destination address for UDP broadcasts.

Example:

```
Device(config-if)# ip helper-address ip-address
```

Step 6 Disable MOP for an interface.

Example:

```
Device(config-if)# no mop enabled
```

Step 7 Disable the task of sending MOP periodic system ID messages.

Example:

```
Device(config-apgroup)# no mop sysid
```

The system now inserts the subscriber-ID suboption (DHCP Option 82) into relayed DHCP packets on the specified VLAN interface.

```
Device# configure terminal
Device(config)# interface vlan 72
Device(config-if)# ip dhcp relay information option subscriber-id test10
Device(config-if)# ip address 9.3.72.38 255.255.255.0
Device(config-if)# ip helper-address 92.0.2.1
Device(config-if)# no mop enabled
Device(config-apgroup)# no mop sysid
```

Configure DHCP Option 82 through server-ID-override and subscriber-ID commands (CLI)

Enable customized handling of DHCP Option 82 information for relayed DHCP requests by setting server and subscriber ID options.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a VLAN ID.

Example:

```
Device(config)# interface vlan vlan-id
```

Step 3 Insert server ID override and link selection suboptions.

Example:

```
Device(config-if)# ip dhcp relay information option server-id-override
```

Step 4 Insert the subscriber identifier suboption.

Example:

```
Device(config-if)# ip dhcp relay information option subscriber-id subscriber-id
```

Step 5 Configure the IP address for the interface.

Example:

```
Device(config-if)# ip address ip-address
```

Step 6 Configure the destination address for UDP broadcasts.

Example:

```
Device(config-if)# ip helper-address ip-address
```

Step 7 Disable the MOP for an interface.

Example:

```
Device(config-if)# no mop enabled
```

Step 8 Disable the task of sending MOP periodic system ID messages.

Example:

```
Device(config-apgroup)# no mop sysid
```

The interface relays DHCP requests with Option 82 data, including server ID override and subscriber ID.

```
Device# configure terminal
Device(config)# interface vlan 72
Device(config-if)# ip dhcp relay information option server-id-override
Device(config-if)# ip dhcp relay information option subscriber-id test10
Device(config-if)# ip address 9.3.72.38 255.255.255.0
Device(config-if)# ip helper-address 9.3.72.1
Device(config-if)# no mop enabled
Device(config-apgroup)# no mop sysid
```

Configure DHCP Option 82 through different SVIs (CLI)

Enable DHCP Option 82 using different switch virtual interfaces (SVIs) for relayed requests.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a VLAN ID.

Example:

```
Device(config)# interface vlan vlan-id
```

Step 3 Configure a source interface on the VLAN to relay messages.

Example:

```
Device(config-if)# ip dhcp relay source-interface vlan vlan-id
```

Step 4 Configure the IP address for the interface.

Example:

```
Device(config-if)# ip address ip-address
```

Step 5 Configure the destination address for UDP broadcasts.

Example:

```
Device(config-if)# ip helper-address ip-address
```

Step 6 Disable the Maintenance Operations Protocol (MOP) on the interface.

Example:

```
Device(config-if)# no mop enabled
```

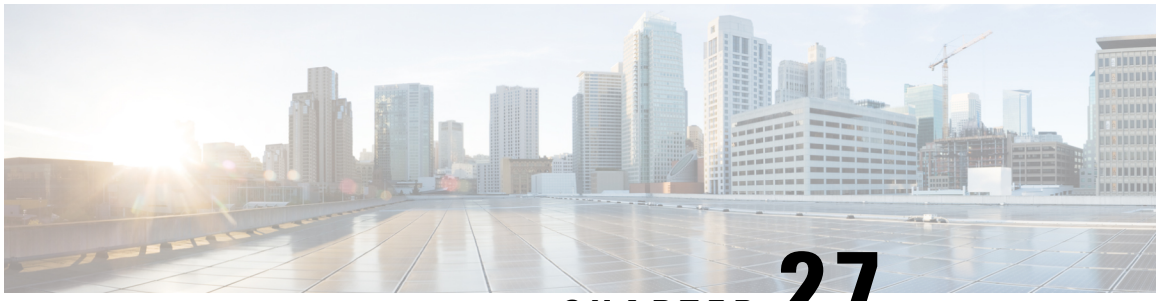
Step 7 Disable periodic system ID message transmission for MOP.

Example:

```
Device(config-apgroup)# no mop sysid
```

The device relays DHCP messages with Option 82 through the configured VLAN SVIs.

```
Device# configure terminal
Device(config)# interface vlan 72
Device(config-if)# ip dhcp relay source-interface vlan 74
Device(config-if)# ip address 9.3.72.38 255.255.255.0
Device(config-if)# ip helper-address 9.3.72.1
Device(config-if)# no mop enabled
Device(config-apgroup)# no mop sysid
```



CHAPTER 27

RADIUS Realm

- RADIUS realms, on page 211
- Enable RADIUS realm, on page 212
- Configure realm to match the RADIUS server for authentication and accounting, on page 213
- Configure AAA policy for WLANs, on page 214
- Verify RADIUS-realm configuration, on page 216

RADIUS realms

A RADIUS realm is an AAA configuration element that

- enables assigning authentication and accounting requests to specific RADIUS servers based on user domain information
- uses the domain portion of a user's Network Access Identifier (NAI) to select the appropriate RADIUS server, and
- provides realm-based filtering and control for authentication and accounting requests within a WLAN.

Feature history

Table 17: Feature history for RADIUS realms

Feature name	Release information	Feature description
RADIUS realms	Cisco IOS XE 16.9.1	RADIUS realms are configuration elements in AAA (Authentication, Authorization, and Accounting) systems. They use the domain portion of a user's Network Access Identifier (NAI)—such as the part after "@" in an email address—to direct authentication and accounting requests to specific RADIUS servers. Realms help organizations manage user access and resource usage across different groups or domains.

When mobile clients connect to a WLAN, the RADIUS realm is included in the Extensible Authentication Protocol Method for UMTS Authentication and Key Agreement (EAP-AKA) identity response of the authentication request packet. For WLAN, the NAI format for EAP-AKA can be specified as

username@domain.com. In the NAI format, the realm follows the @ symbol and is specified as *example.com*. If the vendor-specific attribute "test" is added, the NAI format becomes *test@example.com*.

The RADIUS Realm feature can be enabled and disabled on a WLAN. If Realm is enabled on a WLAN, the corresponding user should send the username in the NAI format. The controller sends the authentication request to the AAA server only after it receives a realm in NAI format from the client and verifies that the realm complies with the required standards. Additionally, the controller sends accounting requests to the AAA server based on realm filtering.

Realm support on a WLAN

Each WLAN is configured to support NAI realms. Once the realm is enabled on a specific SSID, the system compares the received realms in the EAP identity response to those configured on the RADIUS server. If a username with the realm is not sent by the client, the WLAN uses the default RADIUS server for authentication. When the client's realm does not match the realms configured on the WLAN, the client is deauthenticated and dropped.

If the RADIUS Realm feature is not enabled on a WLAN, the controller uses the username received in the EAP identity request directly and authenticates the user using the configured RADIUS server. The RADIUS Realm feature is disabled on WLANs by default.

- **Realm match for authentication**: In dot1x with EAP methods (similar to EAP AKA), the username is received as part of an EAP identity response. A realm is derived from the username and is matched with the realms that are already configured in the corresponding RADIUS authentication server. If there is a match, the authentication requests are forwarded to the RADIUS server. If there is a mismatch, the client is deauthenticated.
- **Realm match for accounting**: After receiving a client's username through an access-accept message, the system derives the realm from the username when accounting messages are triggered. The realm is compared with the configured accounting realms on the RADIUS accounting server. When there is a match, the server receives the accounting requests. If there is no match, the system drops the accounting requests.

Enable RADIUS realm

Enable the RADIUS realm to allow the WLAN to use the RADIUS realm selection for AAA authentication.

Enabling the RADIUS realm is required when configuring wireless AAA policies that use RADIUS for authentication on your Cisco device.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a new AAA policy.**wireless aaa policy**

Example:

```
Device(config)# wireless aaa policy aaa-policy
```

Step 3 Enable AAA RADIUS realm selection.

Example:

```
Device(config-aaa-policy)# aaa-realm enable
```

Note
Use the **no aaa-realm enable** or the **default aaa-realm enable** command to disable the RADIUS realm.

The AAA RADIUS realm is now enabled and available for authentication purposes in the specified wireless AAA policy.

```
Device# configure terminal
Device(config)# wireless aaa policy policy-1
Device(config-aaa-policy)# aaa-realm enable
```

Configure realm to match the RADIUS server for authentication and accounting

Configure the realm to use your chosen RADIUS server group for authentication and accounting network access requests.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a AAA authentication model.

Example:

```
Device(config)# aaa new-model
```

Step 3 Set the authorization method.

Example:

```
Device(config)# aaa authorization network default group radius-server-group
```

Step 4 Indicate that 802.1x must use the realm group RADIUS server.

Example:

```
Device(config)# aaa authentication dot1x realm group radius-server-group
```

Step 5 Define the authentication method at login.

Example:

```
Device(config)# aaa authentication login realm group radius-server-group
```

Step 6 Enable accounting so the system sends a start record notice when a client is authorized and a stop record notice when the session ends.

Example:

```
Device(config)# aaa accounting identity realm start-stop group radius-server-group
```

Your device now uses the realm and RADIUS server group for authentication, authorization, and accounting.

```
Device# configure terminal
Device(config)# aaa new-model
Device(config)# aaa authorization network default group aaa_group_name
Device(config)# aaa authentication dot1x cisco.com group cisco1
Device(config)# aaa authentication login cisco.com group cisco1
Device(config)# aaa accounting identity cisco.com start-stop group v
```

Configure AAA policy for WLANs

Configure authentication, authorization, and accounting (AAA) policies to control and secure access for WLAN users.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a new AAA policy for wireless.

Example:

```
Device(config)# wireless aaa policy aaa-policy-name
```

Step 3 Enable AAA RADIUS server selection by realm.

Example:

```
Device(config-aaa-policy)# aaa-realm enable
```

Step 4 Return to global configuration mode.

Example:

```
Device(config-aaa-policy)# exit
```

Step 5 Configure a WLAN policy profile.

Example:

```
Device(config)# wireless profile policy wlan-policy-profile
```

Step 6 Map the AAA policy.**aaa-policy***aaa-policy*

Example:

```
Device(config-wireless-policy)# aaa-policy aaa-policy
```

Step 7 Set the accounting list.**accounting-list***acct-config-realm*

Example:

```
Device(config-wireless-policy)# accounting-list acct-config-realm
```

Step 8 Return to global configuration mode.

Example:

```
Device(config-wireless-policy)# exit
```

Step 9 Configure a WLAN.**wlan***wlan-namewlan-idssid*

Example:

```
Device(config)# wlan wlan-name wlan-id ssid
```

Step 10 Enable the security authentication list for IEEE 802.1x.

Example:

```
Device(config-wlan)# security dot1x authentication-list auth-list-realm
```

Step 11 Return to global configuration mode.

Example:

```
Device(config-wlan)# exit
```

Step 12 Configuresa policy tag.

Example:

```
Device(config)# wireless tag policy policy-name
```

Step 13 Map a policy profile to the WLAN.

Example:

```
Device(config-policy-tag)# wlan wlan-name policy policy-profile
```

Step 14 Return to global configuration mode.

Example:

```
Device(config-policy-tag)# exit
```

The AAA policy is successfully applied to the target WLAN, enabling centralized authentication and accounting for users connecting to that WLAN.

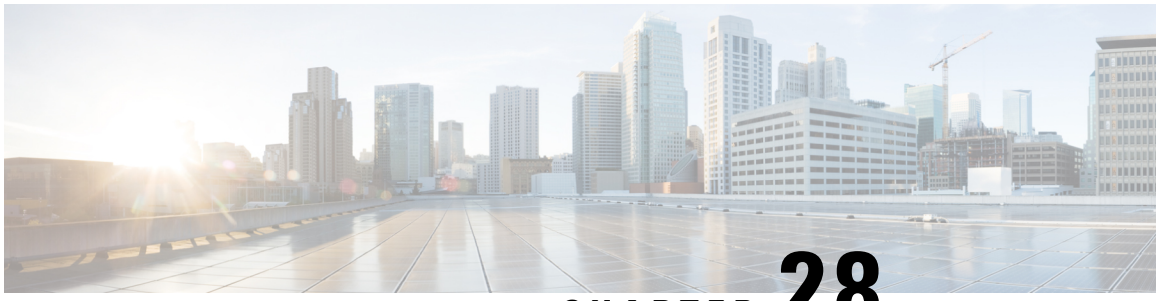
```
Device# configure terminal
Device(config)# wireless aaa policy aaa-policy-1
Device(config-aaa-policy)# aaa-realm enable
Device(config-aaa-policy)# exit
Device(config)# wireless profile policy wlan-policy-1
Device(config-wireless-policy)# aaa-policy aaa-policy-1
Device(config-wireless-policy)# accounting-list cisco.com
Device(config-wireless-policy)# exit
Device(config)# wlan wlan2 14 wlan-aaa
Device(config-wlan)# security dot1x authentication-list cisco.com
Device(config-wlan)# exit
Device(config)# wireless tag policy tag-policy-1
Device(config-policy-tag)# wlan Abc-wlan policy wlan-policy-a
Device(config-policy-tag)# exit
```

Verify RADIUS-realm configuration

Run this command to verify the RADIUS-realm configuration.

```
Device# show wireless client mac-address 14bd.61f3.6a24 detail
Client MAC Address : 14bd.61f3.6a24
Client IPv4 Address : 192.0.2.1
Client IPv6 Addresses : fe80::286e:9fe0:7fa6:8f4
Client Username : cisco-mac@cisco.com
AP MAC Address : 4c77.6d79.5a00
AP Name: AP4c77.6d53.20ec
AP slot : 1
Client State : Associated
Policy Profile : name-policy-profile
Flex Profile : N/A
Wireless LAN Id : 3
Wireless LAN Name: ha_realm_WLAN_WPA2_AES_DOT1X
BSSID : 4c77.6d79.5a0f
Connected For : 26 seconds
Protocol : 802.11ac
Channel : 44
Client IIF-ID : 0xa0000001
Association Id : 1
Authentication Algorithm : Open System
Client CCX version : No CCX support
Re-Authentication Timeout : 1800 sec (Remaining time: 1775 sec)
Input Policy Name  : None
Input Policy State : None
Input Policy Source : None
Output Policy Name  : None
Output Policy State : None
Output Policy Source : None
WMM Support : Enabled
U-APSD Support : Enabled
  U-APSD value : 0
  APSD ACs    : BK, BE, VI, VO
Fastlane Support : Disabled
Power Save : OFF
Supported Rates : 9.0,18.0,36.0,48.0,54.0
Mobility:
  Move Count                  : 0
  Mobility Role               : Local
  Mobility Roam Type          : None
  Mobility Complete Timestamp : 06/12/2018 19:52:35 IST
Policy Manager State: Run
NPU Fast Fast Notified : No
Last Policy Manager State : IP Learn Complete
Client Entry Create Time : 25 seconds
Policy Type : WPA2
Encryption Cipher : CCMP (AES)
Authentication Key Management : 802.1x
Encrypted Traffic Analytics : No
Management Frame Protection : No
Protected Management Frame - 802.11w : No
EAP Type : PEAP
VLAN : 113
Multicast VLAN : 0
Access VLAN : 113
Anchor VLAN : 0
WFD capable : No
Managed WFD capable : No
Cross Connection capable : No
```

```
Support Concurrent Operation : No
Session Manager:
  Interface        : capwap_9040000f
  IIF ID           : 0x9040000F
  Authorized       : TRUE
  Session timeout  : 1800
  Common Session ID: 097704090000000DF4607B3B
  Acct Session ID  : 0x00000fa2
  Aaa Server Details
  Server IP        : 192.0.2.2
  Auth Method Status List
       Method : Dot1x
              SM State         : AUTHENTICATED
              SM Bend State    : IDLE
  Local Policies:
       Service Template : wlan_svc_name-policy-profile_local (priority 254)
              Absolute-Timer   : 1800
              VLAN             : 113
  Server Policies:
  Resultant Policies:
              VLAN             : 113
              Absolute-Timer   : 1800
DNS Snooped IPv4 Addresses : None
DNS Snooped IPv6 Addresses : None
Client Capabilities
  CF Pollable : Not implemented
  CF Poll Request : Not implemented
  Short Preamble : Not implemented
  PBCC : Not implemented
  Channel Agility : Not implemented
  Listen Interval : 0
Fast BSS Transition Details :
  Reassociation Timeout : 0
11v BSS Transition : Not implemented
FlexConnect Data Switching : Central
FlexConnect Dhcp Status : Central
FlexConnect Authentication : Central
FlexConnect Central Association : No
.
.
.
Fabric status : Disabled
Client Scan Reports
Assisted Roaming Neighbor List
```



CHAPTER 28

RADIUS Accounting

- RADIUS accounting of AP events, on page 219
- Configure accounting method-list for an AP profile, on page 220
- Verify AP accounting information, on page 221
- Device ecosystem data, on page 221
- Enable device ecosystem data, on page 222
- Verify device ecosystem data, on page 223

RADIUS accounting of AP events

RADIUS accounting of AP events is a network monitoring mechanism that

- Tracks the status transitions of APs within a wireless controller environment
- Records AP join and disjoin events
- Provides historical visibility into AP downtime and uptime through accounting messages sent to a RADIUS server.

Feature History

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

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 18: Feature history table

Feature Name	Release	Description
Device Ecosystem Data	Cisco IOS XE 17.10.1	This feature sends device analytics data that is present in the RADIUS accounting request to Cisco ISE to profile endpoints The command is introduced: • dot11-tlv-accounting

Feature Name	Release	Description
Chargeable User Identity in RADIUS Accounting	Cisco IOS XE 17.9.1	Chargeable User Identity (CUI) is a unique identifier for a client visiting a network. This attribute can be used as an alternative for the client's username as part of the authentication process. The command is introduced: • dot11-tlv-accounting
Improved Logging in RADIUS Accounting	Cisco IOS XE 17.1.1	Prior to Cisco IOS XE Amsterdam 17.1.1 release, the controller did not send accounting messages for AP join and disjoin events during network issues. From Cisco IOS XE Amsterdam 17.1.1 Release and later, the RADIUS server keeps a record of all APs that were down and have come up.

Configure accounting method-list for an AP profile

Define an accounting method list within an access point (AP) profile to enable or disable accounting for AP operations.

Use this task to specify how accounting is managed for an AP profile on your device. This allows tracking of AP events and assists with auditing and troubleshooting

Before you begin

- Identify the AP profile name you want to configure. The default AP profile name is `default-ap-profile`.
- Determine the accounting method list name you wish to apply.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the AP profile. The default AP join profile name is default-ap-profile.

Example:

```
Device(config)# ap profile ap-profile-name
```

Step 3 Configure the accounting method list for the AP profile.

Example:

```
Device(config-ap-profile)# [no] accounting method-list method-list-name
```

Use the **no** form of this command to disable the accounting method list.

The system associates the specified accounting method list with the AP profile, enabling or disabling accounting

Example

```
Device# configure terminal
Device(config)# ap profile ap-profile-name
Device(config-ap-profile)# [no] accounting method-list method-list-name
```

Verify AP accounting information

Verify the AP accounting information, including the MAC address, packets sent, packets received, and the method list.

```
Device#show wireless stats ap accounting
Base MAC       Total packet Send    Total packet Received Methodlist
-------------------------------------------------------------------------------------
00b0.e192.0f20     4       3    abc
38ed.18cc.5788     8       8         ML_M
70ea.1ae0.af08     0       0         ML_A
```

View details for a method list configured for an AP profile.

```
Device# show ap profile name Method-list detailed
AP Profile Name               : test-profile
Description                   :
.
.
.
Method-list name              : Method-list
Packet Sequence Jump DELBA    : ENABLED
Lag status                    : DISABLED
.
Client RSSI Statistics
  Reporting                   : ENABLED
  Reporting Interval          : 30 seconds
```

Device ecosystem data

A device ecosystem data set is a collection of endpoint analytics that

- aggregates key attributes such as model number, OS version, and device type
- enables controllers to build comprehensive profiles of endpoints in a network, and
- supports integration with systems like Cisco Identity Services Engine (ISE) for security and policy management.

Feature history

Table 19: Feature History for Device ecosystem data

Feature	Release	Feature Information
Device ecosystem data	Cisco IOS XE 17.10.1	This feature includes device analytics data in the RADIUS accounting request sent to Cisco ISE. Cisco ISE uses this data to profile the endpoints.

Device ecosystem data uses device analytics to enhance DHCP and HTTP attribute sharing. This process provides richer endpoint profiling for access control and network management. For example, device ecosystem data can reveal an endpoint's operating system version and model. These insights enable more precise security policies in Cisco ISE.

Enable device ecosystem data

Enable the device ecosystem data feature so that the controller can send enhanced device analytics to ISE for improved endpoint profiling.

Before you begin

Before you proceed with the configuration, ensure that device classifier and accounting features are enabled.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a policy profile for wireless devices.

Example:

```
Device(config)# wireless profile policy policy-profile-name
```

Step 3 Disable the wireless policy profile.

Example:

```
Device(config-wireless-policy)# shutdown
```

Step 4 Configure client RADIUS profiling.

Example:

```
Device(config-wireless-policy)# radius-profiling
```

Step 5 Configure the controller to send device analytics data found in RADIUS accounting requests to Cisco ISE. This enables endpoint profiling.

Example:

```
Device(config-wireless-policy)# dot11-tlv-accounting
```

Use the **no** form of this command to disable the feature.

Step 6 Enable the wireless policy profile.

Example:

```
Device(config-wireless-policy)# no shutdown
```

Step 7 Return to privileged EXEC mode.

Example:

```
Device(config-wireless-policy)# end
```

The controller now sends device analytics data found in RADIUS accounting requests to Cisco ISE for device profiling.

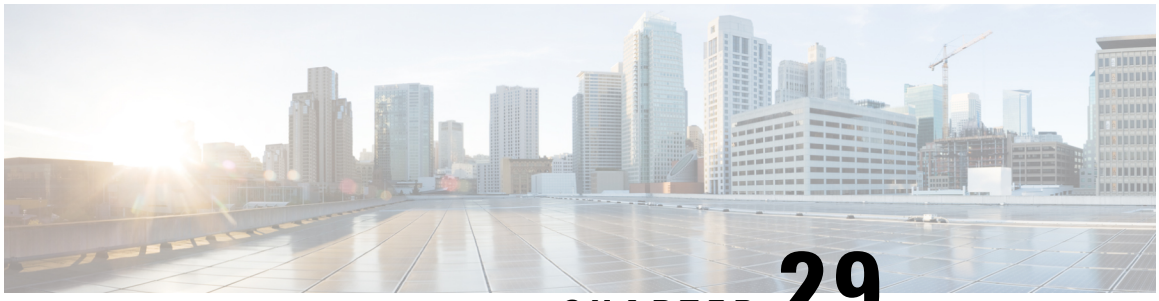
```
Device# configure terminal
Device(config)# wireless profile policy default-profile-policy
Device(config-wireless-policy)# shutdown
Device(config-wireless-policy)# radius-profiling
Device(config-wireless-policy)# dot11-tlv-accounting
Device(config-wireless-policy)# no shutdown
Device(config-wireless-policy)# end
```

Verify device ecosystem data

Use this command to verify device ecosystem data in RADIUS accounting configuration.

```
Device# show wireless profile policy detailed <name>

.
.
.
WLAN Local Profiling
  Subscriber Policy Name            : Not Configured
  RADIUS Profiling                  : ENABLED
  HTTP TLV caching                  : DISABLED
  DHCP TLV caching                  : DISABLED
  DOT11 TLV accounting              : ENABLED
.
.
.
```



CHAPTER 29

Persistent SSID Broadcast

This chapter explains the persistent SSID broadcast feature for Cisco Aironet 1542 RAPs and MAPs, providing command steps to enable or disable it and commands to verify AP configuration and behavior when the WAN link is down.

- Persistent SSID broadcast, on page 225

Persistent SSID broadcast

A persistent SSID broadcast is a wireless network feature that

- enables Root APs (RAPs) and Mesh APs (MAPs) to continue broadcasting the SSID when the WAN link is down
- helps operators isolate issues between the backhaul network and the access wireless network, and
- applies specifically to Cisco Aironet 1542 APs operating in FlexConnect plus Bridge mode.

RAPs have a wired connection to the embedded wireless controller while MAPs have wireless connection to the embedded wireless controller.

This requirement helps isolate responsibility, whether the fault lies with the backhaul or the access wireless network. Different operators may own each part of the network.

RAPs and MAPs broadcast the SSID while in standalone mode if the default gateway is reachable.

Also refer Mesh Deployment Guide for Cisco Catalyst 9800 Series Wireless Controllers.

Configure persistent SSID broadcast (CLI)

Enable or disable persistent SSID broadcast so that associated APs re-join and maintain SSID visibility as configured using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the AP profile.

Example:

```
Device(config)# ap profile ap-profile-name
```

Step 3 Configure the SSID broadcast mode.

Example:

```
Device(config-ap-profile)# ssid broadcast persistent

Device(config-ap-profile)# [no] ssid broadcast persistent
```

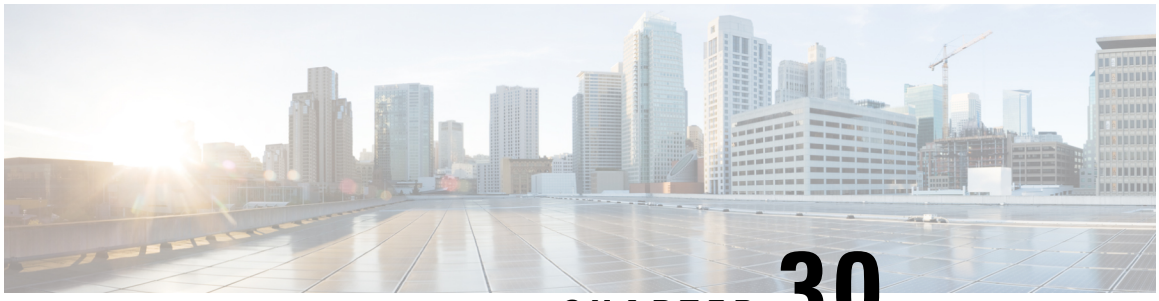
The **persistent** keyword enables a persistent SSID broadcast, where the associated APs re-join. Use the **no** form of the command to disable the feature.

Note
Enabling or disabling this feature causes the AP to re-join.

Verify persistent SSID broadcast

To view the configuration of all Cisco APs, use this **show** command:

```
Device#show ap config general
Cisco AP Name   : AP4C77.6DF2.D598
================================================
Office Extend Mode                              : Disabled
Persistent SSID Broadcast                       : Enabled
Remote AP Debug                                 : Disabled
```



CHAPTER 30

Network Monitoring

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Network Monitoring

The only network monitoring supported on the Embedded Wireless Controller (EWC) is through Cisco Digital Network Architecture (DNA) Center. This is done through NETCONF using a propietary protocol for push and pull of configuration or status information.

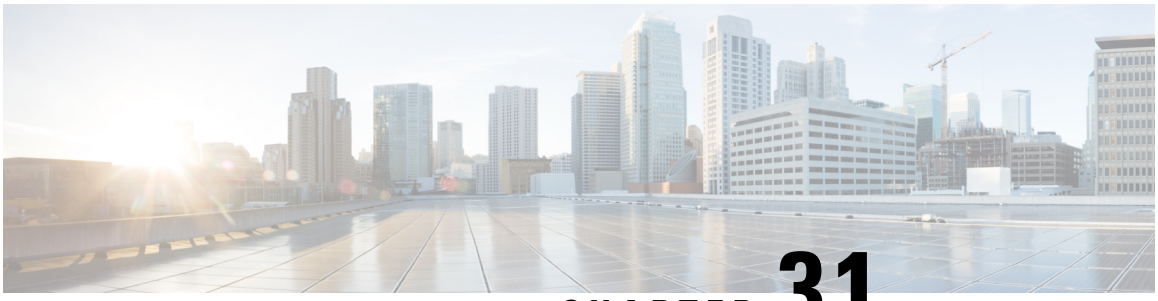
Note Although you can run telemetry commands on EWC, monitoring is only supported through DNA, which is done through NETCONF.



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System Management

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CHAPTER 31

Network Mobility Services Protocol

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Information About Network Mobility Services Protocol

Cisco Network Mobility Services Protocol (NMSP) is a secure two-way protocol that can be run over a connection-oriented (TLS) or connection-less (DTLS) transport. The wireless infrastructure runs the NMSP server and Cisco Connected Mobile Experiences (Cisco CMX) acts as an NMSP client. The embedded wireless controller supports multiple services and multiple Cisco CMXs can connect to the NMSP server to get the data for the services (location of wireless devices, probe RSSI, hyperlocation, wIPS, and so on.) over the NMSP session.

NMSP defines the intercommunication between Cisco CMX and the embedded wireless controller. Cisco CMX communicates to the embedded wireless controller over a routed IP network. Both publish-subscribe and request-reply communication models are supported. Typically, Cisco CMX establishes a subscription to receive services data from the embedded wireless controller in the form of periodic updates. The embedded wireless controller acts as a data publisher, broadcasting services data to multiple CMXs. Besides subscription, Cisco CMX can also send requests to the embedded wireless controller, causing the embedded wireless controller to send a response back.

NMSP essentially provides a way to the applications in the embedded wireless controller to talk to the outside world. The NMSP in the embedded wireless controller also provides the flexibility to change the protocol to talk to the outside world.

The following is a list of the Network Mobility Services Protocol features:

- NMSP is disabled by default.
- NMSP communicates with Cisco CMX using TCP, and uses TLS for encryption.



Note HTTPS is not supported for data transport between embedded wireless controller and Cisco CMX.

Enabling NMSP On-Premises Services

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**nmsp enable** **Example:** `Device(config)# nmsp enable`	Enables NMSP on premises services. **Note** By default, the NMSP is disabled on the embedded wireless controller.
Step 3	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Modifying the NMSP Notification Interval for Clients, RFID Tags, and Rogues

NMSP manages communication between the Cisco Connected Mobile Experiences (Cisco CMX) and the embedded wireless controller for incoming and outgoing traffic. If your application requires more frequent location updates, you can modify the NMSP notification interval (to a value between 1 and 180 seconds) for clients, active RFID tags, and rogue access points and clients.



Note The TCP port (16113) that the embedded wireless controller and Cisco CMX communicate over must be open (not blocked) on any firewall that exists between the embedded wireless controller and the Cisco CMX for NMSP to function.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Modifying the NMSP Notification Threshold for Clients, and Tags

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**location notify-threshold** {**clients** | **tags** } *threshold* **Example:** `Device(config)# location notify-threshold clients 5`	Configures the NMSP notification threshold for clients, and tags. *threshold*- RSSI threshold value in db. Valid range is from 0 to 10.
Step 3	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configure NMSP strong cipher (CLI)

Enable strong cipher suites for NMSP server to enhance security for device communication.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable strong ciphers for NMSP server.

Example:

```
Device(config)# nmsp strong-cipher
```

Strong ciphers for NMSP server contains, "ECDHE-RSA-AES128-GCM-SHA256:, ECDHE-ECDSA-AES128-GCM-SHA256:, AES256-SHA256:AES256-SHA:, and AES128-SHA256:AES128-SHA".

Normal cipher suite contains, "ECDHE-RSA-AES128-GCM-SHA256:, ECDHE-ECDSA-AES128-GCM-SHA256:, and AES128-SHA".

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, press ***Ctrl-Z*** to exit global configuration mode.

Verify NMSP settings

To view the NMSP capabilities of the embedded wireless controller, use the command:

```
Device# show nmsp capability
Service            Subservice
----------------------------
RSSI               Rogue, Tags, Mobile Station,
Spectrum           Aggregate Interferer, Air Quality, Interferer,
Info               Rogue, Mobile Station,
Statistics         Rogue, Tags, Mobile Station,
AP Monitor         Subscription
On Demand Services Device Info
AP Info            Subscription
```

To view the NMSP notification intervals, use the command:

```
Device# show nmsp notification interval
NMSP Notification Intervals
---------------------------

RSSI Interval:
Client              : 2 sec
RFID                : 50 sec
Rogue AP            : 2 sec
Rogue Client        : 2 sec
Spectrum            : 2 sec
```

To view the connection-specific statistics counters for all CMX connections, use the command:

```
Device# show nmsp statistics connection
NMSP Connection Counters
------------------------
 CMX IP Address: 10.22.244.31, Status: Active
 State:
 Connections : 1
```

```
Disconnections : 0
Rx Data Frames : 13
Tx Data Frames : 99244
Unsupported messages : 0
Rx Message Counters:
ID  Name                                  Count
---------------------------------------------
1  Echo Request                          6076
7  Capability Notification                  2
13  Measurement Request                     5
16  Information Request                     3
20  Statistics Request                      2
30  Service Subscribe Request               1

Tx Message Counters:
ID  Name                                  Count
---------------------------------------------
2  Echo Response                          6076
7  Capability Notification                   1
14  Measurement Response                    13
15  Measurement Notification              91120
17  Information Response                      6
18  Information Notification               7492
21  Statistics Response                       2
22  Statistics Notification                 305
31  Service Subscribe Response                1
67  AP Info Notification                    304
```

To view the common statistic counter of the embedded wireless controller's NMSP service, use the command:

```
Device# show nmsp statistics summary
NMSP Global Counters
--------------------
Number of restarts                :

SSL Statistics
--------------------
Total amount of verifications      : 6
Verification failures              : 6
Verification success               : 0
Amount of connections created      : 8
Amount of connections closed       : 7
Total amount of accept attempts    : 8
Failures in accept                 : 0
Amount of successful accepts       : 8
Amount of failed registrations     : 0

AAA Statistics
--------------------
Total amount of AAA requests       : 7
Failed to send requests            : 0
Requests sent to AAA               : 7
Responses from AAA                 : 7
Responses from AAA to validate     : 7
Responses validate error           : 6
Responses validate success         : 1
```

To view the overall NMSP connections, use the command:

```
Device# show nmsp status
NMSP Status
-----------

CMX IP Address   Active    Tx Echo Resp  Rx Echo Req   Tx Data     Rx Data     Transport
```

```
-------------------------------------------------------------------------------------------
127.0.0.1        Active    6             6             1           2           TLS
```

To view all mobility services subscribed by all CMXs, use the command:

```
Device# show nmsp subscription detail
CMX IP address 127.0.0.1:
Service            Subservice
-----------------------------
RSSI               Rogue, Tags, Mobile Station,
Spectrum
Info               Rogue, Mobile Station,
Statistics         Tags, Mobile Station,
AP Info            Subscription
```

To view all mobility services subscribed by a specific CMX, use the command:

```
Device# show nmsp subscription detail
CMX IP address 127.0.0.1:
Service            Subservice
-----------------------------
RSSI               Rogue, Tags, Mobile Station,
Spectrum
Info               Rogue, Mobile Station,
Statistics         Tags, Mobile Station,
AP Info            Subscription

Device# show nmsp subscription summary
Service            Subservice
-----------------------------
RSSI               Rogue, Tags, Mobile Station,
Spectrum
Info               Rogue, Mobile Station,
Statistics         Tags, Mobile Station,
AP Info            Subscription
```

Examples: NMSP settings configuration

This example shows how to configure the NMSP notification interval for RFID tags:

```
Device# configure terminal
Device(config)# nmsp notification interval rssi rfid 50
Device(config)# end
Device# show nmsp notification interval
```

This example shows how to configure the NMSP notification interval for clients:

```
Device# configure terminal
Device(config)# nmsp notification interval rssi clients 180
Device(config)# end
Device# show nmsp notification interval
```

Probe RSSI location

A probe RSSI location is a wireless networking feature that

- allows wireless controllers and Cisco CMX to collect and use the received signal strength indication (RSSI) from client probe requests associated with the identified Service Set Identifiers (SSIDs)
- enables functions such as load balancing, coverage hole detection, and location updates, and
- supports the precise tracking of wireless clients as they move within the network.

After connecting to an AP, the client scans in the background and keeps a list of strong APs. If it loses connection, the client uses this list to reconnect. The APs in the WLAN gather probe requests, RSSI data, and MAC addresses of wireless clients, then forward this information to the wireless embedded wireless controllers. Cisco CMX receives this data from the embedded wireless controller and calculates the client's updated location.

Configuring Probe RSSI

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless probe filter** **Example:** `Device(config)# wireless probe filter`	Enables filtering of unacknowledged probe requests from AP to improve the location accuracy. Use the **no** form of the command to disable the feature. This will forward both acknowledged and unacknowledged probe requests to the embedded wireless controller.
Step 3	**wireless probe limit** *limit-value interval* **Example:** `Device(config)# wireless probe limit 10 100`	Configures the number of probe request reported to the wireless embedded wireless controller from the AP for the same client on a given interval. Use the **no** form of the command to revert to the default limit, which is 2 probes at an interval of 500 ms.
Step 4	**wireless probe locally-administered-mac** **Example:** `Device(config)# wireless probe locally-administered-mac`	Enables the reporting of probes from clients having locally administered MAC address.
Step 5	**location algorithm rssi-average** **Example:** `Device(config)# location algorithm rssi-average`	Sets the probe RSSI measurement updates to a more accurate algorithm but with more CPU overhead.

	Command or Action	Purpose
Step 6	**location algorithm simple** **Example:** `Device(config)# location algorithm simple`	(Optional) Sets the probe RSSI measurement updates to a faster algorithm with smaller CPU overhead, but less accuracy. Use the **no** form of the command to revert the algorithm type to the default one, which is *rssi-average*.
Step 7	**location expiry client** *interval* **Example:** `Device(config)# location expiry client 300`	Configures the timeout for RSSI values. The **no** form of the command sets it to a default value of 15.
Step 8	**location notify-threshold client** *threshold-db* **Example:** `Device(config)# location notify-threshold client 5`	Configures the notification threshold for clients. The **no** form of the command sets it to a default value of 0.
Step 9	**location rssi-half-life client** *time-in-seconds* **Example:** `Device(config)# location rssi-half-life client 20`	Configures half life when averaging two RSSI readings. To disable this option, set the value to 0.

What to do next

Use the **show wireless client probing** command to view each probing client (associated and probing only) by batch of 10 mac addresses.

Verifying Probe RSSI

To view the details of the AP the associated client was detected with, and with which RSSI:

```
Device# show wireless client mac-address 4.4.4 detail
****snippet of the output****
Nearby AP Statistics:
TEST_AP-1 (slot 0)
antenna 0: 0 s ago ........ -77 dBm
antenna 1: 0 s ago ........ -88 dBm
TEST_AP-5 (slot 0)
antenna 0: 0 s ago ........ -64 dBm
antenna 1: 0 s ago ........ -36 dBm
TEST_AP-6 (slot 0)
antenna 0: 0 s ago ........ -69 dBm
antenna 1: 0 s ago ........ -79 dBm
```

RFID tag support

An RFID tag is a small wireless battery-powered tracking device that

- broadcasts its own signal for real-time location tracking, and
- operates using special 802.11 packets processed by APs, wireless controllers, and Cisco CMX.

The embedded wireless controller enables you to configure radio frequency identification (RFID) tag tracking. Only active RFIDs are supported. A combination of active RFID tags and wireless embedded wireless controller allows you to track the current location of equipment. Use *Active* tags to track high-value assets in *closed-loop* systems. These tags remain within the control premises of the owner.

General guidelines

- You can verify the RFID tags on the embedded wireless controller.
- The controller supports high availability for RFID tags.

Configure RFID tag support (CLI)

Enable and configure RFID tag tracking features for WLANs managed by the device using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable RFID tag tracking.

Example:

```
Device(config)# wireless rfid
```

The default value is enabled.

Use the **no** form of this command to disable RFID tag tracking.

Step 3 Configure the RFID tag data timeout value to cleanup the table.

Example:

```
Device(config)# wireless rfid timeout timeout-value 90
```

The timeout value is the amount of time that the embedded wireless controller maintains tags before expiring them. For example, if a tag is configured to beacon every 30 seconds, we recommend that you set the timeout value to 90 seconds (approximately three times the beacon value). The default value is 1200 seconds.

Verify RFID tag support

To view the summary of RFID tags that are clients, use the command:

```
Device# show wireless rfid client
```

To view the detailed information for an RFID tag, use the command:

```
Device# show wireless rfid detail rfid-mac-address

RFID address  000c.cc96.0001
Vendor Cisco
Last Heard 6 seconds  ago
Packets Received 187
Bytes Received 226

Content Header
==============
  CCX Tag Version 0
  Tx power: 12
  Channel: 11
  Reg Class: 4
CCX Payload
==============
  Last Sequence Control 2735
  Payload length 221
  Payload Data Hex Dump:
  00000000  00 02 00 00 01 09 00 00  00 00 0c b8 ff ff ff 02  |................|
  00000010  07 42 03 20 00 00 0b b8  03 4b 00 00 00 00 00 00  |.B. .....K......|
  00000020  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
  00000030  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
  00000040  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  |................|
```

To view the summary information for all known RFID tags, use the command:

```
Device# show wireless rfid summary

Total RFID entries: : 16
Total Unique RFID entries : 16
RFID ID VENDOR Closet AP RSSI Time Since Last Heard
0012.b80a.c791 Cisco 7069.5a63.0520 -31 3 minutes 30 seconds ago
0012.b80a.c953 Cisco 7069.5a63.0460 -33 4 minutes 5 seconds ago
0012.b80b.806c Cisco 7069.5a63.0520 -46 15 seconds ago
0012.b80d.e9f9 Cisco 7069.5a63.0460 -38 4 minutes 28 seconds ago
0012.b80d.ea03 Cisco 7069.5a63.0520 -43 4 minutes 29 seconds ago
0012.b80d.ea6b Cisco 7069.5a63.0460 -39 4 minutes 26 seconds ago
0012.b80d.ebe8 Cisco 7069.5a63.0520 -43 3 minutes 21 seconds ago
0012.b80d.ebeb Cisco 7069.5a63.0520 -43 4 minutes 28 seconds ago
0012.b80d.ec48 Cisco 7069.5a63.0460 -42 4 minutes 7 seconds ago
0012.b80d.ec55 Cisco 7069.5a63.0520 -41 1 minute 52 seconds ago
```

To view the location-based system RFID statistics, use the command:

```
Device# show wireless rfid stats

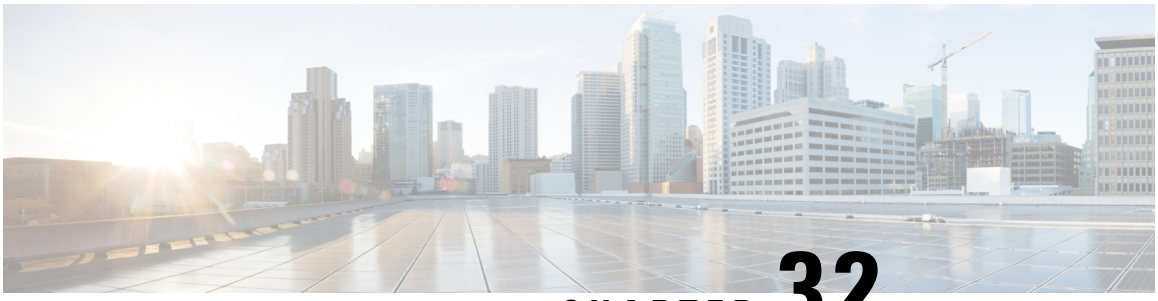
RFID stats :
==============
RFID error db full : 0
RFID error invalid paylod : 0
RFID error invalid tag : 0
RFID error dot11 hdr : 0
RFID error pkt len : 0
RFID error state drop : 0
RFID total pkt received : 369
RFID populated error value : 0
RFID error insert records : 0
RFID error update records : 0
RFID total insert record : 16
RFID ccx payload error : 0
RFID total delete record : 0
RFID error exceeded ap count : 0
```

```
RFID error record remove : 0
RFID old rssi expired count: 0
RFId smallest rssi expireed count : 0
RFID total query insert : 0
RFID error invalid rssi count : 0
```

To view the NMSP notification interval, use the command:

```
Device# show nmsp notification interval
NMSP Notification Intervals
---------------------------

RSSI Interval:
  Client              : 2 sec
  RFID                : 50 sec
  Rogue AP            : 2 sec
  Rogue Client        : 2 sec
  Spectrum            : 2 sec
```



CHAPTER 32

Application Visibility and Control

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Application visibility and control

Application visibility and control is a wireless network feature set that

- enables real-time identification and monitoring of applications using deep packet inspection
- allows creation of policy rules to manage application bandwidth and usage, and
- integrates with Flexible NetFlow (FNF) to report traffic statistics per application or protocol.

Application visibility and control (AVC) is a subset of the Flexible NetFlow (FNF) package. AVC provides traffic information. The AVC feature uses a distributed approach that benefits from NBAR running on the

AP or embedded wireless controller. The goal is to run deep packet inspection (DPI) and report the results using FNF messages.

The NBAR2 engine analyzes and recognizes traffic flows. Each specific flow is marked with the detected protocol or application. You can use this per-flow information for application visibility through FNF. After application visibility is established, you can define control rules with policing mechanisms for a client.

Guidelines for application visibility and control

- Using AVC rules, bandwidth for a particular application can be limited for all clients joined on the WLAN. These bandwidth contracts coexist with per-client downstream rate limiting. The per-client limits take precedence over the per-application rate limits.
- The FNF feature is supported in wireless deployments. It relies on NetFlow enablement on the embedded wireless controller for FlexConnect mode.
-
-
-

The behavior of the AVC solution changes based on the wireless deployment mode. The next sections describe the commonalities and differences in all scenarios.

FlexConnect Mode

- NBAR is enabled on an AP.
- AVC pushes the FNF configuration to the APs.
- Context transfer for roaming is supported in AVC-FNF.
- NetFlow exporter is supported.

Prerequisites for application visibility and control

- The APs should be AVC capable.
- Configure the application visibility feature with FNF to enable AVC control (QoS).

Restrictions for application visibility and control

- Layer 2 roaming is not supported across embedded wireless controller.
- Multicast traffic is not supported.
- AVC is supported only on the following APs:
  - Cisco Aironet 1800 Series Access Points
  - Cisco Aironet 2700 Series Access Point

- Cisco Aironet 2800 Series Access Point
- Cisco Aironet 3700 Series Access Points
- Cisco Aironet 3800 Series Access Points
- Cisco Aironet 4800 Series Access Points

- AVC is not supported on Cisco Aironet 702W, 702I (128 M memory), and 1530 Series APs.
- Only applications recognized by App Visibility can be used for applying QoS control.
- Data link is not supported for NetFlow fields in AVC.
- You cannot map the same WLAN profile to both the AVC-not-enabled policy profile and the AVC-enabled policy profile.
- NBAR-based QoS policy configuration is allowed at client level and BSSID level, configured on policy profile are not supported.
- NBAR cannot classify traffic accurately when SaaS applications use end-to-end encryption, QUIC, or DoH because encryption affects classification. In these cases, encrypted traffic including DoH and QUIC without SNI prevents NBAR from sending the correct Protocol ID, which causes traffic classification issues.

When AVC is enabled, the profile supports a maximum of 23 rules, including the default DSCP rule. If the number of rules exceeds 23, the AVC policy will not be sent to the AP.

Configure AVC

Enable monitoring and policy enforcement for application usage on the wireless network.

Procedure

Step 1 Create a flow monitor using the **record wireless avc basic** command.
Step 2 Create a wireless policy profile.
Step 3 Apply the flow monitor to the wireless policy profile.
Step 4 Create a wireless policy tag.
Step 5 Map the WLAN to the policy profile.
Step 6 Attach the policy tag to the APs.

Create a flow monitor (CLI)

The NetFlow configuration requires a flow record, a flow monitor, and a flow exporter. Make this configuration your first step in the overall AVC configuration.

Note In FlexConnect mode, the default values for **cache timeout active** and **cache timeout inactive** commands do not provide optimal AVC performance. Set both values to 60 in the flow monitor.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a flow monitor.

Example:

```
Device(config)# flow monitor monitor-name fm_avc
```

Step 3 Specify the basic wireless AVC flow template.

Example:

```
Device(config-flow-monitor)# record wireless avc basic
```

Note
The **record wireless avc basic** command is same as **record wireless avc ipv4 basic** command. However, **record wireless avc ipv4 basic** command is not supported in FlexConnect or Fabric modes. In such scenarios, use the **record wireless avc basic** command.

Configure a flow monitor (GUI)

Set up a flow monitor and export data to a collector using a pre-configured flow exporter.

Before you begin

Ensure you have already created a flow exporter.

Procedure

Step 1 Choose **Configuration** > **Services** > **Application Visibility** and go to the **Flow Monitor** tab.

Step 2 In the **Monitor** area, click **Add** to add a flow monitor.

Step 3 In the **Flow Monitor** window, add a flow monitor and a description.

Step 4 Select the Flow exporter from the drop-down list to export data from the flow monitor to the collector.

Note
To export wireless NetFlow data, use these templates:

- ETA (Encrypted Traffic Analysis)

- wireless avc basic
- wireless avc basic IPv6

Step 5 Click **Apply to Device** to save the configuration.

Create a flow exporter (CLI)

Define export parameters for a flow exporter so AVC statistics are visible on the controller embedded wireless controller. This is an optional procedure for configuring flow exporter parameters.

Note For the AVC statistics to be visible at the embedded wireless controller, you should configure a local flow exporter using these commands:

- **flow exporter** *my_local*
- **destination local wlc**

Also, your flow monitor must use this local exporter for the statistics to be visible at the embedded wireless controller.

Procedure

Step 1 Create a flow monitor.

Example:

```
Device(config)# flow exporter flow-export-name export-test
```

Step 2 Describe the flow record as a maximum 63-character string.

Example:

```
Device(config-flow-exporter)# description IPv4flow
```

Step 3 Specify the hostname or IP address of the system or the local controller to which the exporter sends data.

Example:

```
Device(config-flow-exporter)# destination {hostname/ipv4address | hostname/ipv6address |
local wlc}
```

Step 4 **Example:**

```
Device(config-flow-exporter)# destination {hostname/ipv4address | hostname/ipv6address |
local wlc}
```

Step 5 Return to privileged EXEC mode.

Example:

```
Device(config-flow-exporter)# end
```

Step 6 (Optional) Verify your configuration.

Example:

```
Device# show flow exporter
```

Verify the flow exporter

To verify the flow exporter description, use the command:

For example, to verify the flow exporter description for the flow exporter named *my-flow-exporter*, see the example:

```
Device# show flow exporter
Flow Exporter my-flow-exporter:
Description:              User defined
Export protocol:          NetFlow Version 9
Transport Configuration:
Destination type:       Local (1)
Destination IP address: 0.0.0.0
Source IP address:      10.0.0.1
Transport Protocol:     UDP
Destination Port:       9XXX
Source Port:            5XXXX
DSCP:                   0x0
TTL:                    255
Output Features:        Not Used
```

Note A flow exporter with no destination is marked as an UNKNOWN type. These are the two ways the exporter is marked as UNKNOWN:

1. When you configure the flow exporter using the CLI commands without a destination.
2. EWC supports a maximum of one external and one internal flow exporter. If you attempt to configure more than one flow exporter per type, the destination is rejected, and the flow exporter is considered UNKNOWN.

Configure a policy tag (CLI)

Establish a policy tag to control wireless device and SSID behavior.

Policy tags allow you to associate specific policy profiles with APs, enabling customized wireless network behavior.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure policy tag and enter policy tag configuration mode.

Example:

```
Device(config-policy-tag)# wireless tag policy policy-tag-name rr-xyz-policy-tag
```

Step 3 Save the configuration and exit configuration mode and return to privileged EXEC mode. **end**

Example:

```
Device(config-policy-tag)# end
```

Attach a policy profile to a WLAN interface (GUI)

Link the appropriate policy configuration to a WLAN interface for centralized control. Use the GUI to ensure new or modified policy profiles are correctly associated with WLANs before deployment.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags**.

Step 2 On the **Manage Tags** page, click the **Policy** tab.

Step 3 Click **Add** to open the **Add Policy Tag** window.

Step 4 Enter a name and description for the policy tag.

Step 5 Click **Add** to map WLAN and policy.

Step 6 Select the WLAN profile to map with the appropriate policy profile, and click the tick icon.

Step 7 Click **Save & Apply to Device**.

Attach a policy profile to a WLAN interface (CLI)

Assign a policy profile to a WLAN interface to control traffic and services for that WLAN.

Procedure

Step 1 Create a policy tag.

Example:

```
Device(config)# wireless tag policy avc-tag
```

Step 2 Attach a policy profile to a WLAN profile.

Example:

```
Device(config-policy-tag)# wlan wlan_avc policy avc_pol
```

What to do next

- Do not attach different AVC policy profiles to the same WLAN across different policy tags.

  This is an example of incorrect configuration:

  ```
  wireless profile policy avc_pol1
  ipv4 flow monitor fm-avc1 input
  ipv4 flow monitor fm-avc1 outputno shutdown
  wireless profile policy avc_pol2
  ipv4 flow monitor fm-avc2 input
  ipv4 flow monitor fm-avc2 output
  no shutdown
  wireless tag policy avc-tag1
  wlan wlan1 policy avc_pol1
  wireless tag policy avc-tag2
  wlan wlan1 policy avc_pol2
  ```

  This example violates the restriction stated earlier, that is, the WLAN *wlan1* is mapped to 2 policy profiles, *avc_pol1* and *avc_pol2*. This configuration is incorrect because the WLAN *wlan1* must be mapped to either *avc_pol1* or *avc_pol2* throughout the configuration..

- Conflicting policy profiles on the same WLAN are not supported. For example, policy profile (with and without AVC) applied to the same WLAN in different policy tags.

  This is an example of an incorrect configuration:

  ```
  wireless profile policy avc_pol1
  no shutdown
  wireless profile policy avc_pol2
  ipv4 flow monitor fm-avc2 input
  ipv4 flow monitor fm-avc2 output
  no shutdown
  wireless tag policy avc-tag1
  wlan wlan1 policy avc_pol1
  wireless tag policy avc-tag2
  wlan wlan1 policy avc_pol2
  ```

  In this example, a policy profile with and without AVC is applied to the same WLAN in different tags.

- Run the **no shutdown** command on the WLAN after completing the configuration.
- If the WLAN is already in **no shutdown** mode, run the **shutdown** command, then run the **no shutdown** command.

Attach a policy profile to an AP (CLI)

Assign a specific policy profile to an AP through commands.

Procedure

Step 1 Enter AP configuration mode.

Example:

```
Device(config)# ap ap-ether-mac 34a8.2ec7.4cf0
```

Step 2 Specify the policy tag that is to be attached to the AP.

Example:

```
Device(config)# policy-tag avc-tag
```

Verify the AVC configuration (CLI)

Review and validate the Application Visibility and Control (AVC) configuration on a device.

Procedure

Step 1 Display information about the top applications and the users who use them.

Example:

```
Device# show avc wlan wlan_avc top 2 applications {aggregate | downstream | upstream}
```

Note
To collect accurate statistics, ensure that wireless clients are connected to the WLAN and transmitting data. After 90 seconds, run the command.

Step 2 Display information about the top applications for the client.

Example:

```
Device# show avc client 9.3.4 top 3 applications {aggregate | downstream | upstream}
```

Note
Ensure that wireless clients are connected to the WLAN and transmitting data. Wait 90 seconds for statistics to become available, then run the command.

Step 3 Display information about the top applications and the users who uses them.

Example:

```
Device# show avc wlan wlan_avc application app top 4 aggregate
```

Step 4 Display a summary of all the APs attached to the embedded wireless controller.

Example:

```
Device# show ap summary
```

Step 5 Display a summary of all the APs with policy tags.

Example:

```
Device# show ap tag summary
```

AVC-based selective reanchoring

An AVC-based selective reanchoring is a wireless client mobility mechanism that

- reanchors clients as they roam between one embedded wireless controller to another and prevent depletion of available IP addresses, and
- uses AVC profile-based statistics to determine if a client should be reanchored or deferred.

This is useful when a client is actively running a voice or video application defined in the AVC rules.

The reanchoring process also involves deauthentication of anchored clients. The clients get deauthenticated when they do not transmit traffic for the applications listed in the AVC rules while roaming between controllers.

Restrictions for AVC-based selective reanchoring

- This feature operates only in local mode. FlexConnect and fabric modes are not supported.
- This feature does not operate in guest tunneling scenarios or export anchor scenarios.
- After reanchoring, the old IP address is retained until the IP address lease period ends.

Configure the flow exporter (CLI)

Define and configure a flow exporter to specify where and how NetFlow data is exported from the device.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a flow exporter and enter the flow exporter configuration mode.

Example:

```
Device(config)# flow exporter avc-reanchor
```

Note
You can use this command to modify an existing flow exporter too.

Step 3 Set the exporter as local.

Example:

```
Device(config-flow-exporter)# destination local wlc
```

Configure the flow monitor (CLI)

Set up a flexible NetFlow flow monitor to track traffic statistics.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a flow monitor and enter the flexible NetFlow flow monitor configuration mode.

Example:

```
Device(config)# flow monitor fm_avc
```

Note
You can use this command to modify an existing flow monitor too.

Step 3 Specify the name of an exporter.

Example:

```
Device(config-flow-monitor)# exporter avc-reanchor
```

Step 4 Specify the flow record to use to define the cache.

Example:

```
Device(config-flow-monitor)# record wireless avc basic
```

Step 5 Set the active flow timeout, in seconds.

Example:

```
Device(config-flow-monitor)# cache timeout active 60
```

Step 6 Set the inactive flow timeout, in seconds.

Example:

```
Device(config-flow-monitor)# cache timeout inactive 60
```

Configure the AVC reanchoring profile (CLI)

Configure traffic reanchoring for AVC by creating and updating an AVC reanchoring profile using commands.

Before you begin

- Ensure that you use the AVC-Reanchor-Class class map. All other class-map names are ignored by Selective Reanchoring.

- During boot up, the system checks for the existence of the AVC-Reanchor-Class class map. If it is not found, the system creates default protocols, such as jabber-video, WiFi-calling, and others. If the AVC-Reanchor-Class class map is found, configuration changes are not made. Updates to protocols saved to the startup configuration persist across reboots.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the class map.

Example:

```
Device(config)# class-map AVC-Reanchor-Class
```

Step 3 Instruct the device to match with any of the protocols that pass through it.

Example:

```
Device(config-cmap)# match any
```

Step 4 Specify a match to the application name.

Example:

```
Device(config-cmap)# match protocol jabber-audio
```

You can edit the class-map configuration later to add or remove protocols such as **jabber-video and wifi-calling** if needed.

Configure the wireless WLAN profile policy (CLI)

Follow the procedure given below to configure the WLAN profile policy.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN policy profile and enters wireless policy configuration mode and disable the policy profile.

Example:

```
Device(config)# wireless profile policy default-policy-profile
Device(config-wireless-policy)# shutdown
```

Step 3 Enable central switching.

Example:

```
Device(config-wireless-policy)# central switching
```

Step 4 Specify the name of the IPv4 ingress flow monitor.

Example:

```
Device(config-wireless-policy)# ipv4 flow monitor fm_avc input
```

Step 5 Specify the name of the IPv4 egress flow monitor.

Example:

```
Device(config-wireless-policy)# ipv4 flow monitor fm_avc output
```

Step 6 Configure a class map with protocols for the selective reanchoring feature.

Example:

```
Device(config-wireless-policy)# reanchor class AVC-Reanchor-Class
```

Step 7 Enable the policy profile.

Example:

```
Device(config-wireless-policy)# no shutdown
```

Verify AVC reanchoring

Use the commands to verify the AVC reanchoring configuration:

```
Device# show wireless profile policy detailed avc_reanchor_policy

Policy Profile Name           : avc_reanchor_policy
Description                   :
Status                        : ENABLED
VLAN                          : 1
Wireless management interface VLAN        : 34
!
.
.
.
AVC VISIBILITY                : Enabled
Flow Monitor IPv4
  Flow Monitor Ingress Name   : fm_avc
  Flow Monitor Egress Name    : fm_avc
Flow Monitor IPv6
  Flow Monitor Ingress Name   : Not Configured
  Flow Monitor Egress Name    : Not Configured
NBAR Protocol Discovery       : Disabled
Reanchoring                   : Enabled
Classmap name for Reanchoring
  Reanchoring Classmap Name   : AVC-Reanchor-Class
!
.
.
.
  ------------------------------------------------------
```

```
Device# show platform software trace counter tag wstatsd chassis active R0 avc-stats debug

Counter Name Thread ID Counter Value
-----------------------------------------------------------------------------
Reanch_deassociated_clients 28340 1
Reanch_tracked_clients 28340 4
Reanch_deleted_clients 28340 3
```

```
Device# show platform software trace counter tag wncd chassis active R0 avc-afc debug

Counter Name Thread ID Counter Value
-----------------------------------------------------------------------------
Reanch_co_ignored_clients 30063 1
Reanch_co_anchored_clients 30063 5
Reanch_co_deauthed_clients 30063 4
```

```
Device# show platform software wlavc status wncd
Event history of WNCD DB:

AVC key: [1,wlan_avc,N/A,Reanc,default-policy-tag]
Current state : READY
Wlan-id : 1
Wlan-name : wlan_avc
Feature type : Reanchoring
Flow-mon-name : N/A
Policy-tag : default-policy-tag
Switching Mode : CENTRAL

Timestamp FSM State Event RC Ctx
------------------------ ------------------- -------------------------- ---- ----
06/12/2018 16:45:30.630342 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:45:28.822780 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:28.822672 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:15.172073 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:45:12.738367 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:12.738261 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:01.162689 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:44:55.757643 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:55.757542 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:04.468749 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:44:02.18857 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:02.18717 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:38:20.164304 2 :READY 3 :FSM_AFM_SWEEP 0 2
06/12/2018 16:35:20.163877 2 :READY 1 :FSM_AFM_BIND 0 2
06/12/2018 16:35:18.593257 1 :INIT 1 :FSM_AFM_BIND 0 2
06/12/2018 16:35:18.593152 1 :INIT 24:CREATE_FSM 0 0

AVC key: [1,wlan_avc,fm_avc,v4-In,default-policy-tag]
Current state : READY
Wlan-id : 1
Wlan-name : wlan_avc
Feature type : Flow monitor IPv4 Ingress
Flow-mon-name : fm_avc
Policy-tag : default-policy-tag
Switching Mode : CENTRAL

Timestamp FSM State Event RC Ctx
------------------------ ------------------- -------------------------- ---- ----
06/12/2018 16:45:30.664772 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:45:28.822499 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:28.822222 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:15.207605 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:45:12.738105 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:12.737997 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:01.164225 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
```

```
06/12/2018 16:44:55.757266 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:55.757181 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:04.472778 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:44:02.15413 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:02.15263 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:38:20.164254 2 :READY 3 :FSM_AFM_SWEEP 0 2
06/12/2018 16:35:20.163209 1 :INIT 1 :FSM_AFM_BIND 0 2
06/12/2018 16:35:20.163189 1 :INIT 24:CREATE_FSM 0 0

AVC key: [1,wlan_avc,fm_avc,v4-Ou,default-policy-tag]
Current state : READY
Wlan-id : 1
Wlan-name : wlan_avc
Feature type : Flow monitor IPv4 Egress
Flow-mon-name : fm_avc
Policy-tag : default-policy-tag
Switching Mode : CENTRAL

Timestamp FSM State Event RC Ctx
------------------------- ------------------- -------------------------- ---- ----
06/12/2018 16:45:30.630764 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:45:28.822621 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:28.822574 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:15.172357 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:45:12.738212 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:12.738167 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:45:01.164048 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:44:55.757403 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:55.757361 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:04.472561 3 :ZOMBIE 1 :FSM_AFM_BIND 0 2
06/12/2018 16:44:02.18660 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:44:02.18588 2 :READY 2 :FSM_AFM_UNBIND 0 0
06/12/2018 16:38:20.164293 2 :READY 3 :FSM_AFM_SWEEP 0 2
06/12/2018 16:35:20.163799 1 :INIT 1 :FSM_AFM_BIND 0 2
06/12/2018 16:35:20.163773 1 :INIT 24:CREATE_FSM 0 0

Device# show platform software wlavc status wncmgrd

Event history of WNCMgr DB:

AVC key: [1,wlan_avc,N/A,Reanc,default-policy-tag]
Current state : READY
Wlan-id : 1
Wlan-name : wlan_avc
Feature type : Reanchoring
Flow-mon-name : N/A
Policy-tag : default-policy-tag
Switching Mode : CENTRAL
Policy-profile : AVC_POL_PYATS

Timestamp FSM State Event RC Ctx
------------------------- ------------------- -------------------------- ---- ----
06/12/2018 16:45:30.629278 3 :WLAN_READY 24:BIND_WNCD 0 0
06/12/2018 16:45:30.629223 3 :WLAN_READY 4 :FSM_BIND_ACK 0 0
06/12/2018 16:45:30.629179 3 :WLAN_READY 4 :FSM_BIND_ACK 0 0
06/12/2018 16:45:30.510867 2 :PLUMB_READY 22:BIND_IOSD 0 0
06/12/2018 16:45:30.510411 2 :PLUMB_READY 2 :FSM_WLAN_UP 0 0
06/12/2018 16:45:30.510371 2 :PLUMB_READY 1 :FSM_WLAN_FM_PLUMB 0 0
06/12/2018 16:45:28.886377 2 :PLUMB_READY 20:UNBIND_ACK_IOSD 0 0
!

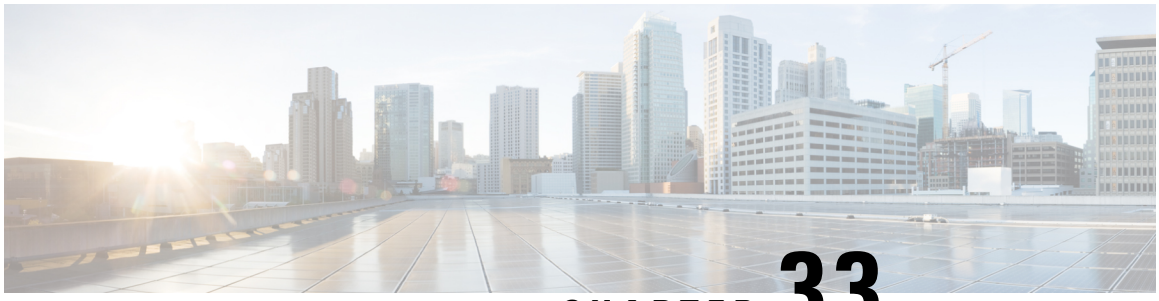
AVC key: [1,wlan_avc,fm_avc,v4-In,default-policy-tag]
Current state : READY
Wlan-id : 1
Wlan-name : wlan_avc
```

```
Feature type : Flow monitor IPv4 Ingress
Flow-mon-name : fm_avc
Policy-tag : default-policy-tag
Switching Mode : CENTRAL
Policy-profile : AVC_POL_PYATS

Timestamp FSM State Event RC Ctx
------------------------- ------------------- -------------------------- ---- ----
06/12/2018 16:45:30.664032 3 :WLAN_READY 24:BIND_WNCD 0 0
06/12/2018 16:45:30.663958 3 :WLAN_READY 4 :FSM_BIND_ACK 0 0
06/12/2018 16:45:30.663921 3 :WLAN_READY 4 :FSM_BIND_ACK 0 0
06/12/2018 16:45:30.511151 2 :PLUMB_READY 22:BIND_IOSD 0 0
06/12/2018 16:45:30.510624 2 :PLUMB_READY 2 :FSM_WLAN_UP 0 0
06/12/2018 16:45:30.510608 2 :PLUMB_READY 1 :FSM_WLAN_FM_PLUMB 0 0
06/12/2018 16:45:28.810867 2 :PLUMB_READY 20:UNBIND_ACK_IOSD 0 0
06/12/2018 16:45:28.807239 4 :READY 25:UNBIND_WNCD 0 0
06/12/2018 16:45:28.807205 4 :READY 23:UNBIND_IOSD 0 0
06/12/2018 16:45:28.806734 4 :READY 3 :FSM_WLAN_DOWN 0 0
!

AVC key: [1,wlan_avc,fm_avc,v4-Ou,default-policy-tag]
Current state : READY
Wlan-id : 1
Wlan-name : wlan_avc
Feature type : Flow monitor IPv4 Egress
Flow-mon-name : fm_avc
Policy-tag : default-policy-tag
Switching Mode : CENTRAL
Policy-profile : AVC_POL_PYATS

Timestamp FSM State Event RC Ctx
------------------------- ------------------- -------------------------- ---- ----
06/12/2018 16:45:30.629414 3 :WLAN_READY 24:BIND_WNCD 0 0
06/12/2018 16:45:30.629392 3 :WLAN_READY 4 :FSM_BIND_ACK 0 0
06/12/2018 16:45:30.629380 3 :WLAN_READY 4 :FSM_BIND_ACK 0 0
06/12/2018 16:45:30.510954 2 :PLUMB_READY 22:BIND_IOSD 0 0
06/12/2018 16:45:30.510572 2 :PLUMB_READY 2 :FSM_WLAN_UP 0 0
06/12/2018 16:45:30.510532 2 :PLUMB_READY 1 :FSM_WLAN_FM_PLUMB 0 0
06/12/2018 16:45:28.886293 2 :PLUMB_READY 20:UNBIND_ACK_IOSD 0 0
06/12/2018 16:45:28.807844 4 :READY 25:UNBIND_WNCD 0 0
06/12/2018 16:45:28.807795 4 :READY 23:UNBIND_IOSD 0 0
06/12/2018 16:45:28.806990 4 :READY 3 :FSM_WLAN_DOWN 0 0
!
```



CHAPTER 33

Flexible NetFlow Exporter on Embedded Wireless Controller

- Flexible NetFlow Exporter on Embedded Wireless Controller , on page 259
- Create a Flow Exporter , on page 260
- Create a Flow Monitor, on page 260
- Configuring the Wireless WLAN Profile Policy , on page 261
- Verifying Flow Exporter in Embedded Wireless Controller , on page 262

Flexible NetFlow Exporter on Embedded Wireless Controller

Flexible Netflow (FnF) Exporter on Embedded Wireless Controller (EWC) is supported from Cisco IOS XE Amsterdam 17.2.1 onwards.

NetFlow is a Cisco IOS technology that provides statistics on packets flowing on the network. NetFlow is the standard for acquiring IP operational data from IP networks. NetFlow provides data to support network and security monitoring, network planning, traffic analysis, and IP accounting.

Flexible NetFlow improves on original NetFlow by adding the capability to customize the traffic analysis parameters for your specific requirements. Flexible NetFlow facilitates the creation of more complex configurations for traffic analysis and data export through the use of reusable configuration components.

FnF Exporter in EWC is supported only in the flex mode.

This feature is part of the AVC solution in EWC. For more information about AVC, refer to the *Application Visibility and Control* chapter.

AVC Configuration Limitations on EWC

- Only one local exporter (statistics collector on EWC) is supported.
- FnF supports only one per IP-type and direction in Flex mode, for Flow Monitor.
- Support of only UDP transport protocol.
- AVC cache is not supported.
- The **option** command and the command related to DP statistics are not supported on EWC.
- Support of only Wireless AVC Basic template.

- Support for only Netflow Version 9.
- IP address 0.0.0.0 is a valid destination address. However, if you use it, the Flexible NetFlow data will be discarded and not collected by any collector.

Create a Flow Exporter

The following procedure shows how to create a flow exporter in EWC:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**flow exporter** *flow-export-name* **Example:** `Device(config)# flow exporter export-test`	Creates a flow exporter.
Step 3	**description** *string* **Example:** `Device(config-flow-exporter)# description IPv4flow`	(Optional) Describes the flow exporter as a maximum 63-character string.
Step 4	**Example:** `Device(config-flow-exporter)# destination 10.0.1.0`	

Create a Flow Monitor

The NetFlow configuration requires a flow record, a flow monitor, and a flow exporter. This configuration should be the first step in the overall AVC configuration.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**flow monitor** *monitor-name* **Example:** `Device(config)# flow monitor monitor-test`	Creates a flow monitor.

	Command or Action	Purpose
Step 3	**exporter** *exporter-name* **Example:** `Device(config-flow-monitor)# exporter export-test`	Binds this flow monitor with an already defined flow exporter.
Step 4	**record wireless avc basic** **Example:** `Device(config-flow-monitor)# record wireless avc basic`	Specifies the basic wireless AVC flow template.

Configuring the Wireless WLAN Profile Policy

This configuration maps the flow-monitor or exporter constructs with wireless WLANs, thereby making APs collect FnF measurements.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile policy** *policy-name* **Example:** `Device(config)# wireless profile policy default-policy-profile`	Configures the WLAN policy profile and enters wireless policy configuration mode.
Step 3	**shutdown** **Example:** `Device(config-wireless-policy)# shutdown`	Disables the policy profile.
Step 4	{**ipv4** | **ipv6**} **flow monitor** *monitor-name* **input** **Example:** `Device(config-wireless-policy)# ipv4 flow monitor monitor-test input`	Specifies the name of the IPv4 or IPv6 ingress flow monitor.
Step 5	{**ipv4** | **ipv6**} **flow monitor** *monitor-name* **output** **Example:** `Device(config-wireless-policy)# ipv4 flow monitor monitor-test output`	Specifies the name of the IPv4 or IPv6 egress flow monitor.

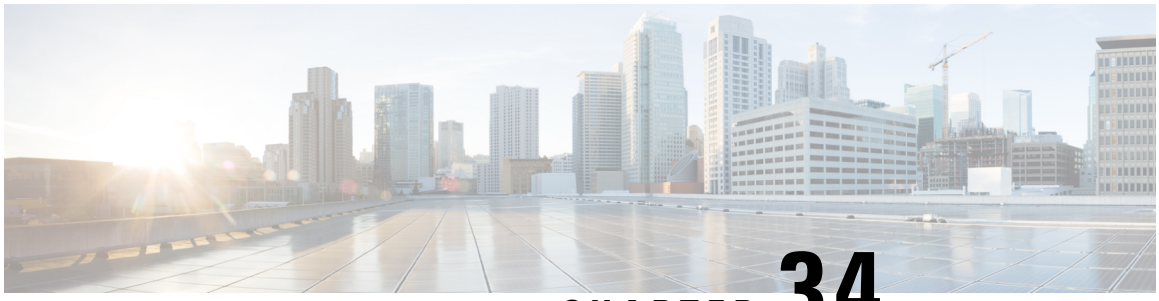
	Command or Action	Purpose
Step 6	**no shutdown** **Example:** `Device(config-wireless-policy)# no shutdown`	Enables the policy profile.

Verifying Flow Exporter in Embedded Wireless Controller

To view the flow exporter details in the Embedded Wireless Controller, use the following command:

show platform software wlavc status cp-exporter

```
show platform software wlavc status cp-exporter
AVC FNF Exporter status
IP: 10.10.1.1
connection statistics
        Sent bytes : 5672
        Sent packets : 569
        Sent records : 240
        Received packets : 800
        Received records : 564
Socket statistics
        New sockets : 3
        Closed sockets : 0
Library statistics  AVC
        cache errors : 0
        Unexpected Flow Monitor ID : 0
        Socket creation error : 0
```



CHAPTER 34

Cisco Connected Mobile Experiences Cloud

A Cisco Connected Mobile Experience (CMX) deployment is a cloud-based indoor location services platform that

- provides real-time location analytics and engagement capabilities for indoor environments
- enables integration with Cisco wireless controllers through secure protocols such as HTTPS, and
- supports scalable, cloud-delivered access to location-based services.

Cisco Connected Mobile Experiences (CMX) communicates with the Cisco wireless embedded wireless controller using the Network Mobility Services Protocol (NMSP). NMSP runs over a connection-oriented (TLS) transport. This transport provides secure two-way connectivity. For the most efficient setup, install both the embedded wireless controller and CMX on-premise with direct IP connectivity.

Cisco CMX Cloud is a cloud-delivered version of the on-premise CMX.

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ConfigureCisco CMX Cloud

Ensure successful operation of NMSP cloud-services by configuring DNS, importing root CAs, and registering to Cisco Spaces.

To configure,CMX Cloudperform these procedures. These steps enable the controller to communicate securely with cloud services and Cisco Spaces.

Before you begin

- *Configure DNS*: To resolve fully qualified domain names used by NMSP cloud-services, configure a *DNS* server using the **ip name-server** *server_address* configuration command as shown in Step 2.
- *Import 3rd party root CAs*: The controller verifies the peer and host based on the certificate sent by the CMX when a connection is established. Root CA certificates are not preinstalled on the controller. Import a set of root CAs trusted by Cisco to the trustpool of the crypto PKI using the **crypto pki trustpool import url <url>** configuration command as shown in Step 3.
- Successful registration to Cisco Spaces is required before configuring the **server url** and **server token** parameters to complete setup.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the DNS on the controller to resolve the FQDN names used by the NMSP cloud-services.

Example:

```
Device(config)# ip name-server 10.10.10.205
```

Step 3 Import the 3rd party root CA.

Example:

```
Device(config)# crypto pki trustpool import url http://www.cisco.com/security/pki/trs/ios.p7b
```

The controller verifies the peer using the imported certificate.

Step 4 Configure the URL used for cloud services.

Example:

```
Device(config)# nmsp cloud-services server url https://cisco.com
```

Use the *no* form of the command to delete the server url from the configuration.

Step 5 Configure the authentication token for the NMSP cloud service.

Example:

```
Device(config)# nmsp cloud-services server token test
```

Use the *no* form of the command to delete the server token from the configuration.

Step 6 (Optional) Configure HTTP proxy details for the NMSP cloud service.

Example:

```
Device(config)# nmsp cloud-services http-proxy 10.0.0.1 port 10
```

Use the *no* form of the command to disable the use of a HTTP proxy.

Step 7 Enable NMSP cloud services.

Example:

```
Device(config)# nmsp cloud-services enable
```

Use the *no* form of the command to disable the feature.

VerifyCisco CMX Cloudconfiguration

Use the commands to verify theCMX Cloudconfiguration.

To view the status of active NMSP connections, use the command:

```
Device# show nmsp status

MSE IP Address   Tx Echo Resp  Rx Echo Req   Tx Data     Rx Data   Transport
------------------------------------------------------------------------------
192.0.2.1        0             0             1           1         TLS
198.51.100.1     0             0             1230        2391      HTTPs
```

To view the NMSP cloud service status, use the command:

```
Device# show nmsp cloud-services summary

CMX Cloud-Services Status
-------------------------
Server:                                 https://yenth8.cmxcisco.com
IP Address:                             198.51.100.1
Cmx Service:                            Enabled
Connectivity:                           https: UP
Service Status:                         Active
Last Request Status:                    HTTP/1.1 200 OK
Heartbeat Status:                       OK
```

To view the NMSP cloud service statistics, use the command:

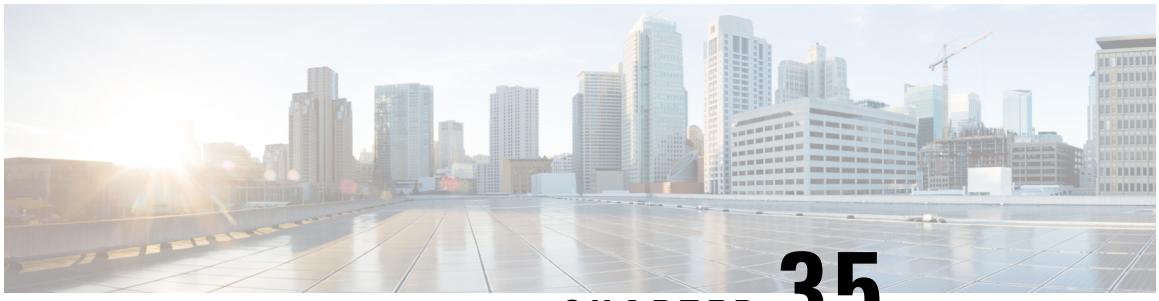
```
Device# show nmsp cloud-services statistics

CMX Cloud-Services Statistics
-----------------------------
Tx DataFrames:                           3213
Rx DataFrames:                           1606
Tx HeartBeat Req:                       31785
Heartbeat Timeout:                          0
Rx Subscr Req:                           2868
Tx DataBytes:                           10069
Rx DataBytes:                           37752
Tx HeartBeat Fail:                          2
Tx Data Fail:                               0
Tx Conn Fail:                               0
```

To view the mobility services summary, use the command:

```
Device# show nmsp subscription summary

Mobility Services Subscribed:
Index Server IP Services
----- --------- --------
1 209.165.200.224 RSSI, Info, Statistics, AP Monitor, AP Info
2 209.165.200.224 RSSI, Statistics, AP Info
```



CHAPTER 35

EDCA Parameters

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EDCA parameters

An Enhanced Distributed Channel Access (EDCA) parameter is a wireless channel access configuration that

- assigns preferential access to voice, video, and other quality of service (QoS) traffic
- differentiates wireless traffic priority through distinct parameter settings, and
- enables customization of wireless performance using controller GUI or CLI interfaces.

Configure EDCA parameters (GUI)

Set global EDCA parameters to optimize channel access for voice, video, and quality-of-service traffic on your wireless networks using GUI.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **Parameters**. On this window, you can configure global parameters for 802.11a/n/ac (5 GHz) and 802.11b/g/n (2.4 GHz) radios.

Note
You cannot configure or modify parameters, if the radio network is enabled. Disable the network status in the **Configuration** > **Radio Configurations** > **Network** window before proceeding. To apply the EDCA settings to the WLANs, disable and then re-enable the WLANs.

Step 2 In the **EDCA Parameters** section, select an EDCA profile from the **EDCA Profile** drop-down list. Enhanced Distributed Channel Access (EDCA) parameters provide preferential wireless channel access for voice, video, and other QoS traffic.

Step 3 Click **Apply**.

Configure EDCA parameters (CLI)

Set EDCA parameters on a wireless controller to optimize Quality of Service (QoS) for different traffic profiles and improve network performance using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Disable the radio network.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz} shutdown
```

Step 3 Enable specific EDCA parameters for the 802.11a or 802.11b/g network.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz} edca-parameters {custom-voice | fastlane |
optimized-video-voice | optimized-voice | svp-voice | wmm-default}
```

- **custom-voice**: Enables custom voice parameters for the 802.11a or 802.11b/g network.
- **fastlane**: Enables the fastlane parameters for the 802.11a or 802.11b/g network.
- **optimized-video-voice**: Enables EDCA voice-optimized and video-optimized parameters for the 802.11a or 802.11b/g network. Choose this option when both voice and video services are deployed on your network.
- **optimized-voice**: Enables non-SpectraLink voice-optimized profile parameters for the 802.11a or 802.11b/g network. Choose this option when voice services other than SpectraLink are deployed on your network.
- **svp-voice**: Enables SpectraLink voice-priority parameters for the 802.11a or 802.11b/g network. Choose this option if SpectraLink phones are deployed on your network to improve the quality of calls.
- **wmm-default**: Enables the Wi-Fi Multimedia (WMM) default parameters for the 802.11a or 802.11b/g network. This is the default option. Choose this option when voice or video services are not deployed on your network.

Step 4 Re-enable the radio network.

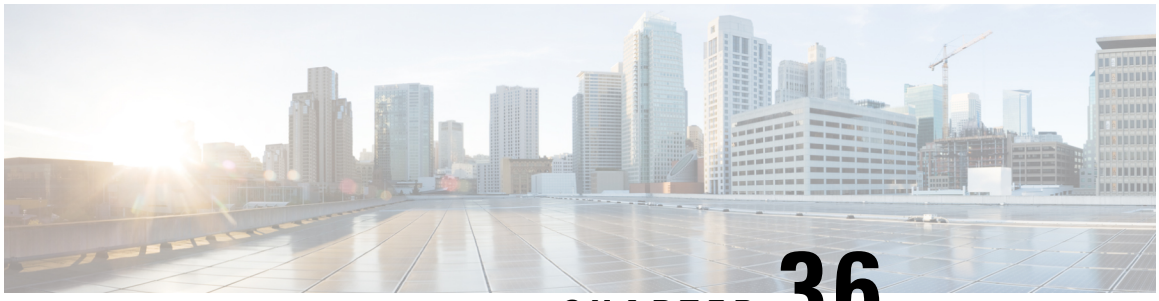
Example:

```
Device(config)# no ap dot11 {5ghz | 24ghz} shutdown
```

Step 5 Display the current status of MAC optimization for voice.

Example:

```
Device# show ap dot11 {5ghz | 24ghz} network
```



CHAPTER 36

802.11 parameters and Band Selection

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Band select

Band selection is a WLAN feature that

- enables dual-band client radios to connect to less congested 5-GHz APs
- improves overall network performance by reducing interference experienced on the controller, and
- uses probe response regulation to make 5-GHz channels more attractive to clients by delaying probe responses to clients on 2.4-GHz channels.

The 2.4-GHz band is often congested. Clients using the 2.4-GHz band often experience interference from Bluetooth devices, microwave ovens, cordless phones, and other access points. The 802.11b/g limit of three nonoverlapping channels also causes co-channel interference.

Band select works by regulating probe responses to clients and can be enabled on a per-WLAN basis. To view the band select table on an AP, run the **show dot11 band-select** command. It can also be viewed by running the **show cont d0/d1 | begin Lru** command.

Band Select Algorithm

The band select algorithm affects clients that use 2.4-GHz band. When a client sends a probe request to an access point, the client's probe Active and Count values become one as seen in the band select table. The algorithm functions based on the following scenarios:

- Scenario 1: The client RSSI (as seen from the show cont d0/d1 | begin RSSIcommand output) is greater than both Mid RSSI and Acceptable Client RSSI.
  1. For dual-band clients, the access point does not send 2.4-GHz probe responses but sends 5-GHz probe responses for all 5-GHz probe requests.
  2. For single-band (2.4-GHz) clients, the access point sends 2.4-GHz probe responses only after the probe suppression cycle.
  3. When the client's probe count matches the configured probe cycle count, the algorithm waits for the Age Out Suppression time, marks the client probe's Active value as zero, and restarts.
- Scenario 2: Client RSSI (as seen from show cont d0/d1 | begin RSSI) lies between Mid-RSSI and Acceptable Client RSSI.
  1. All 2.4-GHz and 5-GHz probe requests are responded to without any restrictions.
  2. This scenario is similar to when band select is disabled.

     Note: The client RSSI value (from the sh cont d0 | begin RSSI command output) averages all client packets received. The Mid RSSI feature reports the instantaneous RSSI value of probe packets. Therefore, the client RSSI often appears weaker than the configured Mid RSSI value (by 7 dB). The 802.11b probes from the client are suppressed to push the client to associate with the 802.11a band.

802.11 bands

Configure the 802.11b/g/n (2.4 GHz) and 802.11a/n (5 GHz) on the controller to meet your country's regulatory requirements. By default, both 802.11b/g/n and 802.11a/n are enabled.

- 802.11n Parameters
- 802.11h Parameters

802.11n Parameters

This section provides instructions for managing 802.11n APs on your network. The 802.11n devices support the 2.4 and 5-GHz bands and offer high throughput data rates.

The 802.11n high throughput rates are available on all the 802.11n APs for the WLANs using WMM with no Layer 2 encryption or with WPA2/AES encryption enabled.

Note If you want to disable MCS rates for 802.11n, 802.11ac, or 802.11ax, make sure at least one MCS rate remains enabled. To use only legacy 802.11a/b/g rates on your APs, first disable 802.11ax and 802.11ac on the controller for the specific band, then disable 802.11n. When you disable 802.11n globally on the controller, it affects all APs, even those mapped to a Custom RF Profile.

802.11h Parameters

802.11h informs client devices about channel changes and can limit the transmit power for those devices.

Restrictions for band selection, 802.11 bands, and parameters

- Band selection-enabled WLANs do not support time-sensitive applications, such as voice and video, because roaming delays impact performance.
- Band selection is supported only on Cisco Wave 2 and 802.11ax APs.

  For more specific APs, see https://www.cisco.com/c/en/us/td/docs/wireless/access_point/feature-matrix/ap-feature-matrix.html .
- Band selection works only when your AP is connected to a controller. If you use a FlexConnect AP without a controller connection, it does not perform band selection after a reboot.
- Dual-band clients are directed from the 2.4-GHz radio to the 5-GHz radio of the same AP, but only when both radios are operational.
- To enable or disable band selection and client load balancing, configure these features for a specific WLAN. These settings are enabled globally by default, and you cannot change them globally through the controller GUI or CLI.

Configure band selection (GUI)

Before you begin

Ensure that you have configured an AP Join profile prior to configuring the primary and backup controllers.

Optimize wireless client performance by controlling band selection settings on the controller using GUI.

Procedure

Step 1 Choose **Configuration** > **Wireless Advanced** > **Band Select**.

Step 2 In the **Cycle Count** field, enter a value between one and 10. The cycle count sets the number of suppression cycles for a new client. The default cycle count is two.

Step 3 In the **Cycle Threshold (milliseconds)** field, enter a value between one and 1000 milliseconds for the scan cycle period threshold. This setting determines the time threshold during which new probe requests from a client come from a new scanning cycle. The default cycle threshold is 200 milliseconds.

Step 4 In the **Age Out Suppression (seconds)** field, enter a value between 10 and 200 seconds. Age-out suppression sets the expiration time for pruning previously known 802.11b/g/n clients. The default value is 20 seconds. After this time elapses, clients become new and are subject to probe response suppression.

Step 5 In the **Age Out Dual Band (seconds)** field, enter a value between 10 and 300 seconds. The age-out period sets the expiration time for pruning previously known dual-band clients. The default value is 50 seconds. After this time elapses, clients become new and are subject to probe response suppression.

Step 6 In the Client RSSI (dbm) field, enter a value between -90 to -20. This is the average of the client packets received.

Step 7 In the Client Mid RSSI (dbm) field, enter a value between -90 to -20. This is the instantaneous RSSI value of the probe packets.

Step 8 On the **AP Join Profile** page, click the AP Join Profile name.

Step 9 Click **Apply**.

Configure band selection (CLI)

Enable and fine-tune band selection parameters for wireless clients to optimize network performance using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Set the probe cycle count for band select.

Example:

```
Device(config)# wireless client band-select cycle-count 3
```

The valid range is between one and 10.

Step 3 Set the time threshold for a new scanning cycle period.

Example:

```
Device(config)# wireless client band-select cycle-threshold 5000
```

The valid range is between one and 1000.

Step 4 Set the suppression expire to the band select.

Example:

```
Device(config)# wireless client band-select expire suppression 100
```

The valid range is between 10 and 200.

Step 5 Set the dual band expire.

Example:

```
Device(config)# wireless client band-select expire dual-band 100
```

The valid range is between 10 and 300.

Step 6 Set the client RSSI threshold.

Example:

```
Device(config)# wireless client band-select client-rssi 40
```

The valid range is between 20 and 90.

Step 7 Configure band selection on specific WLANs.

Example:

```
Device(config)# wlan wlan1 25 ssid12
Device(config-wlan)# band-select
```

The valid range is between one and 512. You can specify a value for the *SSID_network_name* parameter using up to 32 alphanumeric characters.

Configure the 802.11 bands (GUI)

Modify wireless radio settings to optimize network performance for 2.4 GHz and 5 GHz bands using commands.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **Network**.

Step 2 Click on either **5 GHz Band** or **2.4 GHz Band**. Uncheck the **Network Status** check box to disable the network. This allows configuration of the network parameters.

Step 3 In the **Beacon Interval** field, enter the rate at which the SSID is broadcast by the APs, from 100 to 600 milliseconds. The default is 100 milliseconds. For 802.11b/g/n (2.4-GHz) radios, to enable short preamble on the radio, check the **Short Preamble** check box. A short preamble improves throughput performance.

Step 4 In the **Fragmentation Threshold (in bytes)** field, enter a value between 256 to 2346 bytes. Packets larger than the size you specify here will be fragmented.

Step 5 Check the **DTPC Support** check box to advertise the transmit power level of the radio in the beacons and the probe responses. Client devices using dynamic transmit power control (DTPC) receive channel and power level information from APs. They then adjust their settings automatically. For example, a client device used primarily in Japan could rely on DTPC to adjust its channel and power settings automatically. When it travels to Italy and joins a network there, the settings are updated as needed. If the **DTPC Support** check box is checked, you cannot configure a power constraint value on your 802.11a/n/ac (5-GHz) radio network. Click **Apply**.

Step 6 In the **CCX Location Measurement** section, check the **Mode** check box to globally enable CCX radio management for the network. Once enabled, APs connected to this device issue broadcast radio measurement requests to clients running CCX v2 or later releases.

Step 7 In the **Interval** field, enter a value to specify how often the APs must issue broadcast radio measurement requests. Click **Apply**.

Step 8 In the **Data Rates** section, choose a value to specify the rates at which data can be transmitted between the AP and the client:

- Mandatory: Clients must support this data rate to associate with an AP on the controllerembedded wireless controller.
- Supported: Any associated client supporting this data rate may communicate with the AP using that rate.
- Disabled: Clients specify the data rates used for communication.

Step 9 Click **Apply** and save the configuration.

Configure the 802.11 bands (CLI)

Configure the various 802.11 wireless bands and essential parameters using commands.

Follow the procedure given below to configure 802.11 bands and parameters:

Procedure

Step 1 Disable the 802.11a and 802.11b bands.

Example:

```
Device(config)# ap dot11 5ghz shutdown
Device(config)# ap dot11 24ghz shutdown
```

Note
You must disable the 802.11a band before configuring the 802.11a network parameters.

You must disable the 802.11b band before configuring the 802.11b network parameters.

Step 2 Specify the rate at which the SSID is broadcast by the corresponding AP and the size at which packets are fragmented.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz | } beaconperiod 500
Device(config)# ap dot11 {5ghz | 24ghz | } fragmentation 300
```

The beacon interval is measured in time units (TUs). One TU is 1024 microseconds. You can configure the AP to send a beacon every 20 to 1000 milliseconds.

The threshold is a value between 256 and 2346 bytes (inclusive). Specify a low number for areas where communication is poor or where there is a great deal of radio interference.

Step 3 Enable APs to advertise their channels and transmit the power levels in beacons and probe responses.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz | } dtpc
Device(config)# no ap dot11 {5ghz | 24ghz | } dtpc
```

The default value is enabled. Client devices using dynamic transmit power control (DTPC) receive the channel-level and power-level information from the APs and adjust their settings automatically. For example,

a client device used primarily in Japan can rely on DTPC to adjust its channel and power settings automatically when it travels to Italy and joins a network there.

The **no** form of the command disables the DTPC setting.

Step 4 Specify the maximum allowed number of clients that can be configured.

Example:

```
Device(config)# wireless client association limit number 50 interval milliseconds 1000
```

You can configure the maximum number of association requests on a single access point slot at a given interval. The range of association limit that you can configure is from one to 100.

The association request limit interval is measured between 100 to 10000 milliseconds.

Step 5 Specify the rate at which data can be transmitted between the controllerembedded wireless controller and the client.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz} rate 36 {disable | mandatory | supported}
```

- **disable**: Defines that the clients specify the data rates used for communication.
- **mandatory**: Defines that the clients support this data rate in order to associate to an AP on the controllerembedded wireless controller.
- **supported**: Any associated clients that support this data rate can communicate with the AP using that rate. However, the clients are not required to use this rate in order to associate.
- *rate*: Specifies the rate at which data is transmitted. For the 802.11a and 802.11b bands, the data is transmitted at the rate of one, two, 5.5, six, nine, 11, 12, 18, 24, 36, 48, or 54 Mbps.

Step 6 Enable the 802.11a and 802.11b bands.

Example:

```
Device(config)# no ap dot11 5ghz shutdown
Device(config)# no ap dot11 24ghz shutdown
```

Note
The default value is enabled.

Step 7 Enable or disable 802.11g network support. Then return to privileged EXEC mode.

Example:

```
Device(config)# ap dot11 24ghz dot11g
Device(config)# end
```

The default value is enabled. You can use this command only if the 802.11b band is enabled. If you disable this feature, the 802.11b band is enabled without 802.11g support.

Configure a band-select RF profile (GUI)

Configure specific parameters in a band-select RF profile to optimize client band steering behavior on your wireless network.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Advanced**.

Step 2 In the **Band Select** tab, enter a value between one and 10 in the **Cycle Count** field. The cycle count determines how many suppression cycles are applied to each new client. The default cycle count is two.

Step 3 In the **Cycle Threshold** field, enter a value between one and 1000 milliseconds to define the scan cycle period threshold. his setting specifies the time period in which probe requests from a client are recognized as part of a new scanning cycle. The default cycle threshold value is 200 milliseconds.

Step 4 In the **Age Out Suppression** field, enter a value between 10 and 200 seconds. Age-out suppression establishes the expiration time for removing records of previously known 802.11b/g/n clients. The default value is 20 seconds. After the expiration time, clients are treated as new and become subject to probe response suppression.

Step 5 In the **Age Out Dual Band** field, enter a value between 10 and 300 seconds. The age-out period establishes the expiration time for removing records of previously known dual-band clients. The default value is 50 seconds. After the expiration period, clients are considered new and are subject to probe response suppression.

Step 6 In the **Client RSSI** field, enter a value between -90 dBm and -20 dBm. This value sets the minimum RSSI required for a client to respond to a probe.

Step 7 In the **Client Mid RSSI** field, enter a value between –20 dBm and –90 dBm. This parameter defines the mid-RSSI value, which can be used to toggle 2.4 GHz probe suppression depending on the RSSI.

Step 8 Click **Apply**.

Configure 802.11n parameters (GUI)

Apply custom 802.11n wireless settings to an RF profile in the device management GUI.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **RF**.

Step 2 Click **Add** to view the **Add RF Profile** window.

Step 3 In the **802.11** tab, complete these steps:

a) Choose the required operational rates.

b) Select the required **802.11n MCS Rates** by checking the corresponding check boxes.

Step 4 Click **Save & Apply to Device**.

Configure 802.11n parameters (CLI)

Configure and optimize 802.11n settings on a wireless AP using commands.

Procedure

Step 1 Enable 802.11n support on the network.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz} dot11n
```

The **no** form of this command disables the 802.11n support on the network.

Step 2 Specify the modulation and coding scheme (MCS) rates for data transmission between the access point and the client.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz} dot11n mcs tx 20
```

rtu: The valid range is zero to 23.

The **no** form of this command disables the MCS rates that are configured.

Step 3 Enable WMM on the WLAN and uses the 802.11n data rates that you configured.

Example:

```
Device(config)# wlan wlan1 25 ssid12
Device(config-wlan)# wmm require
```

The **require** keyword requires client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

Step 4 Disable the network.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz} shutdown
```

Step 5 Specify the aggregation method used for 802.11n packets.

Example:

```
Device(config)# {ap | no ap} dot11 {5ghz | 24ghz} dot11n a-mpdu tx priority {all | 0-7}
```

Aggregation is the process of grouping packet data frames together, rather than transmitting them separately. Two aggregation methods are available: Aggregated MAC Protocol Data Unit (A-MPDU) and Aggregated MAC Service Data Unit (A-MSDU). Both A-MPDU and A-MSDU are performed in the software.

You can specify the aggregation method for various types of traffic from the access point to the clients.

The list defines the priority levels (zero-7) assigned per traffic type.

- Zero—Best effort
- One—Background
- Two—Spare

- Three—Excellent effort
- Four—Controlled load
- Five—Video, less than 100-ms latency and jitter
- Six—Voice, less than 100-ms latency and jitter
- Seven—Network control

You can configure each priority level independently or use all the parameters to configure every priority level simultaneously. You can configure priority levels so that the traffic uses either A-MPDU transmission or A-MSDU transmission.

- When you use the **ap** command with other options, traffic at that priority level uses A-MPDU transmission.
- When you use the **no ap** command along with the other options, the traffic associated with that priority level uses A-MSDU transmission.

  Configure the priority levels to match the aggregation method used by the clients. By default, A-MPDU is enabled for priority levels zero, four, and five; all other levels are disabled. In addition, A-MPDU is enabled for every priority except six and seven.

Note
Tracking the TX retries value by internal MSDUs instead of the whole PPDU in Cisco IOS XE 17.12 and later versions provides a more accurate count for the AP's retries. This adjustment has led to a notable increase in retry count values because multiple MSDUs are contained within a single PPDU. This change is intentional and will be implemented in all future versions of Cisco IOS XE.

Step 6 Re-enable the network.

Example:

```
Device(config)# no ap dot11 {5ghz | 24ghz} shutdown
```

Step 7 Configure the guard interval for the network.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz} dot11n guard-interval {any | long}
```

Step 8 Configure the Reduced Interframe Space (RIFS) for the network.

Example:

```
Device(config)# ap dot11 {5ghz | 24ghz} dot11n rifs rx
```

Step 9 Return to privileged EXEC mode. Alternatively, press **Ctrl-Z** to exit global configuration mode.

Example:

```
Device(config)# end
```

Configure 802.11h parameters (CLI)

Configure 802.11h parameters on a wireless AP using commands to manage compliance, interference, and transmit power settings.

Procedure

Step 1 Disable the 802.11 network.

Example:

```
Device(config)# ap dot11 5ghz shutdown
```

Step 2 Enable or disable the AP to announce when it is switching to a new channel.

Example:

```
Device(config)# {ap | no ap} dot11 5ghz channelswitch mode 0
```

switch_mode: Enter zero or one to specify whether transmissions are restricted until the actual channel switch (***zero***) or are not restricted (***one***). The default value is disabled.

Step 3 Configure the 802.11h power constraint value in dB.

Example:

```
Device(config)# ap dot11 5ghz power-constraint 200
```

The valid range is from zero to 255. The default value is three.

Step 4 Re-enable the 802.11a network.

Example:

```
Device(config)# no ap dot11 5ghz shutdown
```

Step 5 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Verify configuration settings using band selection and 802.11 bands commands

Use these commands to verify band selection, 802.11 bands, and parameters on the device.

Table 20: Monitoring configuration settings using band selection and 802.11 band commands

Command	Purpose
show ap dot11 5ghz network	Displays 802.11a band network parameters, 802.11a operational rates, 802.11n MCS settings, and 802.11n status information.
show ap dot11 24ghz network	Displays 802.11b band network parameters, 802.11b/g operational rates, 802.11n MCS settings, and 802.11n status information.
show wireless dot11h	Displays 802.11h configuration parameters.

show wireless band-select	Displays band-select configuration settings.

Example: view the configuration settings for the 5-GHz band

```
Device# show ap dot11 5ghz network

802.11a Network : Enabled
11nSupport : Enabled
  802.11a Low Band : Enabled
  802.11a Mid Band : Enabled
  802.11a High Band : Enabled
802.11a Operational Rates
  802.11a 6M : Mandatory
  802.11a 9M : Supported
  802.11a 12M : Mandatory
  802.11a 18M : Supported
  802.11a 24M : Mandatory
  802.11a 36M : Supported
  802.11a 48M : Supported
  802.11a 54M : Supported
802.11n MCS Settings:
  MCS 0 : Supported
  MCS 1 : Supported
  MCS 2 : Supported
  MCS 3 : Supported
  MCS 4 : Supported
  MCS 5 : Supported
  MCS 6 : Supported
  MCS 7 : Supported
  MCS 8 : Supported
  MCS 9 : Supported
  MCS 10 : Supported
  MCS 11 : Supported
  MCS 12 : Supported
  MCS 13 : Supported
  MCS 14 : Supported
  MCS 15 : Supported
  MCS 16 : Supported
  MCS 17 : Supported
  MCS 18 : Supported
  MCS 19 : Supported
  MCS 20 : Supported
  MCS 21 : Supported
  MCS 22 : Supported
  MCS 23 : Supported
802.11n Status:
  A-MPDU Tx:
    Priority 0 : Enabled
    Priority 1 : Disabled
    Priority 2 : Disabled
    Priority 3 : Disabled
    Priority 4 : Enabled
    Priority 5 : Enabled
    Priority 6 : Disabled
    Priority 7 : Disabled
  A-MSDU Tx:
    Priority 0 : Enabled
    Priority 1 : Enabled
    Priority 2 : Enabled
    Priority 3 : Enabled
```

```
    Priority 4 : Enabled
    Priority 5 : Enabled
    Priority 6 : Disabled
    Priority 7 : Disabled
Guard Interval : Any
  Rifs Rx : Enabled
Beacon Interval : 100
CF Pollable mandatory : Disabled
CF Poll Request Mandatory : Disabled
CFP Period : 4
CFP Maximum Duration : 60
Default Channel : 36
Default Tx Power Level : 1
DTPC Status : Enabled
Fragmentation Threshold : 2346
Pico-Cell Status : Disabled
Pico-Cell-V2 Status : Disabled
TI Threshold : 0
Legacy Tx Beamforming setting : Disabled
Traffic Stream Metrics Status : Disabled
Expedited BW Request Status : Disabled
EDCA profile type check : default-wmm
Call Admision Control (CAC) configuration
Voice AC
  Voice AC - Admission control (ACM) : Disabled
  Voice Stream-Size : 84000
  Voice Max-Streams : 2
  Voice Max RF Bandwidth : 75
  Voice Reserved Roaming Bandwidth : 6
  Voice Load-Based CAC mode : Enabled
  Voice tspec inactivity timeout : Enabled
CAC SIP-Voice configuration
  SIP based CAC : Disabled
  SIP Codec Type : CODEC_TYPE_G711
  SIP call bandwidth : 64
  SIP call bandwidth sample-size : 20
Video AC
  Video AC - Admission control (ACM) : Disabled
  Video max RF bandwidth : Infinite
  Video reserved roaming bandwidth : 0
```

Example: view the configuration settings for the 2.4-GHz band

```
Device# show ap dot11 24ghz network

802.11b Network : Enabled
11gSupport : Enabled
11nSupport : Enabled
  802.11b/g Operational Rates
  802.11b 1M : Mandatory
  802.11b 2M : Mandatory
  802.11b 5.5M : Mandatory
  802.11g 6M : Supported
  802.11g 9M : Supported
  802.11b 11M : Mandatory
  802.11g 12M : Supported
  802.11g 18M : Supported
  802.11g 24M : Supported
  802.11g 36M : Supported
  802.11g 48M : Supported
  802.11g 54M : Supported
```

```
802.11n MCS Settings:
  MCS 0 : Supported
  MCS 1 : Supported
  MCS 2 : Supported
  MCS 3 : Supported
  MCS 4 : Supported
  MCS 5 : Supported
  MCS 6 : Supported
  MCS 7 : Supported
  MCS 8 : Supported
  MCS 9 : Supported
  MCS 10 : Supported
  MCS 11 : Supported
  MCS 12 : Supported
  MCS 13 : Supported
  MCS 14 : Supported
  MCS 15 : Supported
  MCS 16 : Supported
  MCS 17 : Supported
  MCS 18 : Supported
  MCS 19 : Supported
  MCS 20 : Supported
  MCS 21 : Supported
  MCS 22 : Supported
  MCS 23 : Supported
802.11n Status:
  A-MPDU Tx:
    Priority 0 : Enabled
    Priority 1 : Disabled
    Priority 2 : Disabled
    Priority 3 : Disabled
    Priority 4 : Enabled
    Priority 5 : Enabled
    Priority 6 : Disabled
    Priority 7 : Disabled
  A-MSDU Tx:
    Priority 0 : Enabled
    Priority 1 : Enabled
    Priority 2 : Enabled
    Priority 3 : Enabled
    Priority 4 : Enabled
    Priority 5 : Enabled
  Priority 6 : Disabled
    Priority 7 : Disabled
  Guard Interval : Any
  Rifs Rx : Enabled
Beacon Interval : 100
CF Pollable Mandatory : Disabled
CF Poll Request Mandatory : Disabled
CFP Period : 4
CFP Maximum Duration : 60
Default Channel : 11
Default Tx Power Level : 1
DTPC Status : true
Call Admission Limit : 105
G711 CU Quantum : 15
ED Threshold : -50
Fragmentation Threshold : 2346
PBCC Mandatory : Disabled
Pico-Cell Status : Disabled
Pico-Cell-V2 Status : Disabled
RTS Threshold : 2347
Short Preamble Mandatory : Enabled
Short Retry Limit : 7
```

```
Legacy Tx Beamforming setting : Disabled
Traffic Stream Metrics Status : Disabled
Expedited BW Request Status : Disabled
EDCA profile type : default-wmm
Call Admision Control (CAC) configuration
Voice AC
  Voice AC - Admission control (ACM) : Disabled
  Voice Stream-Size : 84000
  Voice Max-Streams : 2
  Voice Max RF Bandwidth : 75
  Voice Reserved Roaming Bandwidth : 6
  Voice Load-Based CAC mode : Enabled
  Voice tspec inactivity timeout : Enabled
CAC SIP-Voice configuration
  SIP based CAC : Disabled
  SIP Codec Type : CODEC_TYPE_G711
  SIP call bandwidth : 64
  SIP call bandwidth sample-size : 20
Video AC
  Video AC - Admission control (ACM) : Disabled
  Video max RF bandwidth : Infinite
  Video reserved roaming bandwidth : 0
```

Example: view the status of 802.11h parameters

```
Device# show wireless dot11
Power Constraint: 0
Channel Switch : Enabled
Channel Switch Mode : Quiet
Smart DFS : Enabled
```

Example: verify the band-selection settings

This example displays a band-select configuration:

```
Device# show wireless band-select

Band Select Probe Response   : per WLAN enabling
Cycle Count                  : 2
Cycle Threshold (millisec)   : 200
Age Out Suppression (sec)    : 20
Age Out Dual Band (sec)      : 60
Client RSSI (dBm)            : -80
Client Mid RSSI (dBm)        : -80
```

Examples: band selection configuration

This example shows how to set the probe cycle count and time threshold for a new scanning cycle period for band select:

```
Device# configure terminal
(config)# wireless client band-select cycle-count 3
(config)# wireless client band-select cycle-threshold 5000
(config)# end
```

This example shows how to set the suppression expiry time to the band select:

```
Device# configure terminal
(config)# wireless client band-select expire suppression 100
(config)# end
```

This example shows how to set the dual-band expiry time for the band select:

```
Device# configure terminal
(config)# wireless client band-select expire dual-band 100
(config)# end
```

This example shows how to set the client RSSI threshold for the band select:

```
Device# configure terminal
(config)# wireless client band-select client-rssi 40
(config)# end
```

This example shows how to configure band selection on specific WLANs:

```
Device# configure terminal
(config)# wlan wlan1 25 ssid12
(config-wlan)# band-select
(config)# end
```

Examples: 802.11 bands configuration

This example shows how to configure 802.11 bands using beacon interval, fragmentation, and dynamic transmit power control:

```
Device# configure terminal
config)# ap dot11 5ghz shutdown
(config)# ap dot11 24ghz shutdown
(config)# ap dot11 5ghz beaconperiod 500
(config)# ap dot11 5ghz fragmentation 300
(config)# ap dot11 5ghz dtpc
(config)# wireless client association limit 50 interval 1000
(config)# ap dot11 5ghz rate 36 mandatory
(config)# no ap dot11 5ghz shutdown
(config)# no ap dot11 24ghz shutdown
(config)# ap dot11 24ghz dot11g
(config)# end
```

Examples: 802.11n configuration

This example shows how to configure 802.11n parameters for 5-GHz band using aggregation method:

```
Device# configure terminal
(config)# ap dot11 5ghz dot11n
(config)# ap dot11 5ghz dot11n mcs tx 20
(config)# wlan wlan1 25 ssid12
(config-wlan)# wmm require
(config-wlan)# exit
(config)# ap dot11 5ghz shutdown
(config)# ap dot11 5ghz dot11n a-mpdu tx priority all
(config)# no ap dot11 5ghz shutdown
(config)# exit
```

This example shows how to configure the guard interval for 5-GHz band:

```
Device# configure terminal
(config)# ap dot11 5ghz dot11n
(config)# ap dot11 5ghz dot11n mcs tx 20
```

```
(config)# wlan wlan1 25 ssid12
(config-wlan)# wmm require
(config-wlan)# exit
(config)# no ap dot11 5ghz shutdown
(config)# ap dot11 5ghz dot11n guard-interval long
(config)# end
```

This example shows how to configure the RIFS for 5-GHz band:

```
Device# configure terminal
(config)# ap dot11 5ghz dot11n
(config)# ap dot11 5ghz dot11n mcs tx 20
(config)# wlan wlan1 25 ssid12
(config-wlan)# wmm require
(config-wlan)# exit
(config)# ap dot11 5ghz shutdown
(config)# ap dot11 5ghz dot11n rifs rx
(config)# end
```

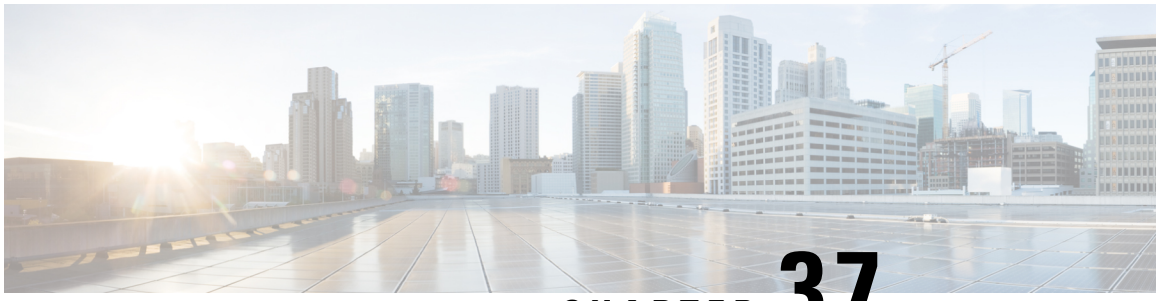
Examples: 802.11h configuration

This example shows how to configure the AP to announce when it is switching to a new channel using restriction transmission:

```
Device# configure terminal
(config)# ap dot11 5ghz shutdown
(config)# ap dot11 5ghz channelswitch mode 0
(config)# no ap dot11 5ghz shutdown
(config)# end
```

This example shows how to configure the 802.11h power constraint for 5-GHz band:

```
Device# configure terminal
(config)# ap dot11 5ghz shutdown
(config)# ap dot11 5ghz power-constraint 200
(config)# no ap dot11 5ghz shutdown
(config)# end
```



CHAPTER 37

Image Download

- Information About Image Download, on page 289
- Prerequisites for Image Download, on page 293
- Configuring Image Download Profile, on page 294
- Initiating Pre-Download (CLI), on page 303
- Verifying Image Download, on page 304

Information About Image Download

Software updates ensure that all the access points in the Cisco Embedded Wireless Controller network are running the latest software. The software update or image download can be performed using both the GUI and the CLI.

A typical Cisco Embedded Wireless Controller network contains the following components:

- Cisco Catalyst APs acting as controller (embedded wireless controller)
- Cisco Embedded Wireless Controller-capable APs (Other Cisco Catalyst series APs that participate in the Virtual Router Redundancy Protocol (VRRP)-based election process)
- Subordinate APs (Cisco Catalyst Series or Cisco Aironet Series Wave 2 APs)
- External TFTP and SFTP server.

Note For best user experience when using the GUI, view the browser at 100% resolution. The lines may break if the resolution is greater than 100%.

Updates to the AP Image Predownload Status (GUI)

From Cisco IOS XE Amsterdam, Release 17.3.1 onwards, during an access point (AP) image download, the Cisco Embedded Wireless Controller on Catalyst Access Points calculates the current percentage of the download and the estimated completion time of the download. (You can view these values in the CLI output by running the **show wireless ewc-ap ap image predownload status** command.)

To access the **Software Upgrage** window, from the Cisco Embedded Wireless Controller on Catalyst Access Points home page, choose **Administration** > **Software Management** > **Software Upgrade**.

The **Software Update Status** section in the GUI displays the update status bar that shows the progress of a software update, such as, **Initiate**, **Controller Image Download**, **AP Image Download**, **Network Upgrade**, **Activate**, and **Reload**.

To view the logs, click the **Show Install Logs** link.

The **Status** field displays the current status of the upgrade and indicates further action, if any, that you should perform.

The other details displayed in the window are - **Total Number of APs**, **Initiated**, **Predownloading AP Image**, **Predownloading Controller Image**, **Completed Predownloading AP Image**, **Completed Predownloading Controller Image**, **Failed to Predownload AP Image**, **Failed to Predownload Controller Image**.

The currently active AP, the AP on standby, and the preferred active AP are also displayed.

Image Download Scenarios

In a Cisco Embedded Wireless Controller network, image download from the embedded wireless controller to the subordinate AP takes place in the following scenarios:

- During AP join
- During network software upgrade (pre-download)

Note The following is recommended for EWC deployments:

In a normal EWC (EWC on AP) network, the controller image is transferred to all EWC capable APs. However, in a mesh topology, it adds additional traffic flow on the wireless backhaul when there are EWC capable MAPs. This could make the image download procedure slow and error prone. To elevate the issue, an option has been added, where the controller image is not copied to the EWC capable MAPs, when they are in CAPWAP mode. Changing the EWC capable MAPs to CAPWAP APs, does not impact the EWC network redundancy design, as MAPs do not spawn the controller.

Image Download During AP Join

APs with older software trying to join the Cisco Embedded Wireless Controller network are automatically upgraded to match the latest software version on the embedded wireless controller. The embedded wireless controller compares the software version on the new AP with that on itself. If there is a mismatch, the AP requests the controller for a software upgrade and image download is triggered. The embedded wireless controller facilitates the transfer of the latest software from an external TFTP server or SFTP server, to the new AP.

Depending on the new AP joining the network, there are two image downloads that take place:

- **AP software image download:** This applies to all new APs joining the Cisco Embedded Wireless Controller.
- **Controller software image download:** This applies only to Cisco Catalyst series APs, capable of becoming a controller, trying to join the Cisco Embedded Wireless Controller network.

AP Software Image Download

Any Cisco Catalyst Series AP or Cisco Aironet Series Wave 2 AP can only join an embedded wireless controller if its AP software image version matches that of the controller.

During the AP join process, the embedded wireless controller first checks the AP software image version on the new AP and if it does not match what is on the controller, the latest AP software is downloaded from the controller to the new AP. Once the AP software image on the new AP is upgraded to match the version that is on the embedded wireless controller in the network, the new AP reloads. Once the new AP is back up with the upgraded AP software image, it joins the embedded wireless controller.

Controller Software Image Download

If the new AP joining the network is a CiscoCatalyst Series AP capable of becoming an embedded wireless controller, first the controller checks the AP software image on the new AP and if outdated, it is upgraded to match the AP software version on the controller. The AP then reloads with the new AP software image and joins theembedded wireless controller in the network.

Next, the embedded wireless controller does a similar check to compare the controller software version on the embedded wireless controller-capable AP. Similar to the AP software upgrade, if there is a mismatch, the controller software on this CiscoCatalyst Series AP is also upgraded to the latest version on the embedded wireless controller. The AP reloads again, this time with the upgraded controller software image.

Efficient AP Join

If the Cisco Embedded Wireless Controllerr network contains an AP of the same image type as the newly joining AP, then the new AP downloads the AP software image from this AP. For example, if a CiscoCatalyst 9130AX Series AP is newly joining the Cisco Embedded Wireless Controller network and another CiscoCatalyst 9130AX Series AP already exists in the network, then the new AP gets its AP software image from the already joined AP.

This method, known as efficient AP join, enables homogenous APs to get the software locally (within the Cisco Embedded Wireless Controller network) rather than downloading it from an external server. This improves software download efficiency.

The first AP of a series that joins the network and downloads the software from the embedded wireless controller is called a primary image. The other APs of the same series are known as image subordinates.

Network Software Upgrade (Pre-Download)

In the pre-download scenario, image download in the Cisco Embedded Wireless Controller network occurs to upgrade the software on all the APs from one software version to another. However, these APs continue to serve existing as well as new clients and there is no network disruption.

For pre-download, all the APs should be connected to the embedded wireless controller in a stable join state. Once image download is initiated during pre-download, new APs are not allowed to join the embedded wireless controller.

Efficient AP Upgrade

In this method, the first AP of an AP series to get the image from the embedded wireless controller becomes the primary image. The remaining APs of the same AP series, the image subordinates, then download the software image locally from this primary image. This method is also known as efficient AP upgrade.

Methods Supported for Image Download

In a Cisco Embedded Wireless Controller network, there are four ways in which the software image can be downloaded from the embedded wireless controller. These methods are based on the location from where the controller transfers the software image to the subordinate AP:

- From an external TFTP server
- From an external SFTP server
- From the desktop (via HTTP)

TFTP Image Download Method

In the TFTP method, the AP and controller software images are stored on a TFTP server. To download the software images from the TFTP server, you need to specify the IP address of the TFTP server and the path to the software image bundle on the TFTP server.

The TFTP image download method can be triggered using both the GUI and CLI.

SFTP Image Download Method

In the SFTP method, the AP and controller software images are stored on an SFTP server. To download the software images from the SFTP server, in addition to the IP address of the SFTP server and the software image bundle path, you need to specify the SFTP server credentials.

The SFTP image download method also can be triggered using both the GUI and CLI.

Desktop (HTTP) Image Download Method

Image download through desktop (HTTP) is applicable only in the network software upgrade (pre-download) scenario.

For the desktop (HTTP) method, download the software image bundle for the Cisco Embedded Wireless Controller to your computer or laptop desktop. This downloaded bundle contains the AP and controller software images which need to be extracted to the computer or laptop desktop before they can be uploaded to the embedded wireless controller.

Note that the desktop (HTTP) method works only for a homogenous network. A homogenous Cisco Embedded Wireless Controller network is one which contains APs that have the same AP software image type. For example, the Cisco Catalyst 9115AX series AP and the Cisco Catalyst 9120AX series AP use the ap1g7 AP software image file. So, the Cisco Embedded Wireless Controller network in this example containing Cisco Catalyst 9115AX series and 9120AX series APs is a homogenous network.

The embedded wireless controller CLI can only be used to set the mode for image download as desktop (HTTP). The Cisco Embedded Wireless Controller GUI has to be used to configure and trigger network software upgrade (pre-download) using the desktop (HTTP) image download method.

Parallel Image Download

Software and network updates ensure that all the access points in the Cisco Embedded Wireless Controller network are running the latest software. The methods supported for image download are from an external TFTP server, or from an external SFTP server, or from the desktop (via HTTP), or via CCO.

In the Cisco IOS XE Bengaluru 17.6.1 Release, the image download procedure for mesh networks (subtree level-by-level download) was adapted, and the overall process of flex EWC networks is enhanced for TFTP and SFTP. This new method of downloading the image is called parallel download. With this enhancement, the gains seen are significant.

The image download process typically involves the following steps:

1. Fetch the controller image for active and standby APs.
2. Fetch AP image for each AP type once from external image server.
3. Distribute it to the other APs of the same type, from the AP mentioned above.

The new image download procedure is as follows:

1. Fetch the controller image for active and standby APs.
2. Fetch all the AP images from an external image server, such as TFTP and SFTP, in parallel.



Note In the Cisco IOS XE Bengaluru 17.5.x and earlier releases, the image was first copied to an active EWC, and then the image was sent to the image master via CAPWAP. With the parallel download method, the image master receives the image directly.

For TFTP, the AP must have direct connectivity to the image server. Direct connectivity is not required for SFTP.

With the introduction of the parallel download method, Step 2 finishes quickly and Step 3 is initiated sooner than before.



Note The command for parallel image download, in a EWC mesh topology, takes into consideration the topology hierarchy and distributes or predownloads the image level by level starting with the RAPs. This increases the possibility that an AP predownloading the image over the mesh link, could find an AP one hop away that could provide the image to it.

3. Distribute it to the other APs of the same type, from the AP mentioned above.

Prerequisites for Image Download

- Connectivity to an external (TFTP or SFTP) server is required for image download during AP join in a Cisco Embedded Wireless Controller network.
- Connectivity to a PC or laptop is required for image download during network software upgrade in a Cisco Embedded Wireless Controller network.
- All APs should be connected to the embedded wireless controller for image download in the network software upgrade (pre-download) scenario.
- For image upgrade, you must not configure a preferred-master. If you configure a preferred-master, ensure that it points to the currently active AP, which is displayed in the **show wireless ewc-ap redundancy summary** command.

If a different AP is configured as the preferred-master, the upgrade process will not take place in the **install activate** step. If the upgrade does not take place, you should either remove the preferred-master configuration, or re-configure the preferred-master to match the AP that is currently active, and then run the **install activate** command, again.

•

Configuring Image Download Profile

You need to configure the image download profile for both the AP join image download and pre-download scenarios. The only profile supported is *default*. In a Cisco Embedded Wireless Controller network, only one site tag is supported, the *default-site-tag*. The *default* image download profile is attached to the *default-site-tag*.

Note When an AP of a different type tries to join a homogenous network that had earlier used the HTTP mode for image upgrade, the AP join fails. To avoid this failure, you must update the **image-download-mode** to **tftp** in the **wireless profile image-download default** configuration step.

Configuring TFTP Image Download (GUI)

Procedure

Step 1 Choose **Administration** > **Software Management**.

Step 2 On the **Software Management** page, under the **Software Upgrade** tab, select the **Mode** as TFTP.

Step 3 In the **Image Server** field, enter the TFTP server IP address.

Step 4 In the **Image Path** field, enter the absolute or relative path to the software image bundle.

Step 5 Choose one of the following:

- **Save:** Choose this option to save the image download profile and enable image download for new APs joining the Cisco Embedded Wireless Controller network.
- **Save & Download:** Choose this option to save the configuration and enable network software upgrade (pre-download). The image download profile is saved (even if no change is made to the configuration) and the latest image is downloaded in the background. This allows the APs to continue serving the clients.
- **Activate:** Choose this option to enable the APs in the network to swap to the latest image and reboot. The Cisco Embedded Wireless Controller network is activated once the APs come up with the new image file.
- **Cancel:** Choose this option to cancel any changes made to the image download profile.

Option	Description
Save	Choose this option to save the image download profile and enable image download for new APs joining the Cisco Embedded Wireless Controller network.

Option	Description
Save & Download	Choose this option to save the configuration and enable network software upgrade (pre-download). The image download profile is saved (even if no change is made to the configuration) and the latest image is downloaded in the background. This allows the APs to continue serving the clients.
Activate	Choose this option to enable the APs in the network to swap to the latest image and reboot. The Cisco Embedded Wireless Controller network is activated once the APs come up with the new image file.
Cancel	Choose this option to cancel any changes made to the image download profile.

Configuring TFTP Image Download (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	(Optional) **wireless ewc-ap image-download parallel** **Example:** `Device (config)# wireless ewc-ap image-download parallel`	Enables parallel AP image download, during network upgrade. This command is required for a level-by-level image download on mesh networks.
Step 3	**wireless profile image-download default** **Example:** `Device (config)# wireless profile image-download default`	Configures the default AP profile.
Step 4	**image-download-mode tftp** **Example:** `Device(config-wireless-image-download-profile)# image-download-mode tftp`	Configure image download using TFTP.
Step 5	**tftp-image-server** *server-ip* **Example:** `Device(config-wireless-image-download-profile-tftp)# tftp-image-server 10.1.1.1`	Configure the TFTP server for image download by specifying the IPv4 or IPv6 *server-ip* address.

	Command or Action	Purpose
Step 6	**tftp-image-path** *server-path* **Example:** `Device(config-wireless-image-download-profile-tftp)# tftp-image-path /download/object/stream/images/ap-images`	Configure the absolute or relative path to the software image on the TFTP server.
Step 7	**end** **Example:** `Device(config-wireless-image-download-profile-tftp)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring SFTP Image Download (GUI)

Procedure

Step 1 Choose **Administration** > **Software Management**.

Step 2 On the **Software Management** page, under the **Software Upgrade** tab, select the **Mode** as SFTP.

The SFTP port is not configurable and is fixed at 22.

Step 3 In the **Image Server** field, enter the SFTP server IP address.

Step 4 In the **Image Path** field, enter the path to the software image bundle.

Step 5 In the **User Name** field, enter the SFTP server username.

Step 6 Choose the appropriate **Password Type** from Unencrypted or AES Encrypted.

Step 7 In the **Password** field, enter the SFTP server password.

Step 8 Choose one of the following:

Option	Description
Save	Choose this option to save the image download profile and enable image download for new APs joining the Cisco Embedded Wireless Controller network.
Save & Download	Choose this option to save the configuration and enable network software upgrade (pre-download). The image download profile is saved (even if no change is made to the configuration) and the latest image is downloaded in the background. This allows the APs to continue serving the clients.
Activate	Choose this option to enable the APs in the network to swap to the latest image and reboot. The Cisco Embedded Wireless Controller network is activated once the APs come up with the new image file.
Cancel	Choose this option to cancel any changes made to the image download profile.

Configuring SFTP Image Download (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	(Optional) **wireless ewc-ap image-download parallel** **Example:** `Device (config)# wireless ewc-ap image-download parallel`	Enables parallel AP image download, during network upgrade. This command is required for a level-by-level image download on mesh networks.
Step 3	**wireless profile image-download default** **Example:** `Device (config)# wireless profile image-download default`	Configures the default AP profile.
Step 4	**image-download-mode sftp** **Example:** `Device(config-wireless-image-download-profile)# image-download-mode sftp`	Configure image download using SFTP.
Step 5	**sftp-image-server** *server-ip* **Example:** `Device(config-wireless-image-download-profile-sftp)# sftp-image-server 10.1.1.1`	Configure the SFTP server for image download by specifying the IPv4 or IPv6 *server-ip* address.
Step 6	**sftp-image-path** *server-path* **Example:** `Device(config-wireless-image-download-profile-sftp)# sftp-image-path /download/object/stream/images/ap-images`	Configure the path to the software image on the SFTP server.
Step 7	**sftp-username** *username* **Example:** `Device(config-wireless-image-download-profile-sftp)# sftp-username test`	Specify the username to log in to the SFTP server for image download.
Step 8	**sftp-password** {**0** | **8**} *password* **Example:** `Device(config-wireless-image-download-profile-sftp)# sftp-password 0 password1`	Specify the password associated with the above username to download the image from the SFTP server. You need to re-enter the password to confirm the entry.

	Command or Action	Purpose
		To configure an AES encrypted password, specify `8`, else specify `0` to configure an unencrypted password.
Step 9	**end** **Example:** `Device(config-wireless-image-download-profile-tftp)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring CCO Mode for Software Upgrade (GUI)

Before you begin

The CCO account must have a physical address entered at the CCO Profile Manager. The account must have EULA and K9 acknowledged. For more information about creating a CCO account, refer to https://www.cisco.com/c/en/us/about/help/registration-benefits-help.html.

Procedure

Step 1 Choose **Administration** > **Software Management**.

Step 2 On the **Software Management** page, under the **Software Upgrade** tab, select the **Mode** as CCO.

Step 3 In the **User Name** field, enter the CCO username.

Step 4 In the **Password** field, enter the password to access the CCO server.

Step 5 Choose the appropriate **Password Type** from Unencrypted or AES Encrypted.

Step 6 Choose either Enabled or Disabled from the **Automatically Check for Updates** field. If you enable this option, the system automatically checks for software updates.

The interval is for 30 days. After the interval expires, the controller automatically checks and updates for the latest or recommend software version information in the controller configuration.

Step 7 In the **Software Check** field, click the **Check now** button and retrieve up-to-date information about the **Latest software release** (the latest version available on the CCO website) and the **Recommended software release** (the recommended software version for the currently running software) version numbers.

Step 8 The **Last CCO Response** field displays the error messages encountered when configuring the CCO image download method. For example, if you have entered a wrong username and password, the following error message is displayed: `HTTP 400 Error: 400 Client Error: Bad Request for url: https://cloudsso.cisco.com/as/token.oauth2 Please check your username/password and try again.` For more information about the **Last CCO Response** error messages, refer to Troubleshooting - CCO Image Download Error Messages, on page 301.

Step 9 From the **Version** drop-down list, choose either **Recommended** or **Latest**. After fetching the latest and the recommended software versions, you can choose the version to upgrade.

Step 10 Choose one of the following:

Option	Description
Save	Choose this option to save the image download profile and enable image download for new APs joining the Cisco Embedded Wireless Controller network.
Save & Download	Choose this option to save the configuration and enable network software upgrade (pre-download). The image download profile is saved (even if no change is made to the configuration) and the latest image is downloaded in the background. This allows the APs to continue serving the clients.
Activate	Choose this option to enable the APs in the network to swap to the latest image and reboot. The Cisco Embedded Wireless Controller network is activated once the APs come up with the new image file.
Cancel	Choose this option to cancel any changes made to the image download profile.

Configuring CCO Image Download (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile image-download default** **Example:** `Device (config)# wireless profile image-download default`	Configures the default AP profile.
Step 3	**image-download-mode cco** **Example:** `Device(config-wireless-image-download-profile)# image-download-mode cco`	Configure image download using CCO.
Step 4	**cco-username** *username* **Example:** `Device(config-wireless-image-download-profile-cco)# cco-username username`	Specify the username to log in to the CCO server for image download.
Step 5	**cco-password** {**0** | **8**} *password* **Example:** `Device(config-wireless-image-download-profile-cco)# cco-password 0 password1`	Specify the password associated with the above username to download the image from the CCO server. You need to re-enter the password to confirm the entry.

	Command or Action	Purpose
		To configure an AES encrypted password, specify `8`, else specify `0` to configure an unencrypted password.
Step 6	**cco-version** {**latest** | **suggested**} **Example:** `Device(config-wireless-image-download-profile-cco)# cco-version latest`	Specify the **latest** or the **suggested** version to be downloaded from the CCO server. By default the **suggested** version is downloaded.
Step 7	**cco-auto-check** **Example:** `Device(config-wireless-image-download-profile-cco)# cco-auto-check`	Enables or disables automatic check of new software versions at CCO every 30 days. This is applicable to Image Upgrade or Predownload only. By default, **cco-auto-check** is enabled. To disable the command use the **no** form of the command.
Step 8	**end** **Example:** `Device(config-wireless-image-download-profile-cco)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.
Step 9	**wireless ewc-ap predownload poll-cco** **Example:** `Device# wireless ewc-ap predownload poll-cco`	Polls the CCO server to check for the latest software version.
Step 10	**clear ap predownload statistics** **Example:** `Device# clear ap predownload statistics`	Clears the AP predownload statistics.
Step 11	**install remove profile default** **Example:** `Device# install remove profile default`	Removes the image download profile. Choose **Y** to remove the profile or choose **N** to cancel.
Step 12	**install add profile default** **Example:** `Device# install add profile default`	Downloads the controller and AP software image from the embedded wireless controller. The controller image is sent to all Cisco Embedded Wireless Controller-capable APs. The AP image is downloaded to all APs sharing the same image type
Step 13	**install activate** **Example:** `Device# install activate`	Activates the network after upgrade. All the subordinate APs get the new AP image and reboot. Once all APs are rebooted, the embedded wireless controller also reboots.

	Command or Action	Purpose
		Note The network can also be activated if the controller image is downloaded but all APs have not received the AP image via predownload. **Important** If the network is activated during partial predownload success, and a Cisco Embedded Wireless Controller-capable AP with old controller software becomes the controller, then the network will not get upgraded to the new image.
Step 14	**install commit** **Example:** `Device# install commit`	Commits the current software image once the embedded wireless controller comes up after rebooting. **Note** While upgrading, you must not use the **add**, **active**, **commit** keywords in a single command, as the activation process fails.

Troubleshooting - CCO Image Download Error Messages

Following are the expected error messages and the causes, which will be displayed at the **Last CCO Response** field:

DNS resolution or connectivity issue

Connection Error: HTTPSConnectionPool(host='cloudsso.cisco.com', port=443): Max retries exceeded with url: /as/token.oauth2 (Caused by NewConnectionError('<urllib3.connection.VerifiedHTTPSConnection object at 0xf6170250>: Failed to establish a new connection: [Errno -3] Temporary failure in name resolution',))

CCO username/password error

HTTP 400 Error: 400 Client Error: Bad Request for url: https://cloudsso.cisco.com/as/token.oauth2 Please check your username/password and try again

Address missing exception

Thank you for registering with Cisco.com. In order to consume software or services we require your full address. Please follow this link to return to profile manager to complete your profile.

EULA form missing exception

Eula form have not been accepted or rejected to continue download. Please go tohttps://software.cisco.com/download/eula.

K9 form missing exception

K9 form have not been accepted or rejected to continue download. Please go to https://software.cisco.com/download/k9

Configuring Desktop (HTTP) Image Download (GUI)

- Image download using desktop (HTTP) is only enabled in a homogeneous network, that is a network containing APs that have the same image type.
- Image download using desktop (HTTP) can only be configured from the GUI.
- The CLI can only be used to set the image download mode to desktop (HTTP).

Procedure

Step 1 Choose **Administration** > **Software Management**.

Step 2 On the **Software Management** page, under the **Software Upgrade** tab, select the **Mode** as Desktop (HTTP).

Step 3 In the **Controller Image** field, navigate to the embedded wireless controller software image on your computer or laptop desktop.

Step 4 In the **AP Image** field, navigate to the AP software image on your computer or laptop desktop.

The GUI displays the name of the AP image to be used. Depending on the AP model, the name of the AP image varies.

Step 5 Choose one of the following:

Option	Description
Save	Choose this option to save the image download profile and enable image download for new APs joining the Cisco Embedded Wireless Controller network.
Save & Download	Choose this option to save the configuration and enable network software upgrade (pre-download). The image download profile is saved (even if no change is made to the configuration) and the latest image is downloaded in the background. This allows the APs to continue serving the clients.
Activate	Choose this option to enable the APs in the network to swap to the latest image and reboot. The Cisco Embedded Wireless Controller network is activated once the APs come up with the new image file.
Cancel	Choose this option to cancel any changes made to the image download profile.

Initiating Pre-Download (CLI)

Procedure

	Command or Action	Purpose
Step 1	**wireless ewc-ap predownload poll-cco**	Check the latest and recommended version for image upgrade.
Step 2	**clear ap predownload statistics**	Clear AP predownload statistics.
Step 3	**install remove profile default**	Remove the image download profile. Choose **Y** to remove the profile or choose **N** to cancel.
Step 4	**install add profile default**	Download the controller and AP software image from the embedded wireless controller. The controller image is sent to all Cisco Embedded Wireless Controller-capable APs. The AP image is downloaded to all APs sharing the same image type.
Step 5	**show wireless ewc-ap predownload status**	Monitor the overall software download status. The download is successful when the status message is `Controller Image Predownload to EWC Capable APs Complete`.
Step 6	**install activate**	Activate the network after upgrade. All the subordinate APs get the new AP image and reboot. Once all APs are rebooted, the embedded wireless controller also reboots. **Note** The network can also be activated if the controller image is downloaded but all APs have not received the AP image via predownload. **Important** If the network is activated during partial predownload success, and a Cisco Embedded Wireless Controller-capable AP with old controller software becomes the controller, then the network will not get upgraded to the new image.
Step 7	**show install summary**	Verify the current image status after rebooting.

	Command or Action	Purpose
		If the status is `Activated and Uncommitted`, proceed to Step 7, else wait.
Step 8	**install commit**	Commits the current software image once the embedded wireless controller comes up after rebooting. **Note** While upgrading, you must not use the **add**, **active**, **commit** keywords in a single command, as the activation process fails.

During the image upgrade process, the image predownload status is shown in various stages such as Controller Image Download In Progress, AP Image Predownload in Progress, Controller Image Predownload to EWC Capable APs In Progress, and so on. Sometimes, the image upgrade might fail due to various reasons. In such a case, you can either continue with the **install activate** operation or cancel it, based on the output of the **show wireless ewc-ap ap image predownload status** command, which displays the individual predownload status for each AP.

Verifying Image Download

To monitor the overall progress of the software download process during predownload, run the following command.

```
Device# show wireless ewc-ap predownload status
```

The following are the various status messages indicating the status of the predownload operation. These are displayed when you run the **show wireless ewc-ap predownload status** command:

- None
- Controller Image Download Initiated
- Controller Image Download In Progress
- Controller Image Download Complete
- Controller Image Download Failed
- AP Image Predownload Initiated
- AP Image Predownload In Progress
- AP Image Predownload Complete
- AP Image Predownload Unsupported
- AP Image Predownload Failed
- Controller Image Predownload to EWC Capable APs In Progress
- Controller Image Predownload to EWC Capable APs Complete
- Controller Image Predownload to EWC Capable APs Failed

- Image Activation Succeeded
- Image Activation Failed
- Invalid State

To view the AP image predownload statistics, run the following command:

```
Device# show wireless ewc-ap ap image predownload status
Total number of APs                          : 5
Total number of EWC capable APs              : 4
Number of APs
        Initiated                            : 0
        Predownloading AP image              : 0
        Predownloading Controller image      : 1
        Completed predownloading AP          : 5
        Completed predownloading Controller : 0
        Failed to Predownload AP             : 0
        Failed to Predownload Controller     : 0
AP Name                Primary Image (AP/Controller)          Backup Image (AP/Controller)
          Predownload Status         Predownload Version                    AP Image
Role    Retries  AP image       Controller image

                                                                                  Type
                ETA/Percent    ETA/Percent
-----------------------------------------------------------------------------------------------------------------
APXXXX.9XXX.8FXX       17.3.0.85      /17.3.01.0.XXXX         17.2.2.2       /17.2.02.0.XXXX
         Complete                  17.2.2.2       /17.2.02.0.2XXX         ap1g7       Slave
   0        00:00:00/100%  00:00:00/  0%
APXXXX.5XXX.71XX       17.3.0.85      /                       17.2.2.2       /
          Complete                   17.2.2.2       /                       ap1g5
Master  0        00:00:00/100%  00:00:00/  0%
APXXXX.8XXX.59XX       17.3.0.85      /17.3.01.0.XXXX         17.2.2.2       /17.2.02.0.XXXX
         Complete                  17.2.2.2       /                       ap1g7       Slave
   0        00:00:00/100%  00:00:00/  0%
APXXXX.8XXX.5AXX       17.3.0.85      /17.3.01.0.XXXX         17.2.2.2       /17.3.01.0.XXX
          Controller Predownloading  17.2.2.2       /                       ap1g7
Master  0        00:00:00/100%  00:00:00/  0%
APXXXX.8XXX.5BXX       17.3.0.85      /17.3.01.0.XXXX         17.2.2.2       /
          Complete                   17.2.2.2       /                       ap1g7
Slave   0        00:00:00/100%  00:00:00/  0%
```

To view details of the AP acting as the primary image , use the following command:

```
Device# show wireless ewc-ap image-master
Image Master List
Image Name: ap1g7
-----------------------------------------------------------------------------------------------------------
Master AP MAC               AP                        AP                Controller
         Controller
                Predownload In Progress   Predownload Complete     Predownload In Progress
  Predownload Complete
-----------------------------------------------------------------------------------------------------------
c0XX.eXXX.90XX    No                          No                      No
   Yes
Image Name: ap1g5
-----------------------------------------------------------------------------------------------------------
Master AP MAC               AP                        AP                Controller
         Controller
                Predownload In Progress   Predownload Complete     Predownload In Progress
  Predownload Complete
-----------------------------------------------------------------------------------------------------------
70XX.1XXX.4bXX    No                          No                      No
   Yes
```

To check the image download status on all the APs, run the following command:

```
Device# show ap image
```

To check AP status during image download, run the following command:

```
Device# show ap summary
```

To monitor efficient AP join status, run the following command:

```
Device# show ap master list
```

To view the details of the last AP image download attempt, run the following command:

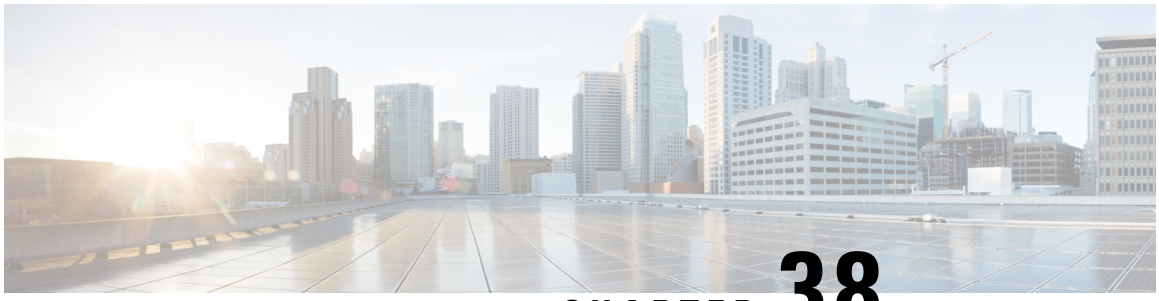
```
Device# show wireless stats ap image-download
```

To check the current status of the upgraded image, run the following command:

```
Device# show install summary
```

To check the download status from external servers (TFTP or SFTP), run the following command:

```
Device# show install log
```



CHAPTER 38

Conditional Debug and Radioactive Tracing

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Feature history for conditional debug and radioactive tracing

This table provides release and related information about the feature explained in this section.

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 21: Feature history for conditional debug and radioactive tracing

Feature Name	Release Information	Feature Description
Conditional debug and radioactive tracing	Cisco IOS XE 17.11.1	Conditional debugging is a diagnostic feature that selectively activates debugging and logging based on defined conditions to optimize resource usage and performance in complex networks, while radioactive tracing is a diagnostic mechanism that stitches together execution chains with increased verbosity, enabling conditional detailed debug information across system components for troubleshooting specific features.

Conditional debugging

A conditional debugging is a diagnostic feature that

- enables selective activation of debugging and logging for specific features based on conditions you define
- allows you to define custom conditions such as interface, IP address, or MAC address to narrow debug scope, and
- helps reduce system resource usage and performance impact in large, complex networks.

Use this feature in systems with many supported features.

Conditional debug allows granular debugging in networks operating at large scale with many features. It allows you to observe detailed debug output for specific instances within the system.

In contrast, the general debug command produces output without filtering feature objects being processed. The general debug command uses significant system resources and affects performance.

Radioactive tracing

A radioactive tracing is a diagnostic tracing mechanism that

- stitches together a chain of execution for operations of interest across the system, at an increased verbosity level
- enables conditional printing of detailed debug information across threads, processes and function calls, and
- troubleshoot system features, especially First-Hop Security (FHS) and mesh networking functions.

Note

-
- The radioactive tracing filter does not work, if the certificate is not valid.
- To debug mesh features effectively, add both Ethernet and Radio MAC addresses as conditional MACs for RA tracing when you collect logs.
- To enable debugging for wireless IPs, use the **debug platform condition feature wireless ip** *ip-address* command.

Conditional debugging and radioactive tracing

A conditional debugging and radioactive tracing feature is a diagnostic mechanism that

- combines the precision of conditional debugging to target specific execution contexts
- leverages radioactive tracing to follow code paths across multiple control flows, and
- enables use of a single debug CLI to debug all execution contexts related to the condition.

Note Use the **clear platform condition all** command to remove the debug conditions applied to the platform.

Location of tracefiles

Tracefiles are generated for each process and saved in either the `/tmp/rp/trace` or `/tmp/fp/trace` directory. Each trace log is written to a file of 1 MB. The directory can hold up to a maximum of 25 such files for a given process. When a tracefile in the `/tmp` directory reaches its 1MB limit or the configured size, it is rotated out to an archive location in the `/crashinfo` partition under the `tracelogs` directory.

- Process-name_Process-ID_running-counter.timestamp.gz

  Example: IOSRP_R0-0.bin_0.14239.20151101234827.gz

- Process-name_pmanlog_Process-ID_running-counter.timestamp.bin.gz

  Example: wncmgrd_R0-0.27958_1.20180902081532.bin.gz

The `/tmp` directory holds only a single tracefile for a given process. Once a tracefile reaches its size limit, the system moves it to `/crashinfo/tracelogs`. The archive directory stores up to 25 files and replaces the oldest file with each new file from `/tmp`. File size varies by process. Some processes use larger files that can reach 10 MB.

- The number of files stored in the `tracelogs` directory also depends on the process. For example, the WNCD process may use a limit of up to 400 files per instance, depending on the platform.
- You can verify these logs (per-process) using the **show platform software trace message** *process_name* **chassis active R0** command.

Configure conditional debugging (GUI)

Enable targeted troubleshooting by configuring conditional debugging through the GUI, allowing you to capture and analyze logs for specific MAC or IP addresses.

Procedure

Step 1 Choose **Troubleshooting** > **Radioactive Trace**. Click **Add**.

Step 2 Enter the **MAC/IP Address**.

Step 3 Click **Apply to Device**.

Step 4 Click **Start** to start or **Stop** to stop the conditional debug.

Step 5 Click **Generate** to create a radioactive trace log.

Step 6 Click the radio button to set the time interval.

Step 7 Click the **Download Logs** icon that is displayed next to the trace file name, to download the logs to your local folder.

Step 8 Click the **View Logs** icon that is displayed next to the trace file name, to view the log files on the GUI page.

Step 9 Click **Load More** to view more lines of the log file. Click **Apply to Device**.

Configure conditional debugging (CLI)

Enable targeted troubleshooting for wireless features by filtering debug output to specific APs, clients, or IP addresses using commands.

Procedure

Step 1 Configure conditional debugging for a feature using the specified MAC address.

Example:

```
Device# debug platform condition feature wireless mac b838.61a1.5433
```

Note
This is supported with AP or client MAC/IP and also on CMX IP address and mobility peer IP.

Step 2 Start conditional debugging.

Example:

```
Device# debug platform condition start
```

This starts radioactive tracing if there is a match on one of the conditions above.

Note
This is supported with AP or client MAC/IP and also on CMX IP address and mobility peer IP.

Step 3 Display the current conditions set.

Example:

```
Device# show platform condition
```

```
Device# show debugging
```

Step 4 Stop conditional debugging.

Example:

```
Device# debug platform condition stop
```

This will stop radioactive tracing.

Note
This is supported with AP or client MAC/IP and also on CMX IP address and mobility peer IP.

Step 5 Display the logs from the latest wireless profile.

Example:

```
Device# show logging profile wireless [ counter start last {20 minutes} | filter mac
{mac-address}  to-file bootflash:logs.txt]
```

Note

You can use either the **show logging profile wireless** command or **show logging process** command to collect the logs.

Step 6 Display the logs collection specific to the process.

Example:

```
Device# show logging process wncd to-file flash:wncd.txt
```

Step 7 Clear all conditions.

Example:

```
Device# clear platform condition all
```

What to do next

The command **request platform software trace filter-binary wireless** *mac-address* generates 3 flash files:

- collated_log_<.date..>
- mac_log <..date..>
- mac_database .. file

The *mac_log <..date..>* file is the most important because it contains messages related to the MAC address under investigation. The **show platform software trace filter-binary** command generates the same flash files and displays the mac_log on the screen.

Recommended workflow for trace files

The recommended workflow for trace files is listed below:

- To request the tracelogs for a specific time period, such as 1 day, use the command: Device# **show logging process wncd to-file flash:wncd.txt**.
- The system generates a text file of the tracelogs in the location /flash:
- Copy the file off the device so the tracelogs can be used to work offline. For more details on copying files, see section below.
- Delete the tracelog file (.txt) from the /flash: location to ensure enough space on the device for other operations.

Copy tracefiles off the box

This is an example of the tracefile:

```
Device# dir flash:/tracelogs
Directory of crashinfo:/tracelogs/
50664 -rwx 760 Sep 22 2015 11:12:21 +00:00 plogd_F0-0.bin_0.gz
50603 -rwx 991 Sep 22 2015 11:12:08 +00:00 fed_pmanlog_F0-0.bin_0.9558.20150922111208.gz
```

```
50610 -rw- 11 Nov 2 2015 00:15:59 +00:00 timestamp
50611 -rwx 1443 Sep 22 2015 11:11:31 +00:00
auto_upgrade_client_sh_pmanlog_R0-.bin_0.3817.20150922111130.gz
50669 -rwx 589 Sep 30 2015 03:59:04 +00:00 cfgwr-8021_R0-0.bin_0.gz
50612 -rwx 1136 Sep 22 2015 11:11:46 +00:00 reflector_803_R0-0.bin_0.1312.20150922111116.gz

               50794 -rwx 4239 Nov 2 2015 00:04:32 +00:00
IOSRP_R0-0.bin_0.14239.20151101234827.gz
50615 -rwx 131072 Nov 2 2015 00:19:59 +00:00 linux_iosd_image_pmanlog_R0-0.bin_0
```

The trace files can be copied using one of the various options shown below:

```
Device# copy flash:/tracelogs ?
  crashinfo: Copy to crashinfo: file system
  flash: Copy to flash: file system
  ftp: Copy to ftp: file system
  http: Copy to http: file system
  https: Copy to https: file system
  null: Copy to null: file system
  nvram: Copy to nvram: file system
  rcp: Copy to rcp: file system
  running-config Update (merge with) current system configuration
  scp: Copy to scp: file system
  startup-config Copy to startup configuration
  syslog: Copy to syslog: file system
  system: Copy to system: file system
  tftp: Copy to tftp: file system
  tmpsys: Copy to tmpsys: file system
```

The general syntax for copying onto a TFTP server is as follows:

```
Device# copy source: tftp:
Device# copy crashinfo:/tracelogs/IOSRP_R0-0.bin_0.14239.20151101234827.gz tftp:
Address or name of remote host []? 2.2.2.2
Destination filename [IOSRP_R0-0.bin_0.14239.20151101234827.gz]?
```

Note Clear the generated report and archive files from the switch to ensure that sufficient flash space remains available for tracelog and other uses.

Configuration examples for conditional debugging

This is an output example of the **show platform condition** command.

```
Device# show platform condition
Conditional Debug Global State: Stop
Conditions Direction
------------------------------------------------------------------------------------------|---------
MAC Address 0024.D7C7.0054 N/A
Feature Condition Type Value
----------------------|----------------------|--------------------------------
```

This is an output example of the **show debug** command.

```
Device# show debug
IOSXE Conditional Debug Configs:
Conditional Debug Global State: Start
```

```
Conditions Direction
-------------------------------------------------------------------------------------------------|---------
MAC Address 0024.D7C7.0054 N/A
Feature Condition Type Value
----------------------|----------------------|--------------------------------
Packet Infra debugs:
Ip Address Port
-------------------------------------------------------|----------
```

Verify conditional debugging

The table shown below lists the various commands that can be used to verify conditional debugging:

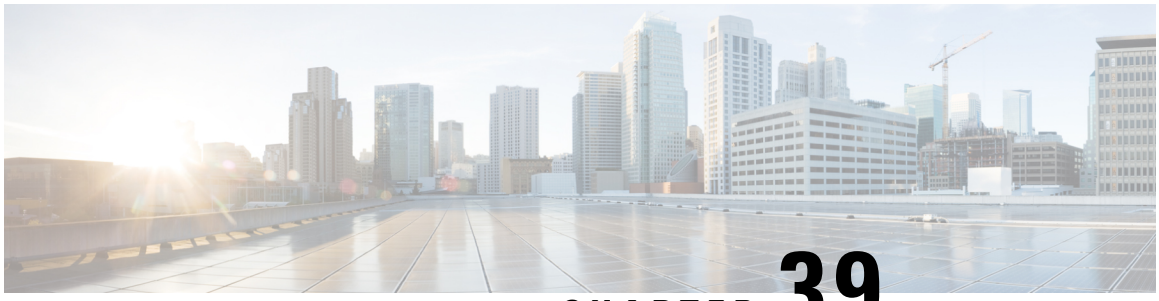
Command	Purpose
show platform condition	Displays the current conditions set.
show debug	Displays the current debug conditions set.
show platform software trace filter-binary	Displays logs merged from the latest tracefile.
request platform software trace filter-binary	Displays historical logs of merged tracefiles on the system.

Example: verify radioactive tracing log for SISF

This is an output example of the **show platform software trace message ios chassis active R0 | inc sisf** command.

```
Device# show platform software trace message ios chassis active R0 | inc sisf
2017/10/26 13:46:22.104 {IOSRP_R0-0}{1}: [parser]: [5437]:  UUID: 0, ra: 0 (note):  CMD:
'show platform software trace message ios switch active R0 | inc sisf' 13:46:22 UTC Thu Oct
 26 2017
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
   FF8E802918 semaphore system unlocked
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Unlocking, count is now 0
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
   FF8E802918 semaphore system unlocked
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Unlocking, count is now 1
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Gi1/0/5 vlan 10 aaaa.bbbb.cccc Setting State to 2
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Gi1/0/5 vlan 10 aaaa.bbbb.cccc Start timer 0
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Gi1/0/5 vlan 10 aaaa.bbbb.cccc  Timer value/granularity for 0 :299998/1000
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Gi1/0/5 vlan 10 aaaa.bbbb.cccc Updated Mac Timer : 299998
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Gi1/0/5 vlan 10 aaaa.bbbb.cccc Before Timer :  350000
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Gi1/0/5 vlan 10 aaaa.bbbb.cccc Timer 0, default value is 350000
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
   Allocating timer wheel for 0
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Gi1/0/5 vlan 10 aaaa.bbbb.cccc No timer running
```

```
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Granularity for timer MAC_T1  is 1000
2017/10/26 13:46:10.667 {IOSRP_R0-0}{1}: [sisf]: [5437]:  UUID: 4800000000060, ra: 7 (debug):
  Gi1/0/5 vlan 10 aaaa.bbbb.cccc Current State :MAC-STALE, Req Timer : MAC_T1  Current Timer
 MAC_T1
```



CHAPTER 39

Aggressive Client Load Balancing

- Aggressive client load balancing, on page 315
- Guidelines of aggressive client load balancing, on page 315
- Restrictions of aggressive client load balancing, on page 316
- Enable aggressive client load balancing (GUI), on page 316
- Configure aggressive client load balancing (GUI), on page 316
- Configure aggressive client load balancing (CLI), on page 317

Aggressive client load balancing

Aggressive client load balancing is a wireless network feature that

- distributes wireless clients across lightweight APs managed by the same controller
- redirects client association attempts from overutilized APs to less busy APs using standardized response codes, and
- helps optimize overall network performance by preventing AP overload.

Guidelines of aggressive client load balancing

When a wireless client attempts to associate to a lightweight AP, the associated response packets are sent to a client with an 802.11 response packet including status code 17. This code 17 indicates that the corresponding AP is busy. The AP does not respond with 'success' if the AP threshold is not met. If the AP utilization threshold is exceeded and another less busy AP hears the client request, the AP responds with code 17 (AP busy).

If AP1 has more clients than AP2 during the load-balancing window, AP1 is considered busier. When a client attempts to associate to AP1, the client receives an 802.11 response packet with status code 17, indicating that the AP is busy, and the client attempts to associate to a different AP.

Configure the embedded wireless controller to deny client associations up to 10 times. If a client tries to connect 11 times, it will connect on the 11th attempt. Enable or disable load balancing on a particular WLAN. This option is helpful if you need to exclude time-sensitive voice clients from load balancing.

Note For a FlexConnect AP, the association is locally handled. The controller makes load-balancing decisions. A FlexConnect AP sends an initial response to the client before knowing the result of the calculations in the controller. Load balancing does not work when the FlexConnect AP is in standalone mode.

In this mode, the FlexConnect AP does not send a (re)association response with status 17 for load balancing. Instead, it first sends a (re)association response with status zero (success), and then sends a deauthentication with reason five.

Restrictions of aggressive client load balancing

- This feature is not supported on the APs joined on default-site-tag.
- This feature is not supported on the APs across different named site-tags.
- This feature is supported only on the APs within a named-site-tag.

Enable aggressive client load balancing (GUI)

Ensure clients are evenly distributed across APs to maximize WLAN performance using GUI.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **WLANs** > **Wireless Networks**.

Step 2 Select a **WLAN** to view the **Edit WLAN** window.

Step 3 Click on the **Advanced** tab.

Step 4 Check the **Load Balance** check box to enable the feature.

Step 5 Click **Update & Apply to Device**.

Configure aggressive client load balancing (GUI)

Set the number of clients and denial count for aggressive load balancing to optimize wireless network performance using GUI.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Advanced**.

The **Load Balancing** window appears.

Step 2 In the **Aggressive Load Balancing Window (clients)** field, enter the number of clients for the aggressive load balancing client window.

Step 3 In the **Aggressive Load Balancing Denial Count** field, enter the load balancing denial count.

Step 4 Click **Apply**.

Configure aggressive client load balancing (CLI)

Configure aggressive client load balancing to optimize WLAN performance and distribute clients across APs using commands.

Procedure

Step 1 Enter the global configuration mode and specify the WLAN name.

Example:

```
Device# configure terminal
Device(config)# wlan test-wlan
```

Step 2 Disable the WLAN.

Example:

```
Device(config-wlan)# shutdown
```

Step 3 Configure a guest embedded wireless controller as mobility controller, in order to enable client load balance to a particular WLAN.

Example:

```
Device(config-wlan)# load-balance
```

Configure the WLAN security settings as the WLAN requirements.

Step 4 Enable WLAN.

Example:

```
Device(config-wlan)# no shutdown
```

Step 5 Return to the privileged EXEC mode and enter the global configuration mode.

Example:

```
Device(config)# end
Device(config)# configure terminal
```

Step 6 Configure the load balancing denial count.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} load-balancing denial 10
```

Step 7 Configure the number of clients for the aggressive load balancing client window.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} load-balancing window 10
```

Step 8 Return to the privileged EXEC mode.

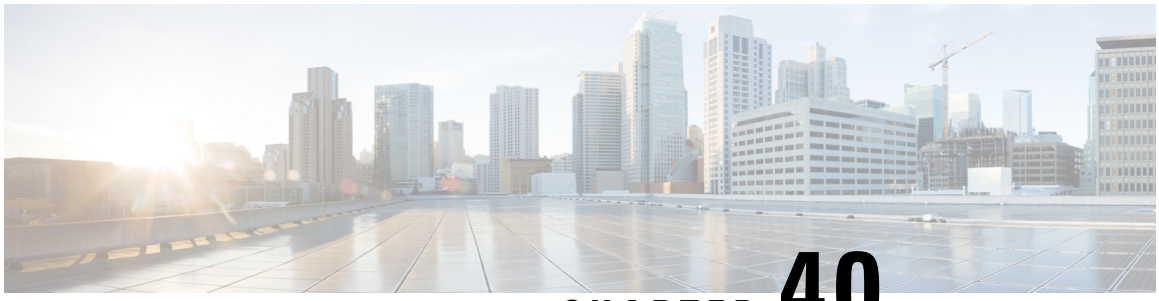
Example:

```
Device(config-wlan)# end
```

Step 9 Display a filtered section of the current configuration.

Example:

```
Device# show running-config | section test-wlan
```



CHAPTER 40

Accounting Identity List

- Configure accounting identity list (GUI), on page 319
- Configure accounting identity list (CLI), on page 319
- Configure client accounting (GUI), on page 320
- Configure client accounting (CLI), on page 320

Configure accounting identity list (GUI)

Create a method list for accounting identity using the GUI to control and monitor user access to your network.

Procedure

Step 1	Choose **Configuration** > **Security** > **AAA**.
Step 2	In the **AAA Method List** tab, go to the **Accounting** section, and click **Add**.
Step 3	In the **Quick Setup: AAA Accounting** window that is displayed, enter a name for your method list.
Step 4	Select the type of authentication as identity, in the **Type** drop-down list.
Step 5	Choose the server groups you want to use to authenticate access to your network, from the **Available Server Groups** list and click > icon to move them to the **Assigned Server Groups** list.
Step 6	Click **Save & Apply to Device**.

Configure accounting identity list (CLI)

Enable RADIUS accounting with an identity list to log user actions and network usage events using commands.

When a user successfully executes an action, the RADIUS accounting server logs the changed attributes, user ID, remote host, date and time of execution, authorization level, description of the action performed, and values provided.

Follow the procedure given below to configure accounting identity list.

Before you begin

Configure the RADIUS server and AAA group server.

Procedure

Enable accounting to send a start-record accounting notice when a client is authorized and a stop-record at the end.

Example:

```
Device(config)# aaa accounting identity user1 start-stop group aaa-test
```

Note
You can also use the default list, instead of a named list.

Configure client accounting (GUI)

Enable client accounting on a specified policy profile through the GUI.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 Click the **Policy Profile Name**. In the **Edit Policy Profile** window, go to the **Advanced** tab.

Step 3 From the **Accounting List** drop-down, select the appropriate accounting list for this policy profile. The policy profile uses the accounting type you selected before gaining access to the network.

Step 4 Click **Save & Apply to Device**.

Configure client accounting (CLI)

Enable client accounting on a WLAN policy profile to track user activity and support auditing with an accounting server using commands.

Procedure

Step 1 Configure WLAN policy profile and enter the wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy default-policy-profile
```

Step 2 Disable the policy profile.

Example:

```
Device(config-wireless-policy)# shutdown
```

Step 3 Set the accounting list.

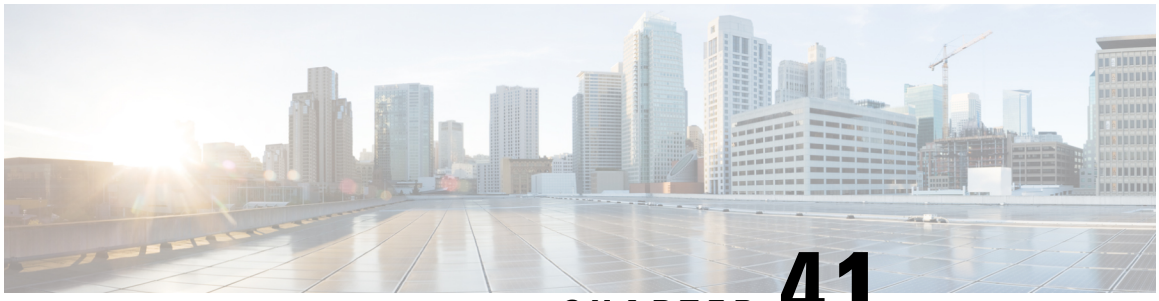
Example:

```
Device(config-wireless-policy)# accounting-list user1
```

Step 4 Enable the policy profile.

Example:

```
Device(config-wireless-policy)# no shutdown
```



CHAPTER 41

Volume metering

A volume metering feature is an access point data reporting capability that

- allows you to set the interval for client accounting statistics updates from the access point (AP) to the network controller,
- supports configurable reporting frequencies from five to 90 seconds, and
- helps minimize delays in updating usage data for connected devices.

Additional information

By default, the access point sends client accounting updates to the controller every 90 seconds, which then forwards this information to the RADIUS server. With volume metering features, you can adjust the reporting interval from five seconds to 90 seconds.

This flexibility enables network administrators to better control the timeliness of usage data, ensuring more immediate reporting and improved network accounting accuracy.

Example

If you want to decrease the delay in receiving accounting data for a device, you can configure the reporting interval to 10 seconds so that the access point sends updates to the controller—and subsequently to the RADIUS server—much more frequently than the default 90 seconds.

This supports more accurate, real-time accounting of network usage.

• Configure volume metering (CLI), on page 323

Configure volume metering (CLI)

Configure device parameters to control how often the system reports wireless usage data and sends accounting updates to the Remote Authentication Dial-In User Service (RADIUS) server.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an access point (AP) profile and enter AP profile configuration mode.

Example:

```
Device(config)# ap profile profile-name
```

Step 3 Configure the 2.4 GHz (802.11ax) reporting interval.

Example:

```
Device(config-ap-profile)# dot11 24ghz reporting-interval reporting-interval
```

Step 4 Configure the 5 GHz (802.11ax) reporting interval.

Example:

```
Device(config-ap-profile)# dot11 5ghz reporting-interval reporting-interval
```

Step 5 Return to global configuration mode.

Example:

```
Device(config-ap-profile)# exit
```

Step 6 Set the time interval (in minutes) at which the embedded wireless controller sends interim accounting updates for the client to the RADIUS server.

Example:

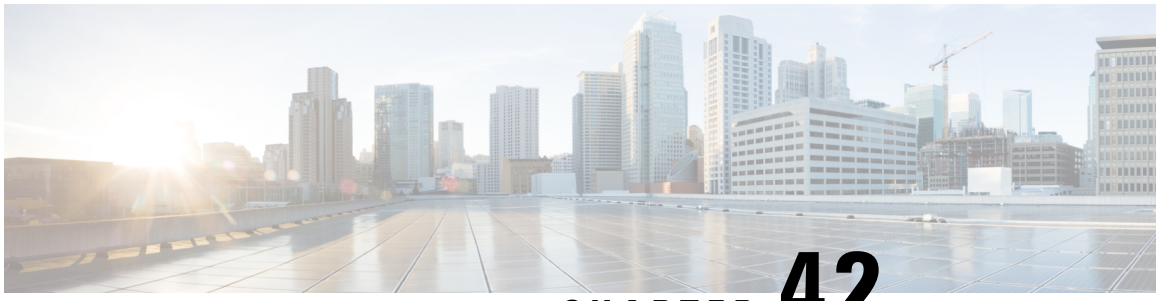
```
Device(config)# aaa accounting update periodic interval-in-minutes
```

Step 7 Exit configuration mode and return to privileged EXEC mode.

Example:

```
Device(config)# exit
```

The device reports volume metering data at your specified intervals and sends accounting updates to the RADIUS server.



CHAPTER 42

AP Group NTP Server

- Feature History for AP Group NTP Server, on page 325
- AP group NTP server, on page 325
- Configure an AP group NTP server (CLI), on page 326
- Configure AP timezone (CLI), on page 327
- Verify Cisco Hyperlocation, on page 327

Feature History for AP Group NTP Server

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

This feature is available in all the releases subsequent to the one in which it is introduced in, unless noted otherwise.

Table 22: Feature History for AP Group NTP Server

Release	Feature	Feature Information
Cisco IOS XE Bengaluru 17.6.1	AP Group NTP Server	From this release, the global NTP server configuration is replaced with the per-AP group NTP server configuration. Now, you cannot configure the Cisco Hyperlocation feature without the per-AP group NTP server.

AP group NTP server

An AP group NTP server is a time synchronization mechanism that

- ensures precise time alignment across all APs within an AP group to achieve location accuracy
- reduces synchronization delays compared to using a WAN-based global NTP server, and
- supports features that rely on accurate timing, such as Cisco Hyperlocation, BLE AoA, and Intelligent Capture.

If your controller and global NTP server are configured on the WAN, the APs may experience significant synchronization delays. These delays can reduce location accuracy.

When all APs in a group synchronize with the same NTP server, you can obtain accurate data for location calculations. Configure the NTP server locally for all APs in an AP group to improve synchronization among the APs.

Feature history

This table provides release and related information about the feature explained in this section.

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 23: Feature history for AP group NTP server

Feature Name	Release Information	Feature Description
AP group NTP server	Cisco IOS XE 17.6.1	From this release, the global NTP server configuration is replaced with per-AP-group NTP server configuration. Per-group NTP is now required for the Cisco Hyperlocation feature. These commands are introduced: • ntpauth-key • timezonedelta • timezoneuse-controller • showap name ntp status • showap ntp status • showap timezone

Configure an AP group NTP server (CLI)

Set a Network Time Protocol (NTP) server for AP groups to ensure time synchronization.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an AP profile and enter the AP profile configuration mode.

Example:

```
Device(config)# ap profile profile-name
```

Step 3 Set the IP address of the NTP server.

Example:

```
Device(config-ap-profile)# [no] ntp ip 9.0.0.4
```

The **no** form of this command removes the NTP server.

Configure AP timezone (CLI)

Set the correct timezone for APs to ensure accurate time-stamping and scheduling using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the AP profile and enter the AP profile configuration mode.

Example:

```
Device(config)# ap profile test
```

Step 3 Configure the timezone offset for AP.

Example:

```
Device(config-ap-profile)# timezone {use-controller | delta hour -12 | minute 2}
```

You can configure the AP timezone for each AP profile only. It is not possible to configure the timezone for individual APs.

To configure the timezone, you can either apply the current controller timezone or specify the time difference. By default, timezone is disabled.

Verify Cisco Hyperlocation

To display the hyperlocation status values and parameters for all the AP profiles, use this command:

```
Device# show ap hyperlocation summary

Profile Name: custom-profile
Hyperlocation operational status: Down
Reason: Hyperlocation is administratively disabled
Hyperlocation NTP server: 209.165.200.224
Hyperlocation admin status: Disabled
Hyperlocation detection threshold (dBm): -100
Hyperlocation trigger threshold: 10
Hyperlocation reset threshold: 8
Profile Name: default-ap-profile
Hyperlocation operational status: Up
Reason: N/A
```

```
Hyperlocation NTP server: 209.165.200.224
Hyperlocation admin status: Enabled
Hyperlocation detection threshold (dBm): -90
Hyperlocation trigger threshold: 22
Hyperlocation reset threshold: 8
```

To display both the overall and the per-AP configuration values and operational status, use this command:

```
Device# show ap hyperlocation detail

Profile Name: house24
Hyperlocation operational status: Up
 Reason: NTP server is not properly configured
Hyperlocation NTP server: 198.51.100.1
Hyperlocation admin status: Enabled
Hyperlocation detection threshold (dBm): -90
Hyperlocation trigger threshold: 8
Hyperlocation reset threshold: 7
AP Name                 Radio MAC         Method      CMX IP             AP Profile
-------------------------------------------------------------------------------------------
APe865.49d9.bfe0        e865.49ea.a4b0    WSM2+Ant    198.51.100.2        house24

APa89d.21b9.69d0        a89d.21b9.69d0    Local       198.51.100.3        house24

APe4aa.5d3f.d750        e4aa.5d5f.3630    WSM         198.51.100.4        house24
```

To display the overall (profile specific) configuration values and operational status for a given profile, use this command:

```
Device# show ap profile profile-name hyperlocation summary

Profile Name:
               profile-name
Hyperlocation operational status: Up
   Reason: N/A
Hyperlocation NTP server: 209.165.200.224
Hyperlocation admin status: Enabled
Hyperlocation detection threshold (dBm): -100
Hyperlocation trigger threshold: 10
Hyperlocation reset threshold: 8
```

To display both the overall (profile specific) and per-AP configuration values and operational status for a given profile, use this command. The APs listed are only those APs that belong to the specified join profile.

```
Device# show ap profile profile-name hyperlocation detail

Profile Name:
               profile-name
Hyperlocation operational status: Up
 Reason: N/A
Hyperlocation NTP server: 209.165.200.224
Hyperlocation admin status: Enabled
Hyperlocation detection threshold (dBm): -90
Hyperlocation trigger threshold: 8
Hyperlocation reset threshold: 7
AP Name                 Radio MAC         Method      CMX IP
-----------------------------------------------------------------
APf07f.0635.2d40        f07f.0635.2d40    WSM2+Ant    198.51.100.2
APf07f.0635.2d41        f07f.0635.2d41    Local       198.51.100.3
APf07f.0635.2d42        f07f.0635.2d42    WSM         198.51.100.4
```

To display configuration values for an AP profile, use this command:

```
Device# show ap profile profile-name detailed
```

```
Hyperlocation :
  Admin State             : ENABLED
  PAK RSSI Threshold Detection: -100
  PAK RSSI Threshold Trigger  : 10
  PAK RSSI Threshold Reset    : 8
.
.
.
```

To display the Cisco CMXs that are correctly joined and used by hyperlocation, use this command:

```
Device# show ap hyperlocation cmx summary

Hyperlocation-enabled CMXs
IP            Port Dest MAC        Egress src MAC Egress VLAN Ingress src MAC Join time

-------------------------------------------------------------------------------------------------
198.51.100.4  2003 aaaa.bbbb.cccc  aabb.ccdd.eeff 2           0000.0001.0001  12/14/18
09:27:14
```

To display the hyperlocation client statistics, use this command:

```
Device# show platform hardware chassis active qfp feature wireless wlclient cpp-client
summary

Client Type Abbreviations:
  RG - REGULAR BL - BLE
  HL - HALO    LI - LWFL INT
Auth State Abbreviations:
  UK - UNKNOWN IP - LEARN IP IV - INVALID
  L3 - L3 AUTH RN - RUN
Mobility State Abbreviations:
  UK - UNKNOWN IN - INIT
  LC - LOCAL   AN - ANCHOR
  FR - FOREIGN MT - MTE
  IV - INVALID
EoGRE Abbreviations:
  N - NON EOGRE Y - EOGRE
 CPP IF_H     DPIDX      MAC Address    VLAN  CT  MCVL  AS  MS  E  WLAN POA
-------------------------------------------------------------------------------
   0X32     0XF0000001  0000.0001.0001   9    HL   0    RN  LC  N       NULL
```

To display the interface handle value statistics, use this command:

```
Device# show platform hardware chassis active qfp feature wireless wlclient datapath
cpp-if-handle 0x32 statistics start
```

To display the recorded flow, use this command:

```
Device# show platform hardware chassis active qfp feature wireless wlclient datapath
cpp-if-handle 0X32 statistics

                   Pkts               Bytes
Rx                  26                3628
```

To stop statistics capture, use this command:

```
Device# show platform hardware chassis active qfp feature wireless wlclient datapath
cpp-if-handle 0x32 statistics stop
```

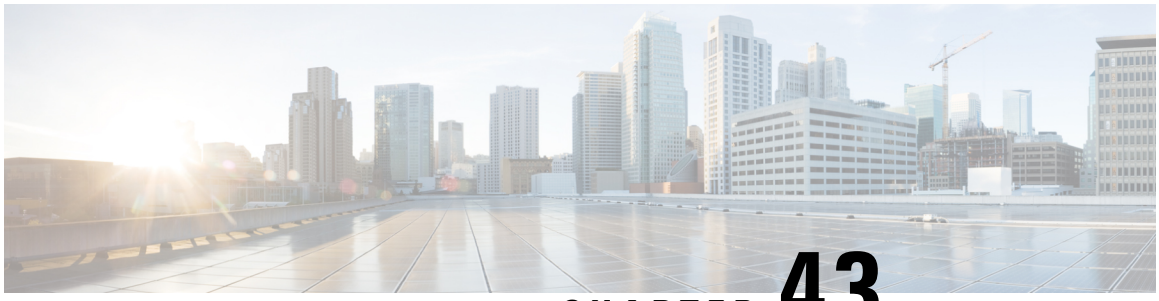
To display the APs requested by Cisco CMX with AP group support, use this command:

```
Device# show nmsp subscription group summary

CMX IP address: 198.51.100.4
  Groups subscribed by this CMX server:
  Group name: CMX_1198.51.100.4
```

```
Device# show nmsp subscription group detail ap-list CMX_198.51.100.1 198.51.100.1

CMX IP address: 198.51.100.1
CMX Group name: CMX_198.51.100.1
CMX Group AP MACs:
: aa:bb:cc:dd:ee:01 aa:bb:cc:dd:ee:02 aa:bb:cc:dd:ee:03 aa:bb:cc:dd:ee:03
```



CHAPTER 43

Enabling Syslog Messages in Access Points and Controller for Syslog Server

- Syslog messages in access points and controllers, on page 331
- AP logging to the in-memory buffer and flash, on page 334

Syslog messages in access points and controllers

A syslog message in access points and controllers is a log communication that

- captures and records operational events generated by each device
- is routed to various destinations, including memory buffers, terminal sessions, device storage, or external syslog servers, and
- allows administrators to configure logging independently on access points and controllers to meet specific network requirements.

Configuring message logging in the IOS XE controller

System Message Logging in Cisco Catalyst 9800 Series Controllers is a platform-independent IOS and IOS XE feature. For more details, see:

- System Message Logging
- Configuration Logger Persistency chapter in *System Management Configuration Guide*
- Logging to Local Nonvolatile Storage chapter in *System Management Configuration Guide*
- Embedded Syslog Manager (ESM) chapter in *System Management Configuration Guide*
- Configuration Change Notification and Logging chapter in *System Management Configuration Guide*

Configure the syslog server for the controller (GUI)

Enable centralized log management by forwarding controller system logs to a designated syslog server through the controller GUI.

Procedure

Step 1 Choose **Troubleshooting** > **Logs**.

Step 2 Click **Manage Syslog Servers**.

Step 3 In **Log Level Settings**, from the **Syslog** drop-down list, choose a severity level.

Step 4 From the **Message Console** drop-down list, choose a logging level.

Step 5 In **Message Buffer Configuration**, from the **Level** drop-down list, choose a server logging level.

Step 6 In **IP Configuration** settings, click **Add**.

Step 7 From the **Server Type** drop-down list, choose **IPv4**, **IPv6**, or **FQDN**.

Step 8 If you choose **IPv4** or **IPv6**, enter the **Server Address**. If you choose **FQDN**, enter the **Host Name**. Then choose the IP type and the appropriate **VRF Name** from the drop-down lists.

To delete a syslog server, click **x** next to the appropriate server entry under the **Remove** column.

Note
Spaces are not allowed in the host name.

Step 9 Click **Apply to Device**.

Note
When you click **Apply to Device**, the system applies the changes. If you click **Cancel**, the system discards the changes.

After you apply the configuration, log messages are forwarded to the specified syslog server.

Configure a syslog server for a controller (CLI)

Configure the controller to send system and event messages to a remote syslog server for monitoring.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enter the syslog server IP address and configure its parameters.

Example:

```
Device(config)# logging hostname ipv6
```

Step 3 Enable the facility parameter for syslog messages.

Example:

```
Device(config)# logging facility {auth | cron | daemon | kern | local0 | local1 | local2 |
 local3 | local4 | local5 | local6 | local7 | lpr | mail | news | sys10 | sys11 | sys12 |
sys13 | sys14 | sys9 | syslog | user | uucp}
```

Example:

```
Device(config)# logging facility syslog
```

You can enable these facility parameters for syslog messages:

- **auth** Authorization system.
- **cron** Cron facility.
- **daemon** System daemons.
- **kern** Kernel.
- **local0** to **local7** Local use.
- **lpr** Line printer system.
- **mail** Mail system.
- **news** USENET news.
- **sys10** to **sys14** and **sys9** System use.
- **syslog** Syslog itself.
- **user** User process.
- **uucp** Unix-to-Unix copy system.

Step 4 Set the logging level for the syslog server.

Example:

```
Device(config)# logging trap {severity-level | alerts | critical | debugging | emergencies
 | errors | informational | notifications | warnings}
```

Example:

```
Device(config)# logging trap 2
```

severity-level Refers to the logging severity level. The valid range is from zero to seven.

These are the syslog server logging levels:

- **emergencies** Signifies severity 0. The system is not usable.
- **alerts** Signifies severity 1. Immediate action is required.
- **critical** Signifies severity 2. Critical conditions.
- **errors** Signifies severity 3. Error conditions.
- **warnings** Signifies severity 4. Warning conditions.
- **notifications** Signifies severity 5. Normal but significant conditions.
- **informational** Signifies severity 6. Informational messages.
- **debugging** Signifies severity 7. Debugging messages.

Note
Select a syslog level to view the supported levels. Selecting a level also enables all lower levels.

If you enable the *critical* syslog level, the system also enables lower levels—*alerts* and *emergencies*.

Step 5 Enter privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, press **Ctrl-Z** to exit global configuration mode.

The controller now forwards syslog messages to the specified syslog server as configured.

AP logging to the in-memory buffer and flash

AP always log messages to an in-memory buffer. Once the buffer reaches 40 KB, its contents are automatically written to flash memory, and a new buffer is created.

Administrators can manage and view these logs using AP commands.

- **show logging** command to display the contents of the in-memory logging buffer
- **show flash syslogs** command to list all log files stored in flash, along with other diagnostic files
- **<filename>** command to display the contents of an individual log file stored in flash
- **copy syslogs <filename>** command to transfer a specific syslog file to an external server. To see available options for this command, use **copy syslogs <filename>**

AP logging to terminal

Access points support real-time logging of messages to an active SSH terminal session, which can be enabled or disabled using the **terminal monitor** and **terminal monitor disable** commands.

Administrators can enable real-time logging to an SSH terminal session using the **terminal monitor** command. To disable real-time logging to the session, use the **terminal monitor disable** command. In addition to SSH terminal sessions, APs send a subset of log messages to the serial console, providing another method for real-time monitoring.

Configure AP logging to a syslog server

Use the **syslog** command in the AP join profile to configure the destination IP address for syslog messages and manage which messages are sent based on severity and facility levels.

Configure the syslog host

- Use the **syslog host <IP address>** command to specify the destination IP address for syslog messages.
- By default, the syslog host is **255.255.255.255** , the IPv4 limited broadcast address.

- Configure IP helper addresses on the AP subnet router to forward broadcasts to one or more syslog servers.
- To reset the syslog host to **255.255.255.255** , use either the **default syslog host** or **no syslog host** command.
- To prevent the AP from sending syslog messages entirely, use **syslog host 0.0.0.0** .
- If a subnet contains more than 20 access points, do not log to the broadcast address. This prevents flooding the broadcast domain with log messages. Configure a specific syslog destination IP address.
- If you do not use the AP syslog feature, set the syslog host to **0.0.0.0** by entering the **syslog host 0.0.0.0** command.

Filter messages by severity

- Use the **syslog level <levelname>** command to filter messages based on severity.
- By default, the severity level is **informational** (**severity=6**), which means the system sends all messages except debugging logs to the server.

Filter messages by facility

- Use the **syslog facility <facilityname>** command to filter messages based on the facility code (facility name).
- By default, the facility is **kernel** (**kern** , **code=0**), so the system sends only kernel-related messages.
- To send messages from all facilities, configure the facility as **local7** .
- The configured facility name is included in the facility field of transmitted syslog messages.



Note Most AP log messages use the **kern** facility, while terminal access logs such as SSH and console access use the **auth** facility.

Secured syslog transmission

- Use the **syslog secured** command to enable Transport Layer Security (TLS), as defined in RFC 5425, to transmit syslog messages securely instead of using UDP.
- TLS-based syslog transmission is supported starting with software versions 17.9.6 and 17.12.1 (released in June 2023 and December 2023, respectively).

View syslog settings

To display the current syslog settings for an AP, use the **show capwap client configuration** command.

Configure a syslog server for an AP profile (CLI)

Configure a syslog server for an AP profile.

This ensures access points send system log messages to a specified remote server for central monitoring and troubleshooting.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an AP profile. Then, enter the AP profile configuration mode.

Example:

```
Device(config)# ap profile ap-profile
```

Step 3 Configure the facility parameter used by syslog messages.

Example:

```
Device(config-ap-profile)# syslog facility
```

Step 4 Enter the Syslog server IP address and parameters to define where the AP profile sends log messages.

Example:

```
Device(config-ap-profile)# syslog host ip-address
```

Step 5 Set the syslog server logging level to determine which messages the AP profile sends.

Example:

```
Device(config-ap-profile)# syslog level {alerts | critical | debugging | emergencies |
errors | informational | notifications | warnings}
```

Example:

```
Device(config-ap-profile)# syslog level
```

The syslog server supports these logging levels:

- **emergencies** —Signifies severity 0. Indicates that the system is not usable.
- **alerts** —Signifies severity 1. Indicates that an immediate action is required.
- **critical** —Signifies severity 2. Indicates a critical condition.
- **errors** —Signifies severity 3. Indicates an error condition.
- **warnings** —Signifies severity 4. Indicates a warning condition.
- **notifications** —Signifies severity 5. Indicates normal, but significant, conditions.
- **informational** —Signifies severity 6. Indicates informational messages.
- **debugging** —Signifies severity 7. Indicates debugging messages.

Note
Select a syslog level to enable it and all lower levels.

If you enable the *critical* syslog level, *alerts* and *emergencies* are also enabled.

Step 6 Return to privileged EXEC mode.

Example:

```
Device(config-ap-profile)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

The syslog server is configured for the specified AP profile. APs that use this profile will send log messages with the selected severity levels to the designated remote server.

Configure the AP syslog settings (GUI)

Set up syslog parameters for access points. This enables monitoring and centralized logging of events.

Procedure

Step 1 Choose **Configuration**, then **Tags and Profiles**, then **AP Join**.

Step 2 Select the APs from the AP list.

The **Edit AP Join Profile** window is displayed.

Step 3 Click the **Management** tab.

Step 4 Select the **Device** tab.

Step 5 In the **System Log** section:

a) From the **Facility Value** drop-down list, select a value.
b) Enter the IP address in the **Host IPv4 or IPv6 Address** field.
c) From the **Log Trap Value** drop-down list, select a value.
d) To enable **Secured**, check the box. To disable **Secured**, clear the box.

Step 6 Click **Update and Apply to Device**

The selected APs are updated with the new syslog configuration, enabling centralized logging according to your specified parameters.

Verify syslog server configurations

Verify global syslog server settings for all APs

To view the global syslog server settings for all access points that joins the controller, use this command:

```
Device# show ap config general
Cisco AP Name : APA0F8.4984.5E48
================================================

Cisco AP Identifier : a0f8.4985.d360
Country Code : IN
Regulatory Domain Allowed by Country : 802.11bg:-A 802.11a:-DN
AP Country Code : IN - India
```

```
AP Regulatory Domain
Slot 0 : -A
Slot 1 : -D
MAC Address : a0f8.4984.5e48
IP Address Configuration : DHCP
IP Address : 9.4.172.111
IP Netmask : 255.255.255.0
Gateway IP Address : 9.4.172.1
Fallback IP Address Being Used :
Domain :
Name Server :
CAPWAP Path MTU : 1485
Telnet State : Disabled
SSH State : Disabled
Jumbo MTU Status : Disabled
Cisco AP Location : default location
Site Tag Name : ST1
RF Tag Name : default-rf-tag
Policy Tag Name : PT3
AP join Profile : default-ap-profile
Primary Cisco Controller Name : WLC2
Primary Cisco Controller IP Address : 9.4.172.31
Secondary Cisco Controller Name : Not Configured
Secondary Cisco Controller IP Address : 0.0.0.0
Tertiary Cisco Controller Name : Not Configured
Tertiary Cisco Controller IP Address : 0.0.0.0
Administrative State : Enabled
Operation State : Registered
AP Certificate type : Manufacturer Installed Certificate
AP Mode : Local
AP VLAN tagging state : Disabled
AP VLAN tag : 0
CAPWAP Preferred mode : Not Configured
AP Submode : Not Configured
Office Extend Mode : Disabled
Remote AP Debug : Disabled
Logging Trap Severity Level : notification
Software Version : 16.10.1.24
Boot Version : 1.1.2.4
Mini IOS Version : 0.0.0.0
Stats Reporting Period : 180
LED State : Enabled
PoE Pre-Standard Switch : Disabled
PoE Power Injector MAC Address : Disabled
Power Type/Mode : PoE/Full Power (normal mode)
Number of Slots : 3
AP Model : AIR-AP1852I-D-K9
IOS Version : 16.10.1.24
Reset Button : Disabled
AP Serial Number : KWC212904UB
Management Frame Protection Validation : Disabled
AP User Mode : Automatic
AP User Name : Not Configured
AP 802.1X User Mode : Global
AP 802.1X User Name : Not Configured
Cisco AP System Logging Host : 9.4.172.116
AP Up Time : 11 days 1 hour 15 minutes 52 seconds
AP CAPWAP Up Time : 6 days 3 hours 11 minutes 6 seconds
Join Date and Time : 09/05/2018 04:18:52
Join Taken Time : 3 minutes 1 second
Join Priority : 1
Ethernet Port Duplex : Auto
Ethernet Port Speed : Auto
AP Link Latency : Disable
```

```
AP Lag Configuration Status : Disabled
AP Lag Operational Status : Disabled
Lag Support for AP : Yes
Rogue Detection : Enabled
Rogue Containment auto-rate : Disabled
Rogue Containment of standalone FlexConnect APs : Disabled
Rogue Detection Report Interval : 10
Rogue AP minimum RSSI : -90
Rogue AP minimum transient time : 0
AP TCP MSS Adjust : Enabled
AP TCP MSS Size : 1250
AP IPv6 TCP MSS Adjust : Enabled
AP IPv6 TCP MSS Size : 1250
Hyperlocation Admin Status : Disabled
Retransmit count : 5
Retransmit interval : 3
Fabric status : Disabled
FIPS status : Disabled
WLANCC status : Disabled
USB Module Type : USB Module
USB Module State : Enabled
USB Operational State : Disabled
USB Override : Disabled
Lawful-Interception Admin status : Disabled
Lawful-Interception Oper status : Disabled
```

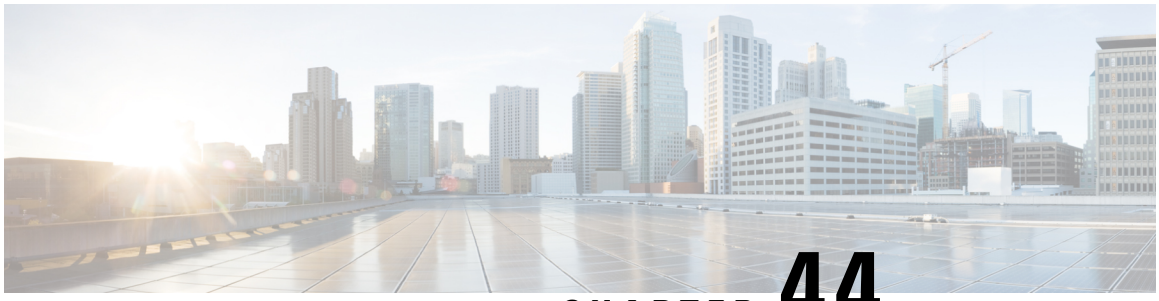
Verify syslog server settings for a specific AP

To view the syslog server settings for a specific access point, use this command:

```
Device# show ap name <ap-name> config general
show ap name APA0F8.4984.5E48 config general
Cisco AP Name : APA0F8.4984.5E48
================================================

Cisco AP Identifier : a0f8.4985.d360
Country Code : IN
Regulatory Domain Allowed by Country : 802.11bg:-A 802.11a:-DN
AP Country Code : IN - India
AP Regulatory Domain
Slot 0 : -A
Slot 1 : -D
MAC Address : a0f8.4984.5e48
IP Address Configuration : DHCP
IP Address : 9.4.172.111
IP Netmask : 255.255.255.0
Gateway IP Address : 9.4.172.1
Fallback IP Address Being Used :
Domain :
Name Server :
CAPWAP Path MTU : 1485
Telnet State : Disabled
SSH State : Disabled
Jumbo MTU Status : Disabled
Cisco AP Location : default location
Site Tag Name : ST1
RF Tag Name : default-rf-tag
Policy Tag Name : PT3
AP join Profile : default-ap-profile
Primary Cisco Controller Name : WLC2
Primary Cisco Controller IP Address : 9.4.172.31
Secondary Cisco Controller Name : Not Configured
Secondary Cisco Controller IP Address : 0.0.0.0
Tertiary Cisco Controller Name : Not Configured
```

```
Tertiary Cisco Controller IP Address : 0.0.0.0
Administrative State : Enabled
Operation State : Registered
AP Certificate type : Manufacturer Installed Certificate
AP Mode : Local
AP VLAN tagging state : Disabled
AP VLAN tag : 0
CAPWAP Preferred mode : Not Configured
AP Submode : Not Configured
Office Extend Mode : Disabled
Remote AP Debug : Disabled
Logging Trap Severity Level : notification
Software Version : 16.10.1.24
Boot Version : 1.1.2.4
Mini IOS Version : 0.0.0.0
Stats Reporting Period : 180
LED State : Enabled
PoE Pre-Standard Switch : Disabled
PoE Power Injector MAC Address : Disabled
Power Type/Mode : PoE/Full Power (normal mode)
Number of Slots : 3
AP Model : AIR-AP1852I-D-K9
IOS Version : 16.10.1.24
Reset Button : Disabled
AP Serial Number : KWC212904UB
Management Frame Protection Validation : Disabled
AP User Mode : Automatic
AP User Name : Not Configured
AP 802.1X User Mode : Global
AP 802.1X User Name : Not Configured
Cisco AP System Logging Host : 9.4.172.116
AP Up Time : 11 days 1 hour 15 minutes 52 seconds
AP CAPWAP Up Time : 6 days 3 hours 11 minutes 6 seconds
Join Date and Time : 09/05/2018 04:18:52
Join Taken Time : 3 minutes 1 second
Join Priority : 1
Ethernet Port Duplex : Auto
Ethernet Port Speed : Auto
AP Link Latency : Disable
AP Lag Configuration Status : Disabled
AP Lag Operational Status : Disabled
Lag Support for AP : Yes
Rogue Detection : Enabled
Rogue Containment auto-rate : Disabled
Rogue Containment of standalone FlexConnect APs : Disabled
Rogue Detection Report Interval : 10
Rogue AP minimum RSSI : -90
Rogue AP minimum transient time : 0
AP TCP MSS Adjust : Enabled
AP TCP MSS Size : 1250
AP IPv6 TCP MSS Adjust : Enabled
AP IPv6 TCP MSS Size : 1250
Hyperlocation Admin Status : Disabled
Retransmit count : 5
Retransmit interval : 3
Fabric status : Disabled
FIPS status : Disabled
WLANCC status : Disabled
USB Module Type : USB Module
USB Module State : Enabled
USB Operational State : Disabled
USB Override : Disabled
Lawful-Interception Admin status : Disabled
Lawful-Interception Oper status : Disabled
```



CHAPTER 44

Software Maintenance Upgrade

- Software maintenance upgrade, on page 341
- Rolling AP upgrade, on page 347
- AP Device Pack (APDP) and AP Service Pack (APSP), on page 350

Software maintenance upgrade

A software maintenance upgrade (SMU) is a software package that

- is installed on a system to provide a patch or a security fix resolution to a released image, and
- is specific to the corresponding platform.

Feature history

This table provides release and related information about the feature explained in this section.

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 24: Feature history for Software maintenance upgrade

Feature Name	Release Information	Feature Description
Software maintenance upgrade	Cisco IOS XE Gibraltar 16.11.1b	This feature provides network administrators with targeted, platform-specific patches and security fixes for released images, applicable either on a per-component basis or for the entire corresponding platform.

A SMU offers significant benefits over classic Cisco IOS software. It lets you address network issues promptly and reduces required testing time and scope. The Cisco IOS XE platform validates SMU compatibility internally and prevents installation of non-compatible SMUs.

All SMUs are also integrated into subsequent Cisco IOS XE software maintenance releases. A SMU is an independent and self-sufficient package without prerequisites or dependencies. You can choose which SMUs to install or uninstall in any order.

Note SMUs are supported only on Extended Maintenance releases and throughout the full lifecycle of the underlying software release.

Note Activate the file using the **install add file** command only from the filesystems of the active device. If you use a file from the standby or member filesystems, the **install add file** command fails.

Note When the SMU file is deleted and the device is rebooted, the device may display an error message such as:

```
--- Starting SMU Add operation ---
Performing SMU_ADD on all members
    FAILED: Improper State./bootflash/<previously-installed-smu-filename>.smu.bin not
present. Please restore file for stability.
Checking status of SMU_ADD on [1/R0]
SMU_ADD: Passed on []. Failed on [1/R0]
Finished SMU Add operation
FAILED: add_activate_commit /bootflash/<tobeinstalled-wlc-smu-filename>.smu.bin Wed Aug 02
 08:30:18 UTC 2023.
```

This error occurs because the previous SMU file was not properly removed from the controller. As a result, you may not be able to install new SMU or APSP files.

Use the **install remove file** command to remove previous instances of APSP or SMU files from the bootflash.

You can use SMU infrastructure to meet these requirements in wireless contexts:

- Controller SMU: Embedded Wireless Controller bug fixes or Cisco Product Security Incident Response information (PSIRT).
- These fixes or features do not require any changes to the embedded wireless controller.
- APDP: APDP supports new AP models without introducing new hardware or software capabilities.

Note The **show ap image** command displays cumulative statistics for AP images in the controller. Clear the statistics using the **clear ap predownload statistics** command, before using the **show ap image** command, to ensure correct data is displayed.

SMU Workflow

Begin the SMU process by requesting approval from the SMU committee. Contact customer support to raise an SMU request. During the release, the SMU package is posted on the Cisco Software Download page. You can then download and install it.

Warning: Commit changes within six hours of activation or deactivation to avoid rollback

Always run the **install commit** command within 6 hours after executing either **install activate** or **install deactivate** .

If you do not commit changes within this window

- the system automatically reverts to the previous commit state
- this reversion can lead to service interruption, especially over low-bandwidth links where image transfers may not complete in time, and
- remote deployments with slow transfer rates are particularly vulnerable.

To reduce these risks

- run **install commit** after activation or deactivation
- monitor image transfer progress proactively, and
- plan for available bandwidth and duration at remote sites.

SMU Package

An SMU package contains the metadata and the fix for the reported issue that prompted the request.

SMU Reload

The SMU type describes the effect to a system after installing the SMU. SMUs can be non-traffic affecting or can result in device restart, reload, or switchover.

Controller hot patching support allows SMU to be effective immediately after activation without reloading the system. Other controller SMUs require a cold reload of the system during activation. A cold reload is the complete reload of the operating system.

This action affects the traffic for the duration of the following two phases:

- The reload of the wireless controller.
- The time it takes for all the access points to rejoin the controller, receive the new image from the controller, and upgrade to the new SMU patch. This reload ensures that all processes are started with the correct libraries and files that are installed as part of the SMU.

After the SMU is committed, the activation changes are persistent across reloads.

Overview of Controller SMUs

The following table describes the SMU types supported in the Cisco Embedded Wireless Controller:

Table 25: Supported SMU Types in the Embedded Wireless Controller

Package Type	Use Case	SMU Type	Supported on EWC
Controller SMU - Cold Patch	Replace impacted binaries, libraries, or subpackages.	Reload	Limited support (Patch size < 20 MB). No support for IOSD.
Controller SMU - Hot Patch	Replace impacted functions.	Nonreload	Yes

Package Type	Use Case	SMU Type	Supported on EWC
APSP	AP fix by replacing the AP image (does not impact the AP running the active controller).	Nonreload	Yes
APSP	AP fix by replacing the AP image (impacts the AP that is running the active controller).	Reload	Yes (EWC specific variation)
APDP	New AP model support without upgrading the controller.	Nonreload	Yes

Managing Controller Hot or Cold SMU Package

Procedure

	Command or Action	Purpose
Step 1	**install add file tftp:**`//<server-ip>/<path>/<smu-filename>` **Example:** `Device# install add file tftp://<server-ip>/<path>/<smu-filename>`	The `install add` command copies the file from the external server to the backup_image directory on the embedded wireless controller.
Step 2	**install activate file backup_image:** *smu-filename* **Example:** `Device# install activate file backup_image:<smu-filename>`	This command is used to activate the patch. The `install activate` causes the controller reload only for a cold patch. There is no reload for a hot patch.
Step 3	**install auto-abort-timer stop** **Example:** `Device# install auto-abort-timer stop`	(Optional) Stops the auto cancel timer in case of activated or deactivated SMUs.
Step 4	**install commit** **Example:** `Device# install commit`	Commits the activation changes to be persistent across reloads. The commit can be done after activation while the system is up, or after the first reload. If a patch is activated and not committed, the auto cancel timer automatically cancels the activation of the patch in six hours .
Step 5	**show install rollback** **Example:**	Displays the list of rollback IDs that are available.

	Command or Action	Purpose
	`Device# show install rollback`	
Step 6	**install rollback to** {**base** | **committed** | **id** | **label** } *specific-rollback-point* **Example:** `Device# install rollback to base`	Rolls back a committed patch. The committed patch can be deactivated and the commit for deactivation can be done using the single install rollback command.
Step 7	**install deactivate file backup_image:** *smu-filename* **Example:** `Device# install deactivate file backup_image:<Smu-Filename>`	Deactivates a comitted patch. The `install deactivate` command causes the reload of the controller in case of a cold patch. There is no reload of the controller in case of a hot patch.
Step 8	**install auto-abort-timer stop** **Example:** `Device# install auto-abort-timer stop`	(Optional) Stops the auto cancel timer in case of activated or deactivated SMUs.
Step 9	**install commit** **Example:** `Device# install commit`	Commits the deactivation changes to be persistent across reloads.
Step 10	**install remove file backup_image:** *smu-filename* **Example:** `Device# install remove file backup_image:<smu-filename>`	Removes a patch that is in the inactive state. This command also removes the file physically from `backup-image:`
Step 11	**install abort** **Example:** `Device# install abort`	Cancels the upgrade by resetting the APs in rolling fashion.
Step 12	**show install summary** **Example:** `Device# show install summary`	Displays information about the active package. The output of this command varies based on the packages, and the package states that are installed.
Step 13	**show install package backup_image:** *smu-filename* **Example:** `Device# show install package backup-image: <smu_filename>`	Displays information about the SMU package.

Configuration Examples for SMU

The following is sample of the SMU configuration:

Device# install add file tftp://10.1.1.2/auto/tftpboot/user1/ewc/ewc-apsp1.bin

```
install_add: START Tue Jun 4 15:08:26 UTC 2019
Downloading file tftp://10.1.1.2/auto/tftpboot/user1/ewc/ewc-smu.bin
Finished downloading file tftp://10.1.1.2/auto/tftpboot/user1/ewc/ewc-smu.bin to
backup_image:ewc-smu.bin
install_add: Adding SMU
install_add: Checking whether new add is allowed ....
install_add: ap image predownload is allowed.

--- Starting initial file syncing ---
Info: Finished copying backup_image: ewc-smu.bin to the selected chassis
Finished initial file syncing

--- Starting SMU Add operation ---
Performing SMU_ADD on all members
[1] SMU_ADD package(s) on chassis 1
MEWLC response success sync_successCumulative SMU Size: 24 KB
Cumulative size of all SMU's will not exceed 20000 KB
Available Memory in /backup_image is 251480 KB
Available memory 251480 KB is greater than available memory required 2000 KB
[1] Finished SMU_ADD on chassis 1
Checking status of SMU_ADD on [1]
SMU_ADD: Passed on [1]
Finished SMU Add operation

SUCCESS: install_add
```

Device# install activate file backup_image:ewc-apsp1.bin

```
install_activate: START Tue Jun 4 15:18:58 UTC 2019
install_activate: Activating SMU
Cumulative SMU Size: 24 KB
Cumulative size of all SMU's will not exceed 20000 KB
Available Memory in /backup_image is 250984 KB
Available memory 250984 KB is greater than available memory required 2000 KB
MEWLC response success sync_successExecuting pre scripts....
Executing pre sripts done.

--- Starting SMU Activate operation ---
Performing SMU_ACTIVATE on all members
ls: cannot access '/tmp/sw/fp/*/*/*/mount/.pkginfo': No such file or directory
ls: cannot access '/tmp/sw/fp/*/*/*/mount/.pkginfo': No such file or directory
[1] SMU_ACTIVATE package(s) on chassis 1
valid
install_activate: FP fp error skipping. Platform to fix this in Fru List
[1] Finished SMU_ACTIVATE on chassis 1
Checking status of SMU_ACTIVATE on [1]
SMU_ACTIVATE: Passed on [1]
Finished SMU Activate operation

Executing post scripts....
Executing post scripts done.
Executing post scripts....
Executing post scripts done.
SUCCESS: install_activate /backup_image/ewc-apsp1.bin
```

Device#install commit

```
install_commit: START Tue Jun 4 16:15:25 UTC 2019
install_commit: Committing SMU
Executing pre scripts....
install_commit:
Executing pre sripts done.
--- Starting SMU Commit operation ---
Performing SMU_COMMIT on all members
```

```
ls: cannot access '/tmp/sw/fp/*/*/*/mount/.pkginfo': No such file or directory
ls: cannot access '/tmp/sw/fp/*/*/*/mount/.pkginfo': No such file or directory
[1] SMU_COMMIT package(s) on chassis 1
valid
[1] Finished SMU_COMMIT on chassis 1
Checking status of SMU_COMMIT on [1]
SMU_COMMIT: Passed on [1]
Finished SMU Commit operation

Waiting for the platform to set the SMU sync timerSMU sync status is sync_successSMU sync
to AP's success
/tmp/rp/chasfs/wireless/wlc_notify
SUCCESS: install_commit /backup_image/ewc-apsp1.bin
```

Device#install rollback to base

```
install_rollback: START Tue Jun 4 16:42:24 UTC 2019
install_rollback: Rolling back SMU
Executing pre scripts....
install_rollback:
Executing pre sripts done.

--- Starting SMU Rollback operation ---
Performing SMU_ROLLBACK on all members
ls: cannot access '/tmp/sw/fp/*/*/*/mount/.pkginfo': No such file or directory
ls: cannot access '/tmp/sw/fp/*/*/*/mount/.pkginfo': No such file or directory
[1] SMU_ROLLBACK package(s) on chassis 1
[1] Finished SMU_ROLLBACK on chassis 1
Checking status of SMU_ROLLBACK on [1]
SMU_ROLLBACK: Passed on [1]
Finished SMU Rollback operation

Executing post scripts....
Executing post scripts done.
Waiting for the platform to set the SMU sync timerSMU sync status is sync_successSMU sync
to AP's success
/tmp/rp/chasfs/wireless/wlc_notifyExecuting post scripts....
Executing post scripts done.
SUCCESS: install_rollback /backup_image/ewc-apsp1.bin Tue Jun 4 16:43:01 UTC 2019
```

Device# install deactivate file backup_image: ewc-apsp1.bin

install remove file backup_image:ewc-apsp1.bin

Device#show install sum

```
[ Chassis 1 ] Installed Package(s) Information:
State (St): I - Inactive, U - Activated & Uncommitted,
C - Activated & Committed, D - Deactivated & Uncommitted
--------------------------------------------------------------------------------
Type St Filename/Version
--------------------------------------------------------------------------------
APSP C backup_image:ewc-apsp1.bin
IMG C 17.1.1.0.69043

--------------------------------------------------------------------------------
Auto abort timer: inactive
--------------------------------------------------------------------------------
```

Rolling AP upgrade

A rolling AP upgrade is an upgrade method that

- updates APs in staggered batches such that some APs are always up in the network and provide seamless coverage to clients while the other APs are selected to be upgraded, and
- requires preloading the image in advance to ensure that all APs scheduled for upgrade have the new version.

Rolling AP upgrade process

Summary

Rolling AP upgrade is done on a per controller basis. The number of APs to be upgraded at a given time is a percentage of the total number of APs connected to the controller. The percentage is capped at a user configured value. The default percentage is 15. Upgrade all non-client APs before upgrading any client APs.

The key components involved in the process are:

- Controller
- APs
- Clients

Workflow

The process involves the following stages:

1. Candidate AP set selection:

   In this stage, a set of AP candidates is selected based on neighboring AP information. For example, if you identify an AP for upgrade, a certain number (N) of its neighbors are excluded from candidate selection. The N values are generated in the following manner:

   If the user configurable capped percentage is 25%, then N=6 (Expected number of iterations =5)

   If the user configurable capped percentage is 15%, then N=12 (Expected number of iterations=12)

   If the user configurable capped percentage is 5%, then N=24 (Expected number of iterations =22)

   If you cannot select candidates using neighboring AP information, select candidates from indirect neighbors. If this still fails, the AP is upgraded without failure.



Note If you have more candidate APs than the configured percentage allows, remove the extra candidates to maintain the percentage cap.

2. Client steering:

   Move clients connected to candidate APs to other APs before rebooting the candidate APs. Each AP sends a request to its associated clients, providing a list of the best available APs (excluding candidate APs). The system marks candidate APs as unavailable for neighbor lists and resets these markings during the AP rejoin and reload process.

3. AP rejoin and reload process:

After steering clients, if any clients remain connected to the candidate AP, de-authorize those clients and reload the AP so it restarts with a new image. Set a three-minute timer for the APs to rejoin. When the timer expires, check if all candidate APs have joined the controller or mobility peer. If 90% have joined, end the iteration. If not, extend the timer by three minutes and check again. After three attempts, start the next iteration. Each iteration usually lasts about 10 minutes.

You only need to configure the number of APs to upgrade at a time as a percentage of the total APs in the network. The default is 15 percent.

```
Device(config)# ap upgrade staggered {25 | 15 | 5}
```

Verifying AP Upgrade on the Controller

Use the following **show** command to verify the AP upgrade on the controller:

```
Device# show ap upgrade
AP upgrade is in progress

From version: 17.1.0.6
To version: 17.1.0.99

Started at: 06/04/2019 15:19:32 UTC
Configured percentage: 15
Percentage complete: 0
Expected time of completion: 06/04/2019 16:39:32 UTC

Progress Report
---------------
Iterations
----------
Iteration Start time End time AP count
-------------------------------------------------------------------------------------------------------
0 06/04/2019 15:19:33 UTC 06/04/2019 15:19:33 UTC 1
1 06/04/2019 15:19:33 UTC ONGOING 1

Upgraded
--------
Number of APs: 1
AP Name Ethernet MAC Iteration Status Site
-------------------------------------------------------------------------------------------------------
AP7069.5A74.7604 7069.5a78.5580 0 Not Impacted default-site-tag

In Progress
-----------
Number of APs: 1
AP Name Ethernet MAC
-------------------------------------------------
APB4DE.3169.7842 4c77.6dc4.a220

Remaining
---------
Number of APs: 0

AP Name Ethernet MAC
-------------------------------------------------

APs not handled by Rolling AP Upgrade
-------------------------------------
AP Name Ethernet MAC Status Reason for not handling by Rolling AP Upgrade
```

AP Device Pack (APDP) and AP Service Pack (APSP)

APSP and APDP

AP Service Pack (APSP) - APSP rolls out fixes to AP images for one or more AP models. Pre-download the AP images and activate (through rolling upgrade) these images to a subset of AP models.

- Patched APs run a different CAPWAP version than the rest of the APs. For e.g. 17.1.0.100 and 17.1.0.0.
- Per site APSP rollout is not supported. In embedded wireless controller APSP all APs must be in a single default site.

AP Device Pack (APDP) -

Currently, when a new AP hardware model is introduced, those get shipped along with the corresponding embedded wireless controller related major software version. Then you need to wait for the release of a corresponding embedded wireless controller version relative to the new AP model and upgrade the entire network.

APDP allows you introduce the new AP model into your wireless network using the SMU infrastructure without the need to upgrade to the new embedded wireless controller version.

AP Image Changes -

When new AP models are introduced, there may or may not be corresponding new AP images. This means that AP images are mapped to the AP model families. If a new AP model belongs to an existing AP model family then you will have existing AP image entries (Example: ap3g3, ap1g5, and so on). For instance, if an AP model belongs to either ap3g3 or ap1g5, the respective image file is bundled with APDP SMU zip file. The corresponding metadata file is updated with the new AP model capability information including the AP image that it requires.

If a new AP model belongs to a new AP model family, a new image file would be bundled in the APDP SMU zip file. The corresponding metadata file is updated with the new AP model capability information including the AP image that it requires.

Information about APSP and APDP

SMU AP images are not part of the SMU binary, and the AP images are hosted outside the contoller.

- Only SFTP and TFTP methods are supported for SMU AP image download.
- HTTP, HTTP, and CCO methods are not supported for APSP or APDP.

A SMU package contains the metadata that carry AP model and its capability related details.

Note All the zipped files are required in order to successfully proceed with the upgrade. All the contained files in the zip folder are made accessible through the download method.

Following are the pre-requisites for TFTP/SFTP software upgrade:

- A TFTP/SFTP server is reachable from the management IP address of the embedded wireless controller.
- The upgrade bundle with the AP images (ap1g6, ap1g6a, ap1g7, ap3g3, and so on) and the controller image (C9800-AP-iosxe-wlc.bin) that is downloaded from the website is unzipped and copied onto the TFTP/SFTP server.

Managing APSP and APDP

AP images are hosted outside the wireless controller. In the embedded wireless controller, only TFTP or SFTP is supported for SMU AP image download.

Configuring the APSP and APDP Files (GUI)

Follow the steps given below to add APSP or APDP files:

Procedure

Step 1 Choose **Administration** > **Software Management** > **AP Service Package (APSP)** or **AP Device Package (APDP)**.
The **Add an AP Device Package** or **Add an AP Service Package** window is displayed.

Step 2 From the **Transport Type** drop-down list,

- **TFTP**: Specify the **Server IP Address (IPv4/IPv6)**, **File Path**, **File Name**, and **File System**.
- **SFTP**: Specify the **Server IP Address (IPv4/IPv6)**, **Port Number** (Default port number is 22), SFTP username and password, **File Path**, **File Name**, and **File System**.

Step 3 Click **Add File**.

Configuring the TFTP Server Directory

To set up the TFTP server directory, complete the following steps:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device#configure terminal`	Enter the configuration mode.

	Command or Action	Purpose
Step 2	**wireless profile image-download default** **Example:** `Device(config)#wireless profile image-download default`	Configures EWC-AP image download parameters. Use only default as the image download profile name.
Step 3	**image-download-mode** {**tftp** | **sftp**} **Example:** `Device(config-wireless-image-download-profile)#image-download-mode tftp`	Configures image download using TFTP.
Step 4	**tftp-image-path** *tftp-image-path* **Example:** `Device(config-wireless-image-download-profile-tftp)#tftp-image-path /tftpboot/cisco/ewc/`	Configures the TFTP server root directory for the AP images.
Step 5	**tftp-image-server** {**A.B.C.D** | **X:X:X:X::X**} **Example:** `Device(config-wireless-image-download-profile-tftp)#tftp-image-server 5.5.5.5`	Configures the TFTP server address.

What to do next

- Set up the remote server directory: When you receive the complete bundle in a zip file, copy the zip file to a root directory, for example, `/tftpboot/user/ewc`. Example of the complete bundle - `/tftpboot/user/ewc/17.1.zip`.
- Unzip the file. The following are the examples of the files that will be present in the root directory: `ap3g3, ap1g4, C9800-AP-iosxe-wlc.bin`, and so on.

Note When there is an issue and you want to patch an APSP SMU based on the 17.1 patch file `C9800_AP.17_1.22.CSCvr11111.apsp.zip` is pasted in the same root folder, that is, `/tftproot/user/ewc/C9800_AP.17_1.22.CSCvr11111.apsp.zip`. When you unzip the file, a sub-directory, for example, `/tftpboot/user/ewc/17_1.22.CSCvr11111/` is created automatically. The AP images (for example, `ap3g3`) and SMU binary (`apsp_CSCvr11111.bin`) are present in that sub-directory.

Configuring the SFTP Server Directory

To set up the SFTP server directory, complete the following steps:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:**	Enter the configuration mode.

	Command or Action	Purpose
	`Device#configure terminal`	
Step 2	**wireless profile image-download default** **Example:** `Device(config)#wireless profile image-download default`	Configures EWC-AP image download parameters. Use only default as the image download profile name.
Step 3	**image-download-mode** {**tftp** | **sftp**} **Example:** `Device(config-wireless-image-download-profile)#image-download-mode sftp`	Configures image download using SFTP.
Step 4	**sftp-image-path** *sftp-image-path* **Example:** `Device(config-wireless-image-download-profile-sftp)#sftp-image-path /sftpboot/cisco/ewc/`	Configures the SFTP server root directory for the AP images.
Step 5	**sftp-image-server** {**A.B.C.D** | **X:X:X:X::X**} **Example:** `Device(config-wireless-image-download-profile-sftp)#sftp-image-server 5.5.5.5`	Configures the SFTP server address.
Step 6	**sftp-password** {**0** | **8**} *password re-enter password* **Example:** `Device(config-wireless-image-download-profile-sftp)#sftp-password 0 admin`	Configures the SFTP password.
Step 7	**sftp-username** *username* **Example:** `Device(config-wireless-image-download-profile-sftp)#sftp-username admin`	Configures the SFTP username.

What to do next

- Set up the remote server directory: When you receive the complete bundle in a zip file, copy the zip file to a root directory, for example, `/sftpboot/user/ewc`. Example of the complete bundle - `/sftpboot/user/ewc/17.1.zip`.
- Unzip the file. The following are the examples of the files that will be present in the root directory: `ap3g3, ap1g4, C9800-AP-iosxe-wlc.bin`, and so on.

Note When there is an issue and you want to patch an APSP SMU based on the 17.1 patch file `C9800_AP.17_1.22.CSCvr11111.apsp.zip` is pasted in the same root folder, that is, `/sftproot/user/ewc/C9800_AP.17_1.22.CSCvr11111.apsp.zip`. When you unzip the file, a sub-directory, for example, `/sftpboot/user/ewc/17_1.22.CSCvr11111/` is created automatically, and the AP images (for example, `ap3g3`) and SMU binary (`apsp_CSCvr11111.bin`) are present in that sub-directory.

Positive Workflow - APSP and APDP

Procedure

	Command or Action	Purpose

Step 1	**install add file** {**tftp:** | **sftp:** | **backup_image:**} `apsp.bin`
	Example:
	TFTP and Backup Image -
	`Device# install add file tftp://server_path/auto/tftpboot/user/ewc/17_1.22.CSCvr11111/apsp_CSCvr11111.bin`
	`Device#install add file backup-image:apsp_CSCvr11111.bin`
		The `install add` command copies the file from the external server to the backup_image directory on the embedded wireless controller.

Step 2	**ap image predownload** **Example:** `Device# ap image predownload`	This command is optional. The command predownloads the AP image. If the predownload has started, ensure that it completes before step 3 is initiated.
Step 3	**install activate file backup-image:** *apsp.bin* **Example:** `Device# install activate file backup-image:apsp.bin`	This command starts the rolling AP upgrade. **Note** For APDP, after activate, the EWC Controller allows APs of the new AP model to join, and get the newly installed SMU AP image.
Step 4	**install commit** **Example:** `Device# install commit`	Commits the activation changes to be persistent across reloads. The commit can be done after activation while the system is up, or after one reload. If a patch is activated and not committed, the auto abort timer automatically cancels the activation of the patch in six hours .

Rollback and Cancel

One-Shot Rollback

Procedure

	Command or Action	Purpose
Step 1	**show install rollback** **Example:** `Device# show install rollback`	Displays the possible rollback points.
Step 2	**install rollback to** {**base** | **committed** | **id** | **label** } *specific-rollback-point* **Example:** `Device# install rollback to base`	This command triggers the Rolling AP upgrade. Rolling upgrade works for all APs that have the required image. Rest of the APs are rebooted together. Rolls back a committed patch. The committed patch can be deactivated and the commit for deactivation can be done using the single install rollback command.

Multi-Step Rollback

Procedure

	Command or Action	Purpose
Step 1	**show install profile** **Example:** `Device# show install profile`	The `show install profile` command displays the profiles corresponding to the rollback points.
Step 2	**install add profile** *profile-rollback-point* **Example:** `Device# install add profile profile-rollback-point`	This command prepares the wireless module for the predownload step corresponding to the rollback point.
Step 3	**install rollback to** {**base** | **committed** | **id** | **label** } *specific-rollback-point* **Example:** `Device# install rollback to base`	This command triggers the Rolling AP upgrade. Rolling upgrade works for all APs that have the required image. Rest of the APs are rebooted together. Rolls back a committed patch. The committed patch can be deactivated and the commit for deactivation can be done using the single install rollback command.

One-Shot Cancel

The following command is used for the One-Shot manual cancel:

Procedure

- **install abort**

  Example:

  ```
  Device# install abort
  ```

  This command triggers rolling AP upgrade. Cancel is allowed only if commit is not yet completed. With One-Shot Cancel there is no predownload step. Rolling AP upgrade works for all APs which have the required image. Rest are rebooted together.

Automatic Timer-Based One-Shot Cancel

After activation, a default 6-hour cancel timer is started. The cancel timer can be set to a different value when the **activate** command is issued, through the **auto-abort-timer** parameter. When the cancel timer expires, cancellation is performed the same way as the manual cancellation.

Configuring Rollback (GUI)

Follow the steps given below to configure rollback for APSP and APDP:

Procedure

Step 1 Choose **Administration** > **Software Management** .

Step 2 Select either **AP Service Pack (APSP)** or **AP Device Pack (APDP)**.

Step 3 From the **Rollback to** drop-down list, choose the Rollback type as *Base* or *Committed*.

Step 4 Click **Submit**.

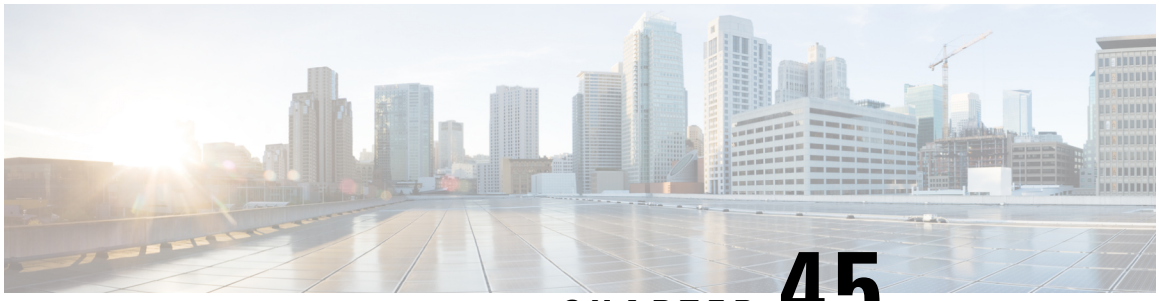
Verify APDP on the Embedded Wireless Controller

To verify the status of APDP packages on the embedded wireless controller, use the command:

```
Device# show install summary

[ Chassis 1 ] Installed Package(s) Information:
State (St): I - Inactive, U - Activated & Uncommitted, C - Activated & Committed, D -
Deactivated & Uncommitted
--------------------------------------------------------------------------------
Type  St   Filename/Version
--------------------------------------------------------------------------------
APDP  I    bootflash:apdp_CSCvp12345.bin
IMG   C    17.1.0.0
--------------------------------------------------------------------------------
Auto abort timer: inactive
--------------------------------------------------------------------------------
```

Note The output of this command varies based on the packages, and the package states that are installed.



CHAPTER 45

Intelligent Capture Hardening

• Cisco Intelligent Capture (iCAP) feature and enhancements, on page 357

Cisco Intelligent Capture (iCAP) feature and enhancements

The Cisco Intelligent Capture (iCAP) feature is a troubleshooting tool for wireless clients and APs that provides aggregated data and enhanced analysis capabilities.

- The feature aggregates data from wireless controllers and APs to make troubleshooting easier,
- the feature includes enhancements such as anomaly detection and RF statistics,
- the feature facilitates the identification of onboarding and transmission issues for wireless clients.

Feature history for Cisco Intelligent Capture hardening

This table provides release and related information about the feature explained in this section.

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 26: Feature history

Release	Feature	Feature information
Cisco IOS XE Dublin 17.12.1	Cisco Intelligent Capture (iCAP) Hardening	The following enhancements are made to the iCAP feature: • Anomaly Detection • RF Statistics

Additional information

Use the Cisco Intelligent Capture (iCAP) feature in the Cisco DNA Center GUI to identify the cause of onboarding or AP transmission issues by gathering and displaying data from wireless controllers and APs.

For example, you can use the iCAP feature's anomaly detection and RF statistics to quickly identify and resolve wireless client onboarding issues.

Anomaly detection

An anomaly is a network event type that

- allows Cisco APs to detect possible irregularities in the behavior or lifecycle of wireless clients and APs
- informs the network administrator of issues, enabling identification of what happened and how to avoid recurrence, and
- supports aggregation and suppression of repeated anomaly notifications to prevent overwhelming Cisco DNA Center with duplicate events from the same client or event type.

How anomaly detection works

Anomaly detection is crucial in identifying network problems and understanding their root causes. Whenever Cisco APs detect an anomaly, they send individual anomaly events to Cisco Catalyst Center. To avoid flooding Cisco Catalyst Center with repeated events of the same type or from the same client within a short time frame, system enhancements automatically collapse and aggregate repeats into a single event.

Anomaly detection configuration enhancements are available on the controller, which now provisions and displays the iCAP (Intelligent Capture) status, providing better visibility into anomaly detection and troubleshooting.

Example of anomaly detection

If a wireless client repeatedly triggers the same anomaly, the AP aggregates these into a single event before sending it to Cisco Catalyst Center, allowing administrators to act on consolidated insights without being overwhelmed by redundant notifications.

RF statistics

A set of RF statistics is a data collection feature that

- gathers real-time and historical information about the radio frequency environment,
- measures the performance and health indicators of wireless network access points, and
- supports monitoring and troubleshooting by providing details such as signal quality, noise levels, and channel usage.

Additional information

In Cisco IOS XE 17.12.1 and later, per-AP RF statistics are delivered directly from the wireless controller through iCAP subscription. In earlier versions (up to Cisco IOS XE 17.11.1), only basic statistical information was available.

Configure anomaly detection in AP profile (CLI)

Enable individual anomaly detection and detailed reporting for clients in an AP profile.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# onfigure terminal
```

Step 2 Configure an AP profile and enter AP profile configuration mode.

Example:

```
Device(config)# ap profile ap-profile
```

Step 3 Enable individual reports for client anomaly-detection subscription.

Example:

```
Device(config-ap-profile)# icap subscription client anomaly-detection report-individual
enable
```

Step 4 Enable individual reports aggregation for client anomaly-detection subscription.

Example:

```
Device(config-ap-profile)# icap subscription client anomaly-detection report-individual
enable aggregate
```

This command is disabled by default.

Step 5 Configure event reports per client, every five minutes.

Example:

```
Device(config-ap-profile)# icap subscription client anomaly-detection report-individual
per-client throttle number-of-event-reports
```

The value of an event report ranges from 0 to 50 reports. The default value is five reports.

Step 6 Configure event reports per type, every five minutes.

Example:

```
Device(config-ap-profile)# icap subscription client anomaly-detection report-individual
per-type throttle number-of-event-reports
```

The value of an event report ranges from 0 to 100 reports. The default value is five reports.

Anomaly detection is activated for the AP profile, and the system generates individual and aggregated anomaly reports.

Configure anomaly detection in an AP (CLI)

Enable and configure anomaly detection features on a specific access point using CLI commands.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Enable individual reports for client anomaly-detection subscription for a single AP.

Example:

```
Device# ap name ap-name icap subscription client anomaly-detection report-individual enable
```

Step 3 Enable individual reports aggregation for client anomaly-detection subscription, for a single AP.

Example:

```
Device# ap name ap-name icap subscription client anomaly-detection report-individual enable
```

Step 4 Configure event reports per client, every five minutes, for a single AP.

Example:

```
Device# ap name ap-name icap subscription client anomaly-detection report-individual
per-client throttle number-of-event-reports
```

The value of an event report ranges from 0 to 50 reports.

Step 5 Configure event reports per type, every five minutes, for a single AP.

Example:

```
Device# ap name ap-name icap subscription client anomaly-detection report-individual per-type
 throttle number-of-event-reports
```

The value of an event report ranges from 0 to 100 reports.

Anomaly detection is enabled on the targeted AP, and report generation is configured according to your specified parameters.

Verify anomaly detection and RF statistics

To verify the current status of the anomaly-detection subscription of an AP, use this command:

```
Device# show ap name cisco-AP icap subscription client anomaly-detection chassis active R0
Per-AP ICap configuration

Anomaly detection subscription
  State                    : enabled
  Client filter            : 006b.f107.a520
  Client filter            : 006b.f107.a521
  DHCP timeout (seconds)   : 5
  Trigger AP packet trace  : enabled
  Report Individual        : enabled
  Report Individual aggregate : enabled
  Report Individual throttled events (per 5 minute) : 5
  Report Individual per type throttled events (per 5 minute) : 14
  Report Individual per client throttled events (per 5 minute) : 15
```

```
  Report Summary           : disabled
  Report Summary frequency (minutes) : 5
```

To verify RF statistics, use this command:



Note The controller **show** command is enhanced to display data from the **txTotalDrops** counter.

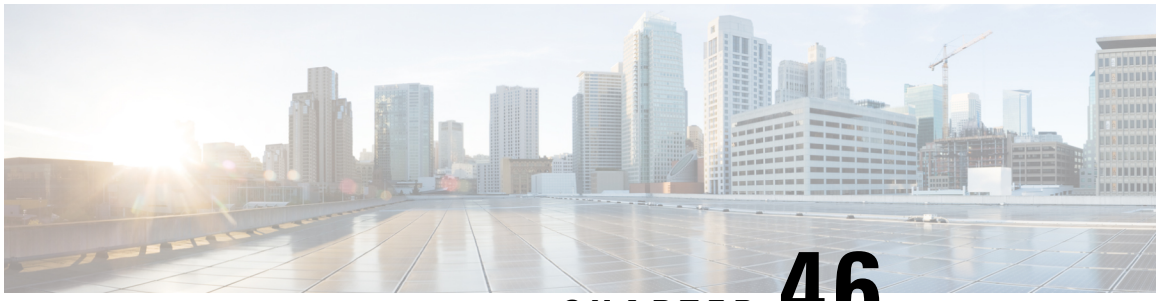
```
Device# show wireless client mac-address 00XX.ecXX.7aXX detail
.
.
.
Client Statistics:
  Number of Bytes Received from Client : 62861
  Number of Bytes Sent to Client : 6754
  Number of Packets Received from Client : 455
  Number of Packets Sent to Client : 65
  Number of Data Retries : 0
  Number of RTS Retries : 0
  Number of Tx Total Dropped Packets: x
  Number of Duplicate Received Packets : 0
  Number of Decrypt Failed Packets : 0
  Number of Mic Failured Packets : 0
  Number of Mic Missing Packets : 0
  Number of Policy Errors : 0
  Radio Signal Strength Indicator : -21 dBm
  Signal to Noise Ratio : 73 dB
.
.
.
```



PART VI

Security

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CHAPTER 46

IPv4 ACLs

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Network security with ACLs

This chapter describes how to configure network security on the switch by using access control lists (ACLs), which in commands and tables are also referred to as access lists.

ACL overview

An access control list (ACL) is a network security mechanism that

- defines permit and deny conditions for network packets
- filters inbound and outbound traffic as it traverses network devices, and
- enforces access and segmentation policies by controlling which packets are forwarded or dropped.

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. The controller checks each packet against the conditions you set in the access list, one at a time. The controller accepts or rejects the packets based on the first matching condition. Arrange your access list conditions carefully because the controller stops checking once it finds a match. If you do not set any restrictions, the controller forwards the packet. If you set restrictions and none are matched, the controller drops the packet. The controller can use ACLs on all packets it forwards . There is an implicit "deny any host" rule.

Configure access list

Configure access lists on the controller to provide basic security for your network. If you do not configure ACLs, the switch might allow all packets onto every part of your network.

Control access and traffic types

You can use ACLs to control which hosts access various parts of your network and to decide which types of traffic are forwarded or blocked at router interfaces. For example, you can allow email traffic but block Telnet traffic.



Note EWC does not support ACLs on the Gi0 port because it does not support interface or port ACLs.

Access control entries

An access control entry (ACE) is a rule component that

- specifies a *permit* or *deny* action for network packets
- defines conditions such as source or destination IP, protocol, or port that packets must meet to match the rule, and
- determines packet handling within an ordered ACL.

The meaning of *permit* or *deny* depends on the context in which the ACL is used.



Note The maximum number of ACEs that can be applied under an access policy (ACL) for central switching is 256 ACEs. For Flex Mode Local Switching, the maximum is 64 ACEs.

ACL supported types

The switch 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 switch also supports quality of service (QoS) classification ACLs.

ACEs and fragmented and unfragmented traffic

A fragmented or unfragmented packet is a type of network traffic that

- may be divided into multiple fragments as it traverses a network
- only includes Layer 4 information in the first fragment (such as TCP/UDP port, ICMP type/code), and
- requires specific ACE matching behavior depending on the presence or absence of Layer 4 information in its fragments.

IP packets can be fragmented as they cross the network. The first fragment, which contains the beginning of the packet, includes Layer 4 information such as TCP or UDP port numbers, or ICMP type and code. All other fragments lack Layer 4 information.

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

- Permit ACEs that check Layer 3 information in the fragment, including protocol type such as TCP or UDP, match the fragment regardless of missing Layer 4 details.



Note For TCP ACEs with Layer 4 options, fragmented packets are dropped in accordance with RFC 1858.

- Deny ACEs that check Layer 4 information match a fragment only if the fragment contains Layer 4 information.

ACEs and fragmented and unfragmented traffic examples

Consider access list 102, configured with these commands, applied to three fragmented packets:

```
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
```



Note In the first and second ACEs, the *eq* keyword after the destination address checks if the TCP destination port matches the well-known port numbers for Simple Mail Transfer Protocol (SMTP) or Telnet.

- Packet A is a TCP packet from host 10.2.2.2, port 65000, sent to host 10.1.1.1 on the SMTP port. If the packet is fragmented, the first fragment matches the first ACE (a permit) because all Layer 4 information is included. The remaining fragments also match the first ACE, even if they do not include the SMTP port information, because the first ACE checks only Layer 3 information when applied to fragments. In this example, the fragment is a TCP packet sent to 10.1.1.1.
- Packet B is sent from host 10.2.2.2, port 65001, to host 10.1.1.2 on the Telnet port. If the packet is fragmented, the first fragment matches the second ACE (a deny) because it includes all Layer 3 and Layer 4 information. 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. As a result, packet B cannot be reassembled on host 10.1.1.2. Permitted fragments still use network bandwidth and resources on host 10.1.1.2 during the attempted reassembly.
- Packet C is sent from host 10.2.2.2, port 65001, to host 10.1.1.3 on the FTP port. This packet is fragmented. If this packet is fragmented, the first fragment matches the fourth ACE (a deny). All other fragments also match the fourth ACE because it does not check Layer 4 information. Layer 3 information in each fragment shows they are sent to host 10.1.1.3, while previous permit ACEs check different hosts.

Standard and extended IPv4 ACLs

An IPv4 access control list (ACL) is a packet-filtering feature that

- sequentially compares packets against a set of permit or deny conditions
- determines packet acceptance or rejection based on the first match, and
- enforces traffic control policies on network interfaces.

The switch stops testing after the first match. The order of the conditions is critical. If no conditions match, the switch denies the packet.

The software supports two types of ACLs 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 can include protocol-type information for more granular control.

Note Only extended ACLs are supported; standard ACLs are not supported.

IPv4 ACL switch unsupported features

Configuring IPv4 ACLs on this switch is similar to configuring IPv4 ACLs on other Cisco switches and routers.

The switch does not support the following ACL-related features:

- Non-IP protocol ACLs or bridge-group ACLs.
- IP accounting.
- Inbound and outbound rate limiting (except with QoS ACLs).
- Reflexive ACLs, URL redirect ACLs and dynamic ACLs are not supported. (except for some specialized dynamic ACLs used by the switch clustering feature).
- ACL logging for port ACLs and VLAN maps.

Access list numbers

The ACL number determines the type of access list you create.

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 27: Access List Numbers

Access List Number	Type	Supported
1–99	IP standard access list	Yes

Access List Number	Type	Supported
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 create standard and extended named IP ACLs with the supported numbers. For example, you can name standard IP ACLs with numbers from 1 to 99, and extended IP ACLs with numbers from 100 to 199. With named ACLs, you can delete individual entries, but with numbered lists, you cannot.

Numbered standard IPv4 ACLs

When you create an ACL, an implicit deny statement is automatically present at the end. Any packet that does not match an earlier entry in the ACL is denied by this statement. For standard access lists, if you omit the mask in an IP host address ACL entry, the switch assumes a mask of 0.0.0.0.

- The switch rewrites standard access lists to move host match entries and entries with a don't care mask of 0.0.0.0 to the top of the list. Entries with non-zero don't care masks are placed below them. As a result, the ACEs may appear in a different order in show command output and in the configuration file than the order in which you entered them.
- After you create a numbered standard IPv4 ACL, you can apply it to VLANs, feature-id terminal lines (virtual teletype (VTY) lines), or interfaces.

Numbered extended IPv4 ACLs

A numbered extended IPv4 ACL is an access control mechanism that

- matches IPv4 traffic using both source and destination addresses

- optionally uses protocol type information for greater refinement, and
- requires that Access Control Entries (ACEs) be appended to the list since reordering or selective removal is unsupported.

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.

The switch 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 switch also supports these IP protocols:

- Authentication Header Protocol (**ahp**)
- Encapsulation Security Payload (**esp**)
- Enhanced Interior Gateway Routing Protocol (**eigrp**)
- generic routing encapsulation (**gre**)
- Internet Control Message Protocol (**icmp**) and Open Shortest Path First routing (**ospf**)
- Internet Group Management Protocol (**igmp**) and Payload Compression Protocol (**pcp**)
- any Interior Protocol (**ip**) and Protocol-Independent Multicast (**pim**)
- IP in IP tunneling (**ipinip**) and Transmission Control Protocol (**tcp**)
- KA9Q NOS-compatible IP over IP tunneling (**nos**) and 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 router 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, at times, not all commands that use IP access lists accept a named access 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.
- VLAN ACLs or VLAN maps are not supported.
- You can use standard or extended ACLs whether named or numbered, in VLAN maps.
- With IPv4 QoS ACLs, if you enter the class-map { match-all | match-any} class-map-name global configuration command, you can enter these match commands:

  1. **match access-group** *acl-name*



Note The ACL must be an extended named ACL.

2. **match input-interface** *interface-id-list*
3. **match ip dscp** *dscp-list*
4. **match ip precedence** *ip-precedence-list*



Note You cannot enter the **match access-group** *acl-index* command.

ACL logging

ACL logging is a router logging feature that

- generates informational messages about packets permitted or denied by a standard IP access control list (ACL)
- records each message with details such as the action taken, the source IP address, and the access list number, and
- supports logging only for router ACLs (RACLs), not for ACLs used with Unicast Reverse Path Forwarding (uRPF).

The controller software can provide logging messages about packets permitted or denied by a standard IP access list. The level of messages logged to the console is controlled by the **logging console** commands, which control the syslog messages.



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 generates a logging message immediately. Subsequent packets are collected over 5-minute intervals before they are logged. The logging message includes the access list number, an indication of whether the packet was permitted or denied, the source IP address, and the number of packets from that source permitted or denied during the prior 5-minute interval.



Note The logging facility might drop some message packets if there are too many to handle, or if more than one logging message must be processed in a second. This behavior prevents the router from crashing due to too many logging packets. Therefore, do not use the logging facility as a billing tool or as an accurate source for 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.

The ACL scale for controllers is as follows:

- Cisco Catalyst 9800-40 wireless controller, Cisco Catalyst 9800-L wireless controller, Cisco Catalyst 9800-CL wireless controller (small and medium) support 128 ACLs with 128 access list entries (ACEs).
- Cisco Catalyst 9800-80 wireless controller and Cisco Catalyst 9800-CL wireless controller (large) support 256 ACLs and 256 ACEs.
- FlexConnect and Fabric mode APs support 96 ACLs.

Note If an ACL configuration cannot be implemented in the hardware due to an out-of-resource condition on the controller, then only the traffic in that VLAN arriving on that controller is affected. Software forwarding of packets might adversely impact the performance of the switch or switch stack, depending on the number of CPU cycles that this consumes.

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

- Using the log keyword
- Generating ICMP unreachable messages

When traffic flows are both logged and forwarded, forwarding is done by hardware, but logging must be done by software. Because of the difference in packet handling capacity between hardware and software, if the sum of all flows being logged (both permitted flows and denied flows) is of great enough bandwidth, not all of the packets that are forwarded can be logged.

If a router ACL configuration cannot be applied in hardware, packets that arrive in a VLAN and must be routed are processed in software. However, packets are bridged in hardware. If ACLs cause large numbers of packets to be sent to the CPU, the switch performance can be negatively affected.

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 access-lists hardware counters and show platform acl counters hardware privileged EXEC commands to obtain basic hardware ACL statistics for switched and routed packets.

Router ACLs operate in this way:

- 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, and if ip unreachables is disabled, the hardware drops flows that match a deny statement in a security ACL. 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 switched and routed in hardware.

IPv4 ACL interface considerations

When you apply the ip access-group interface configuration command to a Layer 3 interface (an SVI, a Layer 3 EtherChannel, or a routed port), the interface must have been configured with an IP address. Layer 3 access groups filter packets that are routed and packets that are received by Layer 3 processes on the CPU. They do not affect packets bridged within a VLAN.

- For inbound ACLs, after receiving a packet, the controller checks the packet against the ACL. If the ACL permits the packet, the controller continues to process the packet. If the ACL rejects the packet, the controller discards the packet.
- For outbound ACLs, after receiving and routing a packet to a controlled interface, the controller checks the packet against the ACL. If the ACL permits the packet, the controller sends the packet. If the ACL rejects the packet, the controller discards the packet.

If an undefined ACL has nothing listed in it, it is an empty access list.

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 half second per input interface. You can change this by using the ip icmp rate-limit unreachable global configuration command.

Restrictions for configuring IPv4 access control lists

General Network Security

These are restrictions for configuring network security with ACLs:

- A standard ACL and an extended ACL cannot have the same name.
- **AppleTalk** appears in the command-line help strings but is not supported as a matching condition for the **deny** and **permit** MAC access-list configuration mode commands.
- DNS traffic is permitted by default for clients that are awaiting web authentication, regardless of ACL entries.

IPv4 ACL Network Interfaces

These restrictions apply to IPv4 ACLs to network interfaces:

- When controlling access to an interface, you can use a named or numbered ACL.
- You do not have to enable routing to apply ACLs to Layer 2 interfaces.

IP Access List Entry Sequence Numbering

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

How to configure ACLs

Configure IPv4 ACLs (GUI)

Define and apply IPv4 ACL rules for traffic management and security.

Procedure

Step 1 Choose **Configuration** > **Security** > **ACL**.

Step 2 Click **Add**.

Step 3 In the **Add ACL Setup** dialog box, enter the details for these parameters.

- ACL Name: Enter the name for the ACL.
- ACL Type: IPv4 Standard.
- Sequence: Enter the sequence number.
- Action: Select ***Permit*** or ***Deny*** the packet flow from the drop-down list.
- Source Type: Choose ***any***, ***Host*** or ***Network*** from which the packet is sent.
- Log: Enable or disable logging.

Step 4 Click **Add**.

Step 5 Add the rest of the rules and click **Apply to Device**.

Configure IPv4 ACLs

Follow the procedure given below to use IP ACLs on the switch:

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. .

Create a numbered standard ACL (GUI)

Define and apply a numbered standard ACL using the device's web interface using GUI.

Procedure

Step 1 Choose **Configuration** > **Security** > **ACL**.

Step 2 On the **ACL** page, click **Add**.

Step 3 In the **Add ACL Setup** window, enter the details for these parameters.

- ACL Name: Enter the name for the ACL.

- ACL Type: IPv4 Standard.
- Sequence: Enter the sequence number.
- Action: Select **Permit** or **Deny** access from the drop-down list.
- Source Type: Choose **any** , **Host** or **Network**.
- Log: Enable or disable logging, this is limited to ACLs associated to Layer 3 interface only.

Step 4 Click **Add**.

Step 5 Click **Save & Apply to Device**.

Create a numbered standard ACL (CLI)

Follow the procedure given below to create a numbered standard ACL using commands:

Procedure

Step 1 Enable the privileged EXEC mode and enter your password if prompted.

Example:

```
Device# enable
```

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Define a standard IPv4 access list by using a source address and wildcard.

Example:

```
Device(config)# access-list 2 {deny | permit} source source-wildcard your_host
```

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. Specify the source as:

- The 32-bit quantity in dotted-decimal format.
- The keyword **any** abbreviates for *source* and *source-wildcard* as 0.0.0.0 255.255.255.255. You do not need to enter a source-wildcard.
- The keyword **host** abbreviates source and *source-wildcard* as *source* 0.0.0.0.

The *source-wildcard* applies wildcard bits to the source address.

Note
Logging is supported only on ACLs attached to Layer 3 interfaces.

Step 4 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Step 5 Verify your entries.

Example:

```
Device# show running-config
```

Step 6 (Optional) Save your entries in the configuration file.

Example:

```
Device# copy running-config startup-config
```

Create a numbered extended ACL (GUI)

Set up a numbered extended ACL to control network traffic based on source, destination, and protocol using the GUI.

Procedure

Step 1 Choose **Configuration** > **Security** > **ACL**.

Step 2 On the **ACL** page, click **Add**.

Step 3 In the **Add ACL Setup** window, enter the details for these parameters.

- ACL Name: Enter the name for the ACL.
- ACL Type: IPv4 Extended.
- Sequence: Enter the sequence number.
- Action: Select **Permit** or **Deny** the packet flow from the drop-down list.
- Source Type: Choose **any** , **Host** or **Network** from which the packet is sent.
- Destination Type: Choose **any** , **Host** or **Network** to which the packet is sent.
- Protocol: Select a protocol from the drop-down list.
- Log: Enable or disable logging.
- DSCP: Enter to match packets with the DSCP value.

Step 4 Click **Add**.

Step 5 Click **Save & Apply to Device**.

Create a numbered extended ACL (CLI)

Follow the procedure given below to create a numbered extended ACL using commands:

Procedure

Step 1 Enters global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Defines an extended IPv4 access list and the access conditions.

Example:

```
Device# access-list 101 {deny | permit} ip host 10.1.1.2 any [precedence 0] [tos 0]
[fragments] log [log-input | smartlog] [time-range time-range-name] [dscp dscp]
```

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.

For *protocol* , enter the name or number of an P protocol: **ahp**, **eigrp**, **esp**, **gre**, **icmp**, **igmp**, **igrp**, **ip**, **ipinip**, **nos**, **ospf**, **pcp**, **pim**, **tcp**, or **udp**, or an integer in the range 0 to 255 representing an IP protocol number. To match any Internet protocol (including ICMP, TCP, and UDP), use the keyword **ip**.

Note
This step includes options for most IP protocols. For additional specific parameters for TCP, UDP, ICMP, and IGMP, see the following steps.

The *source* is the number of the network or host from which the packet is sent.

The *source-wildcard* applies wildcard bits to the source.

The *destination* is the network or host number to which the packet is sent.

The *destination-wildcard* applies wildcard bits to the destination.

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.
- **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
  Your embedded controller must support the ability to:

  - Mark DCSP
  - Mark UP
  - Map DSCP and UP

    For more information on DSCP-to-UP Mapping , see:

    https://tools.ietf.org/html/draft-ietf-tsvwg-ieee-802-11-01

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 3 Define an extended TCP access list and the access conditions.

Example:

```
Device(config)# access-list 101 {deny | permit} tcp source source-wildcard [operator-port]
 destination destination-wildcard 500 [established] [precedence 0] [tos 0] [fragments] log
 [log-input | smartlog] [time-range time-range-name] [dscp dscp] [flag]
```

The parameters are the same as those described for an extended IPv4 ACL, with these exceptions:

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:

- *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 4 Define an extended UDP access list and the access conditions.

Example:

```
Device(config)# access-list 101 {deny | permit} udp source source-wildcard [operator port]
 destination destination-wildcard 100 precedence 0] [tos 0] [fragments] log [log-input |
smartlog] [time-range time-range-name] [dscp dscp
```

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** not valid for UDP.

Step 5 Define an extended ICMP access list and the access conditions.

Example:

```
Device(config)# access-list 101 {deny | permit} icmp source source-wildcard destination
destination-wildcard [ icmp-type | [[ icmp-type icmp-code ] | [ icmp-message ]] precedence
 0] [tos 0] [fragments] log [log-input | smartlog] [time-range time-range-name] [dscp dscp]
```

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 6 (Optional) Define an extended IGMP access list and the access conditions.

Example:

```
Device(config)# access-list 101 {deny | permit} igmp source source-wildcard destination
destination-wildcard [ igmp-type ] precedence 0] [tos 0] [fragments] log [log-input |
smartlog] [time-range time-range-name] [dscp dscp]
```

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 7 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Step 8 (Optional) Save your entries in the configuration file.

Example:

```
Device# copy running-config startup-config
```

Create named standard ACLs (GUI)

Use this procedure to set up and apply ACLs for network security management within the device's GUI.

Procedure

Step 1 Click **Configuration** > **Security** > **ACL**.

Step 2 Click **Add** to create a new ACL setup.

Step 3 In the **Add ACL Setup** window, enter these parameters:

- ACL Name: Enter the name for the ACL.
- ACL Type: IPv4 Standard.
- Sequence: The valid range is between 1 and 99 or 1300 and 1999.
- Action: Select **Permit** or **Deny** access from the drop-down list.

- Source Type: Choose **any**, **Host** or **Network**.
- Log: Enable or disable logging, this is limited to ACLs associated to Layer 3 interface only.

Step 4 Click **Add** to add the rule.

Step 5 Click **Save & Apply to Device**.

Create named standard ACLs (CLI)

Define and apply named standard ACLs to permit or deny traffic from specified IPv4 source addresses using commands.

Procedure

Step 1 Enter the privileged EXEC mode.

Example:

```
Device# enable
```

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Define a standard IPv4 access list using a name, and enter the access-list configuration mode.

Example:

```
Device(config)# ip access-list standard 20
```

The name can be a number from 1 to 99.

Step 4 Specify one or more conditions denied or permitted to decide if the packet is forwarded or dropped in access-list configuration mode. Use one of the these:

- **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
```

- **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 Returns to privileged EXEC mode.

Example:

```
Device(config-std-nacl)# end
```

Step 6 Verify your entries.

Example:

```
Device# show running-config
```

Step 7 (Optional) Save your entries in the configuration file.

Example:

```
Device# copy running-config startup-config
```

Create extended named ACLs (GUI)

Follow these steps to filter traffic based on granular criteria, such as source/destination, protocol, or DSCP using the GUI.

Procedure

Step 1 Choose **Configuration** > **Security** > **ACL**.

Step 2 Click **Add**.

Step 3 In the **Add ACL Setup** window, enter these parameters.

- ACL Name: Enter the name for the ACL.
- ACL Type: IPv4 Extended.
- Sequence: Enter the sequence number.
- Action: Select *Permit* or *Deny* the packet flow from the drop-down list.
- Source Type: Choose *any*, *Host* or *Network* from which the packet is sent.
- Destination Type: Choose *any*, *Host* or *Network* to which the packet is sent.
- Protocol: Select a protocol from the drop-down list.
- Log: Enable or disable logging.
- DSCP: Enter to match packets with the DSCP value.

Step 4 Click **Add**.

Step 5 Add the rest of the rules and click **Apply to Device**.

Create extended named ACLs (CLI)

Use this procedure to create extended named access control lists (ACLs) using CLI commands.

Procedure

Step 1 Enable the privileged EXEC mode and enter your password if prompted.

Example:

```
Device# enable
```

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Define an extended IPv4 access list using a name, and enter the access-list configuration mode.

Example:

```
Device(config)# ip access-list extended 150
```

The name can be a number from 100 to 199.

Step 4 Specify the conditions allowed or denied in access-list configuration mode { **deny** | **permit** } *protocol* { *source* [*source-wildcard*] | **host** *source* | **any** } { *destination* [*destination-wildcard*] | host *destination* | **any** } [**precedence** *precedence*] [**tos***tos*] [**log**] [**time-range** *time-range-name*]

Example:

```
Device(config-ext-nacl)# permit 0 any any
```

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 Return to the privileged EXEC mode.

Example:

```
Device(config-ext-nacl)# end
```

Step 6 Verifiy your entries.

Example:

```
Device# show running-config
```

Step 7 (Optional) Save your entries in the configuration file.

Example:

```
Device# copy running-config startup-config
```

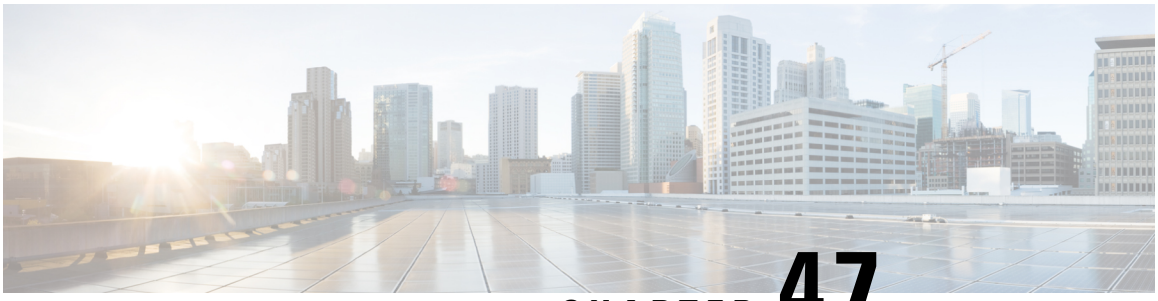
When you create extended ACLs, an implicit deny statement is added by default at the end of the ACL. If no match occurs before reaching the end, all traffic is denied. For standard ACLs, omitting the mask from an IP host address access list specification causes the system to use 0.0.0.0 as the mask.

New entries are always placed at the end of the ACL after you create it. You cannot add ACL entries at specific positions within an ACL. However, you can remove entries from a named ACL using the **no permit** and **no deny** access-list configuration mode commands.

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 you create a named ACL, apply it to interfaces or to VLANs .



CHAPTER 47

DNS-Based Access Control Lists

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- Restrictions on DNS-based access control lists, on page 387
- Flex Mode, on page 388
- Viewing DNS-Based Access Control Lists, on page 391

DNS-based access control lists

A DNS-based access control list is a wireless network security feature that

- allows administrators to permit or deny wireless client access to resources based on DNS domain names
- dynamically learns allowed or denied IP addresses through DNS snooping on access points, and
- enables pre-authentication and post-authentication URL filtering for enhanced client security.

DNS-based ACLs are used for wireless client devices. You can set pre-authentication ACLs on the embedded wireless controller to determine which data requests are allowed or blocked.

To enable DNS-based ACLs on the embedded wireless controller, configure the allowed or denied URLs for the ACLs. The URLs need to be pre-configured on the ACL.

During the registration phase, DNS-based ACLs allow the client to connect to the configured URLs. The embedded wireless controller is configured with the ACL name provided by the AAA server. If the AAA server returns the ACL name, the controller applies the ACL to the client for web redirection.

During client authentication, the AAA server returns the pre-authentication ACL (url-redirect-acl), which is the attribute name assigned to the ACL by the AAA server. The AP performs DNS snooping for each client until registration is complete and the client reaches the SUPPLICANT PROVISIONING state. When the embedded wireless controller receives the ACL configured with URLs, it sends a CAPWAP payload to the access point to enable DNS snooping for those URLs.

When URL snooping is enabled, the access point learns the IP address of the resolved domain name from the DNS response. If the domain name matches a configured URL, the access point parses the DNS response for the IP address. The AP adds the IP address to the allowed list, which allows the client to access the configured URLs.

During pre-authentication or post-authentication, the DNS ACL is applied to the client in the AP. If the client roams from one AP to another AP, tthe DNS-learned IP addresses from the previous access point remain valid on the new AP.

This feature supports:

- A maximum of 32 URL lists.
- A maximum of 32 URLs per URL list.
- Up to 30 IP addresses per URL.
- A maximum of 16 URL lists with wild cards.
- A maximum of 10 URLs per wild-card URL.

Note When configuring wild card based URLs, generic wild-card URLs are not allowed. Wild cards cannot be present within the domain name, and multiple wild cards are not allowed in a single URL. Wild card specification in a URL is only allowed at the third-degree level or higher.

Note Conflicting or invalid configurations are not allowed. The same URL cannot have different actions. For example, Deny and Allow cannot be configured on www.yahoo.com .

Note Attach the URL filter to a policy profile for local mode. In FlexConnect mode, attach the URL filter to the flex profile; attaching it to a policy profile is not required.

Note DNS-based URLs require an active DNS query from the client. For URL filtering to work, configure DNS settings correctly.

Note The URL filter takes precedence over punt or redirect ACLs, as well as custom or static pre-authentication ACLs.

FlexConnect in Embedded Wireless Controller

FlexConnect is a wireless solution for branch office and remote office deployments. It enables customers to configure and control access points in a branch or remote office from the corporate office through a wide area network (WAN) link without deploying a embedded wireless controller in each branch office.

The FlexConnect access points can switch client data traffic locally while carrying the authentication centrally. Also, FlexConnect APs perform client authentication locally when their connection to the controller is lost. When they are connected back to the controller, they can also send authentication/policy details back to the embedded wireless controller.

The embedded wireless controller network comprises of at least one 802.11ax Wave 2 Cisco Aironet Series access point (AP) with a software-based embedded wireless controller managing other APs in the network.

The AP acting as the embedded wireless controller is referred to as the primary AP while the other APs in the network, which are managed by this primary AP, are referred to as subordinate APs. In addition to acting as an embedded wireless controller, the primary AP also operates as an AP to serve clients along with the subordinate APs.

Pre-Auth DNS ACL feature is also known as Walled Garden feature. The walled garden is a list of web sites or domains that you can visit without being authenticated. DNS snooping is performed on the AP for each client and configured rule is applied to client traffic after matching the Source or Destination IP.

Roaming

During Roaming, the support clients roam from one AP to the other using the existing roaming support. DNS ACLs are retained at the target AP even after roaming. For Roaming with DNS Pre-Auth ACL and Post-Auth ACL, the target AP learns the client-resolved IP from the serving AP.

Restrictions on DNS-based access control lists

Restrictions for DNS-based ACLs

- ACLs are only supported for FlexConnect local switching APs with Central Authorization. Post-authentication DNS-based ACLs are not supported for FlexConnect with local Authorization when the AP operates in FlexConnect local switching mode.
- Fully qualified domain name (FQDN) ACLs and DNS-based ACLs are not supported on Cisco Wave 1 Access Points.
- The URL filter considers only the first 20 URLs, though you can add more. It uses regular regex patterns and permits wildcard characters only at the beginning or at the end of an URL. URL ACLs are defined and added to the FlexConnect policy profile, which is then associated with a WLAN. URL ACL creation follows a mechanism similar to local mode URL ACLs.
- In FlexConnect mode, the URL domain ACL works only when it is connected to a FlexConnect policy profile. The ACL can be attached to a WLAN by associating the policy profile with either the WLAN or local policies. However, you can override it using 'url-redirect-acl'. When the Cisco AV pair is received from ISE, the required policy for a client is pushed as part of the ADD MOBILE message.
- When an AP joins or when an existing URL ACL is modified and applied to a FlexConnect profile, the ACL definition, along with the mapped URL filter list, is pushed to the AP. The AP stores the URL ACL definition with the mapped ACL name and snoops DNS packets to learn the first IP address for each URL in the ACL. When the AP learns the IP addresses, it updates the controller of the URL and IP bindings. The controller records this information in the client database for future use.
- When a client roams to another AP during the pre-authentication state, the learned IP addresses are pushed to a new AP. Otherwise, these learned IP addresses are purged when a client enters the post-authentication state or when the TTL for the learned IP address expires.
-

Flex Mode

Configuring the URL Filter List (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile flex** *custom-flex-profile* **Example:** `Device(config)# wireless profile flex custom-flex-profile`	Configures a wireless flex profile and enters wireless flex profile configuration mode.
Step 3	**acl-policy** *acl-policy-name* **Example:** `Device(config-wireless-flex-profile)#acl-policy acl-policy-name`	Configures the ACL policy description
Step 4	**urlfilter list** *url-filterlist-name* **Example:** `Device(config-wireless-flex-profile-acl)# urlfilter list url-filterlist-name`	Configures and applies the name of the URL filter list to the flex profile. This is the Flex URL filter configuration command for ACL binding.

Configuring the URL Filter List (GUI)

Procedure

Step 1 Choose **Configuration** > **Security** > **URL Filters**.
The **URL Filters** page is displayed.

Step 2 Click the **Add** button.
The **Add URL Filters** window is displayed.

Step 3 From the **Type** drop-down list, choose either **PRE-AUTH** or **POST-AUTH**.

a) **POST-AUTH**: Specify the **Redirect Servers** for **IPv4** and **IPv6**.

Step 4 Use the slider to **Permit** or **Deny** the **Action**.

Step 5 Specify the URLs in the **URLs** field. Enter every URL on a new line.

Step 6 Click **Apply to Device**.

Applying Custom Pre-Auth DNS ACL on WLAN

For pre-auth, this configuration should be on a web-auth WLAN.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan***wlan-name wlan-id ssid-name* **Example:** `Device(config)# wlan wlan-name wlan-id ssid-name`	Enters the WLAN configuration sub-mode. 1. wlan-name — Enter the profile name. The range is from 1 to 32 alphanumeric characters. 2. wlan-id—Enter the WLANID. The range is from 1 to 512. 3. SSID-name—Enter the Service Set Identifier (SSID) for this WLAN. If the SSID is not specified, the WLAN profile name is set as the SSID. If you have already configured WLAN, enter wlan wlan-name command.
Step 3	**ip access-group web** *access-list-name* **Example:** `Device(config-wlan)#ip access-group web preauth-acl-wlan`	Maps the ACL to the web auth WLAN. access-list-name is the IPv4 ACL name or ID.

Applying Custom Post-Auth DNS ACL on Policy Profile

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**Wireless profile policy** *profile-name* **Example:** `Device(config)# wireless profile policy custom-policy-profile`	Creates policy profile for the WLAN.
Step 3	{**ipv4** | **ipv6**} **acl** *post-acl-name* **Example:**	Creates ACL configuration for wireless IPv4 or IPv6 configuration.

	Command or Action	Purpose
	`Device(config-wireless-policy)#ipv4 acl post-acl`	

Configure ISE for central web authentication (GUI)

Perform these steps to configure ISE for Central Web Authentication using the GUI.

Procedure

Step 1 Login to the Cisco Identity Services Engine (ISE). Click **Policy** and then click **Policy Elements**. Click **Results**.

Step 2 Expand **Authorization** and click **Authorization Profiles**.

Step 3 Click **Add** to create a new authorization profile for URL filter.

Step 4 Enter a name for the profile in the **Name** field. For example, CentralWebauth.

Step 5 Select **ACCESS_ACCEPT** option from the **Access Type** drop-down list. Alternatively, in the **Common Tasks** section, check **Web Redirection**.

Step 6 Select the **Centralized Web Auth** option from the drop-down list. Specify the ACL and select the ACL value from the drop-down list.

Step 7 In the **Advanced Attributes Setting** section, select **Cisco:cisco-av-pair** from the drop-down list.

Note
Multiple ACL can be applied on the controller based on priority. In L2 Auth + webauth multi-auth scenario, if the ISE returns ACL during L2 Auth then ISE ACL takes precedence over the default webauth redirect ACL. This leads to traffic running in webauth pending state, if ISE ACL has permit rule. To avoid this scenario, you need to set the precedence for L2 Auth ISE returned ACL. The default webauth redirect ACL priority is 100. To avoid traffic issue, you need to configure the redirect ACL priority above 100 for ACL returned by ISE.

Step 8 Enter these one by one and click (+) icon after each of them:

- url-redirect-acl=<sample_name>
- url-redirect=<sample_redirect_URL>

  For example,

```
Cisco:cisco-av-pair = priv-lvl=15
Cisco:cisco-av-pair = url-redirect-acl=ACL-REDIRECT2
Cisco:cisco-av-pair = url-redirect=
https://9.10.8.247:port/portal/gateway?
sessionId=SessionIdValue&portal=0ce17ad0-6d90-11e5-978e-005056bf2f0a&daysToExpiry=value&action=cwa
```

Step 9 Verify contents in the **Attributes Details** section and click **Save**.

Viewing DNS-Based Access Control Lists

To view the URL Lists, use the following command:

```
Device #show wireless urlacl-enhanced summary
URL-List
--------------------------------
urllist_ut
urllist_max1
urllist_max2
urllist_max3
urllist_max4
urllist_max5
```

To view the details of a particular URL List, use the following command:

```
Device#show wireless urlacl-enhanced details urllist_ut
List Name..................... : urllist_ut
Configured List of URLs
URL                  Preference Action Validity Invalidated URL
------------------------------------------------------------------------------
url1.dns.com         1                PERMIT         VALID 0
url2.dns.com         2                DENY           VALID 0
url3.dns.com         3                PERMIT         VALID 0
url4.dns.com         4                DENY           VALID 0
url11.dns.com        6                DENY           VALID 0
url12.dns.com        7                PERMIT         VALID 0
url13.dns.com        8                DENY           VALID 0
www.example.com      14               PERMIT         VALID 0
```

To view the flex profile details, use the following command:

```
Device# sh wireless profile flex detailed custom-flex-profile
Flex Profile Name : custom-flex-profile
Description : custom flex profile
Local Auth :
        AP:
                Radius Enable            : ENABLED
                PEAP                     : DISABLED
                LEAP                     : DISABLED
                TLS                      : DISABLED
                EAP fast profile         : Not Configured
                User List                : Not Configured
        RADIUS:
                RADIUS server group name : Not Configured
        Fallback Radio shut              : DISABLED
        ARP caching                      : ENABLED
        Efficient Image Upgrade          : ENABLED
        OfficeExtend AP                  : DISABLED
        Join min latency                 : DISABLED
        Policy ACL :
                ACL Name                          URL Filter List
        Name                 Central Webauth
        ------------------------------------------------------------
        post-acl               urllist_ut        DISABLED
        pre_v4              urllist_pre_cwa   DISABLED
        ACL-REDIRECTTTTTTT2     urllist_ut        DISABLED
        VLAN Name - VLAN ID mapping       : Not Configured
```

To view client details, use the following command:

```
Device#sh wireless client mac-address <Mac-address> detail
```

Verifying the Access Point

To view the ACL configuration on the AP, use the following command:

```
Device# show ip access-lists
Extended IP access list pre_v4
        1 permit udp any range 0 65535 any eq 53
        2 permit tcp any range 0 65535 any eq 53
        3 permit udp any dhcp_server any range 0 65535
        4 permit udp any range 0 65535 any eq 68
        5 permit udp any dhcp_client any range 0 65535
        6 deny ip any any
```

To view the URL List configuration, use the following command:

```
Device#show flexconnect url-acl
ACL-NAME         ACTION         URL-LIST
pre_v4
                 allow          test.dns.com
                 allow          url2.dns.com
                 allow          url3.dns.com
                 allow          url10.dns.com
                 allow          url11.dns.com
                 allow          www.cwapre.com
                 allow          www.google.com
                 allow          oldconfig.dns.com
                 allow          *.cisco.com
```

To view pre-auth client configuration, use the following command:

```
Device# show client access-lists pre-auth all C0:C1:C0:70:58:2F
Pre-Auth URL ACLs for Client: C0:C1:C0:70:58:2F
IPv4 ACL: pre_v4
IPv6 ACL:
ACTION         URL-LIST
allow          url1.dns.com
deny           url2.dns.com
allow          url3.dns.com
deny           url4.dns.com
allow          www.example.com
deny           url11.dns.com
allow          url12.dns.com
deny           url13.dns.com

Resolved IPs for Client: C0:C1:C0:70:58:2F
HIT-COUNT         URL         ACTION         IP-LIST
post-acl
        rule 0:   allow true
No IPv6 ACL found
```

To view post-auth client configuration, use the following command:

```
Device# show client access-lists post-auth all C0:C1:C0:70:58:2F
Post-Auth URL ACLs for Client: C0:C1:C0:70:58:2F
IPv4 ACL: post-acl
IPv6 ACL:
ACTION         URL-LIST
allow          url1.dns.com
deny           url2.dns.com
allow          url3.dns.com
deny           url4.dns.com
allow          www.example.com
deny           url11.dns.com
allow          url12.dns.com
deny           url13.dns.com
```

```
Resolved IPs for Client: C0:C1:C0:70:58:2F
HIT-COUNT         URL         ACTION         IP-LIST
post-acl
        rule 0: allow true
No IPv6 ACL found
```

To view the IPs learnt in pre-auth, use the following command:

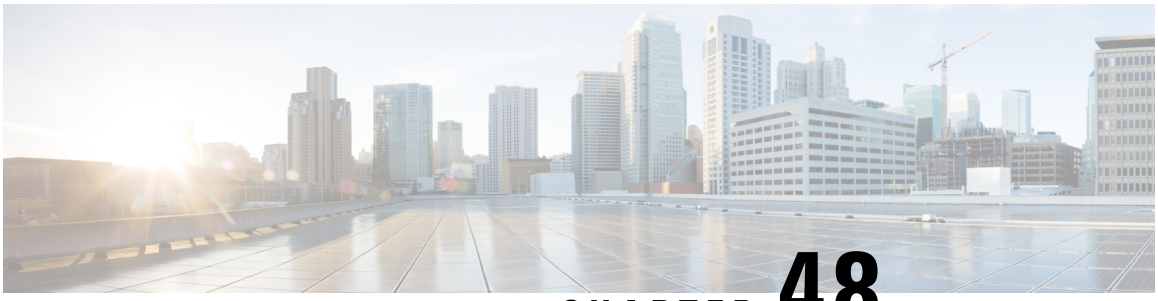
```
Device#show client access-lists pre-auth all 60:14:B3:AA:C6:FB
Pre-Auth URL ACLs for Client: 60:14:B3:AA:C6:FB
IPv4 ACL: acl_1
IPv6 ACL:
ACTION         URL-LIST
allow          url1.dns.com
deny           url2.dns.com

Resolved IPs for Client: 60:14:B3:AA:C5:FB
HIT-COUNT         URL                ACTION         IP-LIST
10                url1.dns.com       allow          9.10.8.1
```

To view the IPs learnt in post-auth, use the following command:

```
Device#show client access-lists post-auth all 60:14:B3:AA:C6:FB
Post-Auth URL ACLs for Client: 60:14:B3:AA:C5:FB
IPv4 ACL: post_acl
IPv6 ACL:
ACTION         URL-LIST
deny           url1.dns.com
allow          url2.dns.com

Resolved IPs for Client: 60:14:B3:AA:C5:FB
HIT-COUNT         URL                ACTION         IP-LIST
16                url2.dns.com       allow          9.10.9.1
postauth_acl
          rule 0: allow true
```



CHAPTER 48

Downloadable ACL

- Downloadable ACLs, on page 395

Downloadable ACLs

A downloadable ACL is a type of access control list that

- restricts network access to users or devices based on predefined criteria
- is specified as a list of Access Control Entries (ACEs), and
- can be maintained centrally in Cisco ISE and downloaded to controllers.

Supporting reference information

You can easily maintain and update ACLs in Cisco ISE.

Each ACE has a matching condition based on packet header fields:

- IP addresses
- ports
- protocols
- combination of IP addresses, ports, and protocols
- Result (permit or deny)

ACLs are applied to each controller on a per-wireless-client basis.

Typically, you can configure ACLs in a controller itself. However, you can also configure ACLs on a connected Cisco ISE server and download them to the controller when a wireless client connects.

These ACLs are referred to as downloadable ACLs, per-user Dynamic ACLs, or dACLs.

You can easily maintain downloadable ACLs because they define or update ACLs in Cisco ISE and can be downloaded to all applicable controllers.

(In Cisco IOS-XE 17.8 and earlier releases, you must configure the name in Cisco ISE and define the ACL individually on each controller.)

Feature history for downloadable ACL

This table provides release and related information about the feature explained in this section. This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Release	Feature	Feature Information
Cisco IOS XE Dublin 17.10.1	Downloadable ACL	The Downloadable ACL (dACL) feature defines and updates access control lists (ACLs) in one place (Cisco ISE) and allows ACL download to all the applicable controllers. In Cisco IOS-XE 17.8 and earlier releases, you had to configure the name in Cisco ISE and define the ACL individually in each of the controllers.

Scale considerations for downloadable ACL

This table provides the ACL scale numbers for controllers.

ACL Scale for Controllers

- Cisco Catalyst 9800-40 Wireless Controller (small or medium): Supports 128 ACLs with 128 ACEs.
- Cisco Catalyst 9800-80 Wireless Controller (large): Supports 256 ACLs and 256 ACEs.

Controllers	ACL Scale
Cisco Catalyst 9800-40 Wireless Controller (small or medium)	Supports 128 ACLs with 128 ACEs.
Cisco Catalyst 9800-80 Wireless Controller (large)	Supports 256 ACLs and 256 ACEs.

Restrictions for downloadable ACL

Restrictions on dACL usage

These restrictions apply to downloadable ACLs (dACL):

- dACL does not support FlexConnect local switching.
- You can use IPv6 dACLs only in Cisco ISE 3.0 or later.

Configuring dACL name and definition in Cisco ISE

Before you configuring a dACL in a controller, you must configure the dACL name and definition in Cisco ISE. For more information, refer to Configure Per-User Dynamic Access Control Lists in ISE.

Configure dACL in a controller (CLI)

Before you begin

Ensure you have configured the RADIUS server and the **aaa-override** command in the policy profile. For more information, see **Configuring AAA for Local Authentication (CLI)**.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the wireless profile policy.

Example:

```
Device(config)# wireless profile policy policy-profile-name
```

Step 3 Configure AAA override to apply policies coming from the Cisco ISE servers.

Example:

```
Device(config-wireless-policy)# aaa-override
```

Step 4 Enable the profile policy.

Example:

```
Device(config-wireless-policy)# no shutdown
```

Configure explicit authorization server list (CLI)

Deploy an explicit authorization server list for network authorization.

This configuration is used to set up RADIUS servers for network authorization in a Cisco device.
Before you begin

Ensure you have the necessary RADIUS server details and access to the device.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify the RADIUS server name.

Example:

```
Device(config)# radius server server-name
```

Step 3 Specify the RADIUS server parameters.

Example:

```
Device(config-radius-server)# address ipv4 ip-address
```

Step 4 Specify the authorization and encryption key used between the device and the RADIUS server.

Example:

```
Device(config-radius-server)# pac key key
```

Step 5 Return to the configuration mode.

Example:

```
Device(config-radius-server)# exit
```

Step 6 Create a RADIUS server-group identification.

Example:

```
Device(config)# aaa group server radius server-group-name
```

server-group-name refers to the server group name. The valid range is from 1 to 32 alphanumeric characters.

Step 7 Create an authorization method list for web-based authorization.

Example:

```
Device(config)# aaa authorization network authorization-list group server-group-name
```

You must use the already created authorization method list.

Step 8 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The explicit authorization server list is now configured and ready for use.

Verify dACL configuration

To verify the dACL, use this command:

```
Device# show wireless client mac-address <client_mac> detail
                Local Policies:
                Service Template : wlan_svc_named-policy-profile_1_local (priority 254)
                VLAN             : 16
                Absolute-Timer   : 1800
                Server Policies:
                ACS ACL          : xACSACLx-IP-tftpv4_2-62de6299
                ACS ACL          : xACSACLx-IPV6-tftpv6_2-62de8087
                Resultant Policies:
                ACS ACL          : xACSACLx-IP-tftpv4_2-62de6299
                ACS ACL          : xACSACLx-IPV6-tftpv6_2-62de8087
                VLAN Name        : VLAN0016
                VLAN             : 16
                Absolute-Timer   : 1800
```

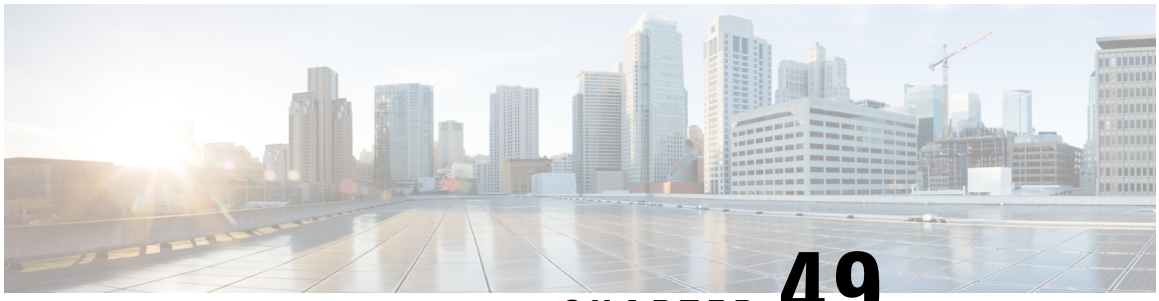
To verify dACLs, use this commands:

```
Device# show ip access-lists xACSACLx-IP-tftpv4_2-62de6299
                Extended IP access list xACSACLx-IP-tftpv4_2-62de6299
                1 deny ip any host 9.8.29.13
                2 permit ip any any (58 matches)
```

```
Device# show ipv6 access-list xACSACLx-IPV6-tftpv6_2-62de8087
               IPv6 access list xACSACLx-IPV6-tftpv6_2-62de8087
               deny ipv6 any host 2001:9:8:29:3AAD:A27A:973A:97CC sequence 1
               permit ipv6 any any (2 matches) sequence 2
```

To view all the downloaded dACLs, use this command:

```
Device# show ip access-lists
```



CHAPTER 49

Allowed List of Specific URLs

- Allowed lists of specific URLs, on page 401
- Add URL to allowed list, on page 401
- Portal resolving to multiple IP addresses, on page 403
- Verify URLs on the allowed list, on page 404

Allowed lists of specific URLs

An allowed list of specific URLs is a wireless controller feature that

- lets you add URLs to a list on the controller or access point so designated sites remain accessible
- enables web authentication use cases such as captive portals and walled gardens, and
- allows users to reach permitted sites before authenticating, even without full internet access.

Additional reference information

You do not need to authenticate to access URLs in the allowed list. If you try to reach a site not in the allowed list, you are redirected to the login page.

Accessing a support site

If "support.example.com" is added to the allowed list, users can access this site for help or information prior to logging into the network.

Add URL to allowed list

To configure a URL filter that allows specific URLs while blocking others.

This procedure is used in network environments where URL filtering is necessary to control access to web resources.

Before you begin

Ensure you have administrative access to the device and that URL filtering is supported.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the URL filter profile.

Example:

```
Device(config)# urlfilter list url-allowedlist-nbn
```

Step 3 Set the action for the URL filter list.

Example:

```
Device(config-urlfilter-params)# action permit
```

Configures the list as an allowed list, and the **deny** command configures the list as a blocked list.

Step 4 Configure the IP address of the redirect servers to which user requests will be redirected in case of denied requests.

Example:

```
Device(config-urlfilter-params)# redirect-server-ipv4 X.X.X.X
```

Step 5 Configure the URL to be allowed.

Example:

```
Device(config-urlfilter-params)# url www.cisco.com
```

Note **redirect-server-ipv4** and **redirect-server-ipv6** is applicable only in the local mode, specifically in post-authentication. For any further tracking or displaying any warning messages, the denied user request is redirected to the configured server.

But the **redirect-server-ipv4** and **redirect-server-ipv6** configurations do not apply to pre-authentication scenario as you will be redirected to the controller for the redirect login URL for any denied access.

You can associate the allowed URL with the ACL policy in flex profile.

Associating the allowed URL with the ACL policy in flex profile:

```
Device(config)# wireless profile flex default-flex-profile
            Device(config-wireless-flex-profile)# acl-policy user_v4_acl
            Device(config-wireless-flex-profile-acl)# urlfilter list url_allowedlist_nbn
            Device(config-wireless-flex-profile-acl)# exit
            Device(config-wireless-flex-profile)# description "default flex profile"

Device(config)# urlfilter enhanced-list urllist_pre_cwa
                Device(config-urlfilter-enhanced-params)# url url1.dns.com preference 1
action permit
                Device(config-urlfilter-enhanced-params)# url url2.dns.com preference 2
action deny
```

```
                Device(config-urlfilter-enhanced-params)# url url3.dns.com preference 3
action permit

Device(config)# wlan wlan5 5 wlan5
                    Device(config-wlan)#ip access-group web user_v4_acl
                    Device(config-wlan)#no security wpa
                    Device(config-wlan)#no security wpa
                    Device(config-wlan)#no security wpa wpa2 ciphers aes
                    Device(config-wlan)#no security wpa akm dot1x
                    Device(config-wlan)#security web-auth
                    Device(config-wlan)#security web-auth authentication-list default
                    Device(config-wlan)#security web-auth parameter-map global
                    Device(config-wlan)#no shutdown
```

Portal resolving to multiple IP addresses

You can use two IP addresses with the controller. However, the Web Auth Parameter Map allows pre-authentication to only one IP address. If an external portal, such as Cisco Spaces, resolves to multiple IP addresses or other HTTP resources require pre-authentication, you need a URL filter. The URL filter dynamically permits traffic to the configured URLs by snooping DNS requests and adding each resolved IP address to the intercept (redirect) and security (pre-auth) ACLs. This process enables you to access clients when necessary.

Additional information

- For FlexConnect deployments with local switching, apply the URL filter to the client at the AP for DNS snooping to work properly.
- Configuring the Web Auth Parameter Map automatically creates the following ACLs:
  - Redirect or intercept ACL (WA-v4-int): handles URL redirection.
  - Security ACL (WA-sec-): permits pre-auth access for HTTP or HTTPS, DNS, DHCP, and other required services.

Configuration steps for URL filter in FlexConnect profile

If you miss this step, the AP cannot dynamically add IP addresses. Clients may fail to redirect to the portal page when they request a secondary portal IP address.



Note Tip: Use visuals, diagrams, or tables as needed to clarify configuration mapping, ACL lists, or traffic flow.

Associating the allowed URL with the ACL policy in a Flex profile

```
  Device(config)# wireless profile flex default-flex-profile
  Device(config-wireless-flex-profile)# acl-policy WA-v4-<ip> (security ACL)
Device(config-wireless-flex-profile-acl)# urlfilter list url_allowedlist_nbn

  Device(config-wireless-flex-profile-acl)# exit
  Device(config-wireless-flex-profile)# description "default flex profile"
```

Verify URLs on the allowed list

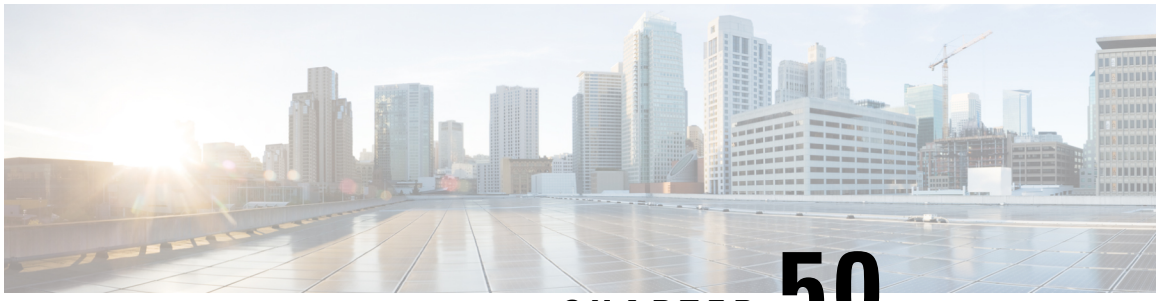
Verify URLs on the Allowed List.

```
Device# show wireless urlfilter summary
Black-list    - DENY
White-list    - PERMIT
Filter-Type   - Specific to Local Mode

URL-List                         ID  Filter-Type  Action   Redirect-ipv4  Redirect-ipv6
-------------------------------------------------------------------------------------------------
url-whitelist                    1    PRE-AUTH     PERMIT   192.0.2.1

Device#

Device# show wireless urlfilter details url-whitelist
List Name..................... : url-whitelist
Filter ID..................... : : 1
Filter Type................... : PRE-AUTH
Action........................ : PERMIT
Redirect server ipv4...... : 192.0.2.1
Redirect server ipv6...... :
Configured List of URLs
   URL....................... : www.example.com
```



CHAPTER 50

Web-Based Authentication

This chapter describes how to configure web-based authentication on the device. It contains these sections:

- Local web authentication , on page 405
- External Web Authentication, on page 425
- Authentication of Sleeping Client, on page 430
- Multiple Authentication Combinations with 802.1X and LWA, on page 433

Local web authentication

Local web authentication is a network security mechanism that

- authenticates users through a web browser login page
- enables access control on host systems that do not run IEEE 802.1X supplicants, and
- communicates with authentication, authorization, and accounting (AAA) servers to enforce security policies.

Feature history

Feature Name	Release	Description
Built-in Captive Portal Improvement	Cisco IOS XE 17.1.1	This release introduces support for special characters in the login portal banner title and banner text. The number of characters supported on the banner text has doubled to 400. The **exec-character-bits** command has been introduced.

Presentation options for local web authentication web pages

Local web authentication intercepts HTTP sessions on Layer 2 interfaces, and in some cases, Layer 3 interfaces (with restrictions for some switch models). When users try to access the network, local web authentication displays a login page and verifies user credentials with AAA servers, granting or denying access accordingly.

Local web authentication is categorized by the location where its web pages are hosted.

- **Internal**: Uses HTML pages (login, success, fail, and expire) stored on the embedded wireless controller .

- **Customized**: Uses customized HTML pages (login, success, fail, and expire) downloaded onto the embedded wireless controller for a customized user experience.
- **External**: Uses HTML pages hosted on an external web server.

We recommend that you follow the Cisco guidelines to create a customized web authentication login page. If you use the latest versions of Google Chrome or Mozilla Firefox browsers, ensure that your webauth bundle uses this line in the *login.html* file:

```
<body onload="loadAction();">
```

Web authentication modes

The types of web authentication differ according to the available web authentication pages.

- **Webauth**—The embedded wireless controller displays a page with the user name and password. Users enter valid credentials to gain network access.
- **Consent or web-passthrough**—The controller presents a policy page with the **Accept** and **Deny** buttons. Users simply click **Accept** to access the network – no credentials are required.
- **Webconsent**—This mode combines the features of Webauth and Consent. The embedded wireless controller displays a policy page with Accept or Deny buttons along with user name or password. Users must enter the correct credentials and click **Accept** to access the network.

Additional reference information

- You can view the webauth parameter-map information using the **show running-config** command.
- If you see tracebacks during client authentication, performance and behavior are not affected. Tracebacks may occur if Flexible Forwarding Mode (FFM) replies to Endpoint Profiler Module (EPM) for ACL application after the session is dequeued, usually because a timer expired or the session became **unauthorized**.
- You can configure web-based authentication on Layer 2 and layer 3 interfaces.
- When a client reaches the maximum limit of 200 HTTP connections, the system resets TCP connections and excludes your client from the network.

How local web authentication works

Summary

authentication enables secure network access for clients by prompting users to authenticate through a web login page. The process coordinates actions between the user, authentication server, and the network switch. The key components are:

- **User**: Initiates the HTTP session and enters authentication credentials.
- **Network switch**: Intercepts traffic, presents login pages, applies policies, and communicates with the authentication server.
- **Authentication server**: Verifies credentials and provides policy enforcement details.

Workflow

These are the stages of the process.

1. **Session initiation**: The user starts an HTTP session by attempting to access the network.
2. **Traffic interception and login page presentation**: The network switch intercepts the HTTP request and triggers the authorization process. It presents a login page for the user to enter their username and password.
3. **Credential submission and authentication**: After the user submits credentials, the switch forwards them to the authentication server
4. **Authentication outcome:**
   - If authentication succeeds, the switch downloads and activates the access policy assigned to the user from the server, then displays a login success page.
   - If authentication fails, the switch displays a login failure page. After a maximum number of failures, the login expired window appears, and the host is put on a watch list. Once the timeout expires, the user may try again
5. **Server non-response handling**: If the authentication server does not respond, and an AAA fail policy is in place, the switch applies the failure policy to the host and displays a login success page.
6. **Reauthentication triggers**: The switch reauthenticates a client if the host does not respond to an ARP probe (Layer 2) or does not send traffic within an idle timeout (Layer 3)

   suppress-feature-id="uabu_2960l_sw"

   .
7. **Session timeout enforcement**: The switch applies either the session timeout configured locally or provided by the server. The default local web authentication session timeout on controller is 1800 seconds from Cisco IOS XE 16.1.1 and later. The default session timeout value was infinite seconds, prior to Cisco IOS XE Denali 16.1.1.
8. **Session termination:**
   - If the terminate action is set to RADIUS, the switch sends a nonresponsive host request to the server; the server's response dictates the next action.
   - If the terminate action is set to default, the switch dismantles the session and removes the access policy.

Result

If authentication succeeds and the correct policies are applied, the user gains network access. If authentication fails, failure policies or timeout mechanisms may deny access.

Restrictions

- You cannot configure bypass authentication with the wireless web authentication feature.
- To update the redirect login URL, enable and then disable the WLAN. The redirect login URL specified in the web authentication parameter map changes when an AP rejoins.
- If authentication fails, users receive a failure page and can try to log in again. If the number of allowed attempts is exceeded, users may be excluded and receive a specific reason for the exclusion.

- Use the local web authentication feature to authenticate end users on host systems that do not run the IEEE 802.1x supplicant.

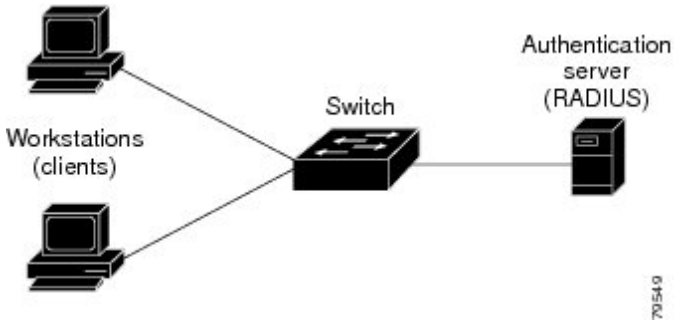
Roles of devices in local web authentication

In a local web authentication scenario, network devices assume specific roles to manage authentication and access to the LAN.

- **Client**: A device, such as a workstation, that requests network access and responds to authentication requests from the switch. The client must have an HTML browser with JavaScript enabled.
- **Authentication server**: A server that validates the identity of the client. The authentication server notifies the switch if the client is allowed or denied access to the LAN and related services.
- **Switch**: A network device that manages physical access to the network based on the authentication status of the client. The switch relays identity information and authorization responses between the client and the authentication server.

These device roles work together to ensure secure access control through local web authentication processes.

Figure 3: Local web authentication device roles



Banner messages for local web authentication

Local web authentication banners provide visual feedback to users during authentication on switches. The banners can display default or customized messages. They may also include branding or additional information on the login and result screens.

Default banner messages

When web authentication is enabled, one of these default messages appears on both the login screen and the authentication result pop-up page:

- Authentication Successful
- Authentication Failed
- Authentication Expired

Commands to configure local web authentication banner

You can configure the local web authentication banner using the .

Use the command in the global configuration mode:

```
Device(config)# parameter map type webauth global
Device(config-params-parameter-map)# banner ?
file <file-name>
text <Banner text>
title <Banner title>
```

You can add a custom message, such as a switch, router, or company name, to the banner using the command:

```
Device(config)# parameter map type webauth global
Device(config-params-parameter-map)# banner text <text>
```

You can add a logo or text file to the banner using the command:

```
Device(config)# parameter map type webauth global
Device(config-params-parameter-map)# banner text <filepath>
```

Banner examples

Figure 4: Customized web banner: Authentication Successful

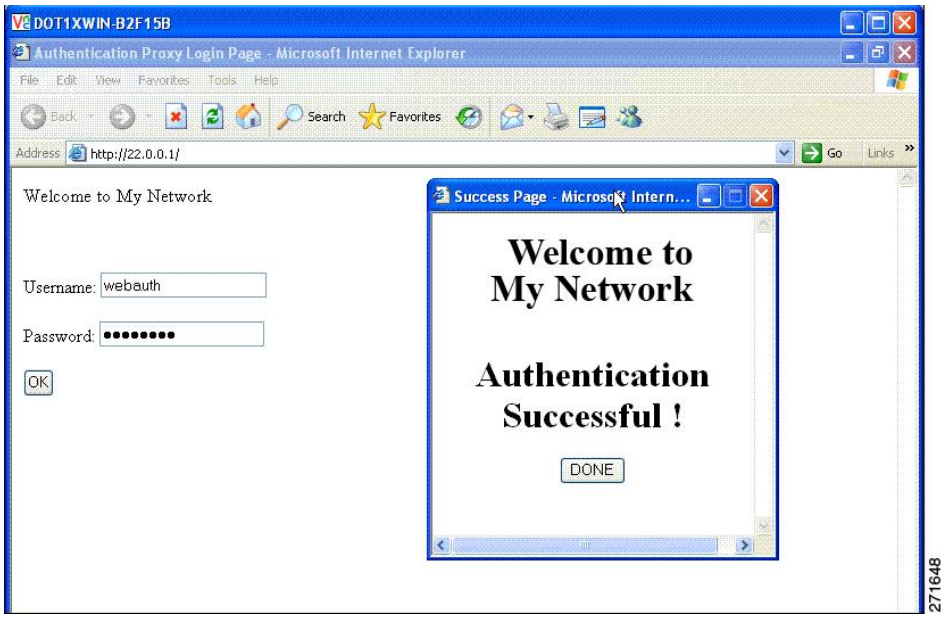
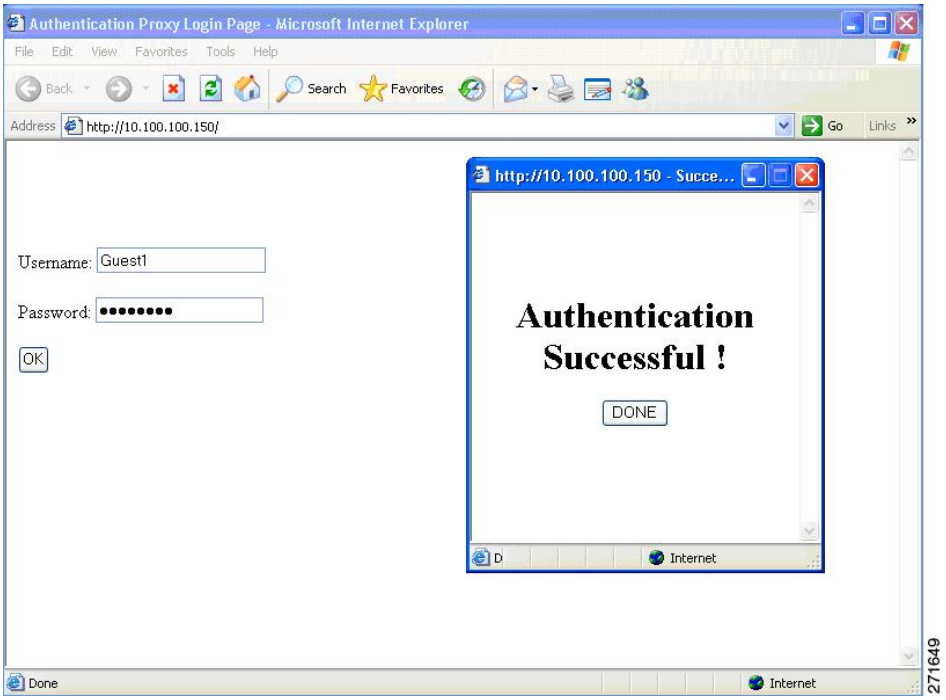


Figure 5: Login screen with no banner



Banner usage and behavior

- The default banners are *Cisco Systems* and *Switch host-name Authentication*. These banners appear on the login page. The *Cisco Systems* banner also appears on the authentication result pop-up page.
- The default banners appear unless custom banners are configured.
- If you do not enable a banner, only username and password dialog boxes appear on the web authentication login screen. You will not see a banner when you log into the switch.

Authentication states in customized local web authentication

During local web authentication, the switch's internal HTTP server hosts four HTML pages that communicate authentication states to the client.

You can replace the default internal HTML pages or specify a URL that redirects users after authentication. This URL replaces the internal Success page.

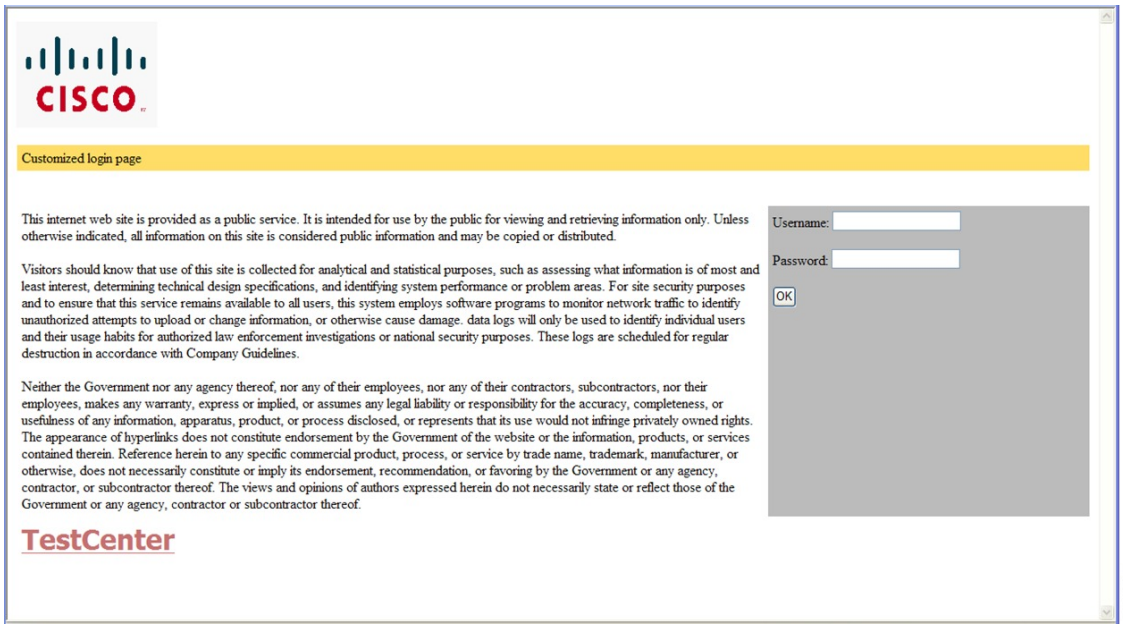
The four authentication pages and states are:

- Login: Credentials are requested from the client.
- Success: The client has authenticated successfully.
- Fail: Authentication attempt failed.
- Expire: The session expires after excessive failures.

You must configure all four pages. You can specify text or add a logo to each of the four pages.

Banner examples

Figure 6: Customizable Authentication Page



Best practices for customizing web authentication pages

- Add appropriate text to the banner and login pages as needed.
- Always include a valid HTML redirect command in the success page to redirect users to a specific URL after login
- Ensure the URL string is well-formed (for example, "http://www.cisco.com") to avoid browser errors.
- If you configure web pages for HTTP authentication, include the appropriate HTML commands. For example, HTML commands to set the page time out, to set a hidden password, or to confirm that the same page is not submitted twice.
- You can copy the configured web pages to the switch boot flash or the flash.
- The login page can reside on one flash device, while the success and failure pages can be stored on another flash device
- You must configure all four pages.
- All logo files—including image, flash, audio, video, and similar file types—stored in the system directory must use *web_auth_<filename>* as the file name. System directory examples are flash, disk0, or disk.
- You can copy the configured web pages to the switch boot flash or the flash.

Restrictions for customizing web authentication pages

- The banner page has no effect if it is configured together with a web authentication page.
- When the configured login form is enabled, the CLI command for redirecting users to a specific URL is unavailable. Configure redirection in the web page.

- If you enter the CLI command to redirect users to a specific URL after authentication and then configure web pages, the redirect command does not take effect.
- The configured authentication proxy feature supports both HTTP and SSL.

Guidelines for configuring a redirection URL for Successful Login page

- If you enable the custom authentication proxy web pages feature, you cannot use the redirection URL feature in the CLI. To redirect users after login, configure redirection in the custom login success page.
- If you enable the redirection URL feature, the configured authorization proxy banner is not be used.
- To remove the specification of a redirection URL, use the **no** form of the command.
- If a redirection URL is required after successful authentication, it must begin with a valid protocol prefix (such as http://) followed by the URL. If http:// is omitted, the browser might show a page not found error or similar issue

How to configure local web authentication

Configure default local web authentication

Table 28: Default local web authentication configuration

Feature	Default Setting
AAA	Disabled
RADIUS server • IP address • UDP authentication port • Key	• None specified
Default value of inactivity timeout	3600 seconds
Inactivity timeout	Enabled

Configure AAA authentication (GUI)

Set up AAA authentication to control network access using the GUI.

Use this task to define and assign authentication methods and server groups for device access.

Before you begin

Confirm that server groups are configured if you plan to use them.

Procedure

Step 1 Choose **Configuration** > **Security** > **AAA**.

Step 2 In the **Authentication** section, click **Add**.

Step 3 In the **Quick Setup: AAA Authentication** window that is displayed, enter a name for your method list.

Step 4 Choose the type of authentication you want to perform before allowing access to the network, in the **Type** drop-down list.

Step 5 In the **Group** Type drop-down list, select either a group of servers as your access server or a local server to authenticate access.

Step 6 To configure a local server to act as a fallback method when servers in the group are unavailable, check the **Fallback** to local check box.

Step 7 Choose the server groups you want to use to authenticate access to your network, from the **Available Server Groups** list and click > icon to move them to the **Assigned Server Groups** list.

Step 8 Click **Save & Apply to Device**.

The controller is now configured with AAA authentication, and users are authenticated using the chosen methods.

Configure AAA authentication (CLI)

Enable authentication, authorization, and accounting (AAA) on the device to manage login methods and network access.

AAA centralizes user authentication for device access and network services. Select a named method list or the default list, depending on your VTY line configuration.

If no method list is configured under VTY lines, add the default method list to the AAA configuration."

```
line vty 0 4
 authorization commands 15 abc
aaa authorization commands 15 abc group tacacs+
```

If a method-list is not configured under VTY lines, you must add the default method list to the AAA configuration:

```
line vty 0 4
 aaa authorization commands 15 default group tacacs+
```



Note Use the default list for AAA authorization if you plan to use features such as dACL.

Before you begin

Ensure that the TACACS+ server address and group name are available.

Procedure

Step 1 Enable AAA functionality.

Example:

```
Device
(config)# aaa new-model
```

Step 2 Define the list of authentication methods at login using the **aaa authentication login {default |** *named_authentication_list*} **group** *AAA_group_name* command.

Example:

```
Device(config)# aaa authentication login default group AAA_group_name
```

named_authentication_list refers to any name that is not greater than 31 characters.

AAA_group_name refers to the server group name. Define the **server_name** at the beginning of the configuration.

Step 3 Create an authorization method list for web-based authorization using the **aaa authorization network {default |** *named_authorization_list*} **group** *AAA_group_name* command.

Example:

```
Device(config)# aaa authorization network default group group1
```

Step 4 Specify a AAA server.

Example:

```
Device(config)# tacacs-server host 10.1.1.1
```

Configure the HTTP or HTTPS server (GUI)

Set up HTTP and HTTPS access to enable secure web-based management of the device.

HTTP provides basic web access; HTTPS secures connections with SSL encryption. You can configure access ports, authentication, trust points, and session policies to meet your security requirements.

Before you begin

Confirm necessary certificates are available if using HTTPS trust points.

Procedure

Step 1 Choose **Administration** > **Management** > **HTTP/HTTPS/Netconf**.

Step 2 In the **HTTP/HTTPS Access Configuration** section, enable HTTP Access and enter the port that will listen for HTTP requests. The default port is 80. Valid values are 80, and ports between 1025 and 65535.

Step 3 Enable **HTTPS Access** on the device and enter the designated port to listen for HTTPS requests. The default port is 1025. Valid values are 443 and ports between 1025 and 65535. Data exchanged over a secure HTTP connection is encrypted before transmission across the Internet. SSL encryption over HTTP enables secure configuration of the switch through a web browser.

Step 4 Choose the **Personal Identity Verification** as enabled or disabled.

Step 5 In the **HTTP Trust Point Configuration** section, enable **Enable Trust Point** to use Certificate Authority servers as trustpoints.

Step 6 From the **Trust Points** drop-down list, choose a trust point.

Step 7 In the **Timeout Policy Configuration** section, enter the HTTP timeout policy in seconds. Enter a value between one to 600 seconds.

Step 8 Enter the number of minutes of inactivity allowed before the session times out. Enter a value between 180 and 1200 seconds.

Step 9 Enter the server life time in seconds. Enter a value between one and 86400 seconds.

Step 10 Enter the maximum number of requests the device can accept. Valid values range from one and 86400 requests.

Step 11 Save the configuration.

The device is configured for HTTP or HTTPS access according to your specified settings.

Configure the HTTP server (CLI)

Enable HTTP or HTTPS server functionality on your device to support local web authentication.

Local web authentication requires the HTTP server to be enabled on the controller.

You can configure both HTTP and HTTPS servers to support device management and user authentication.

Both HTTP and HTTPS servers can be configured to support device management and user authentication.

Note that some browsers, such as the Apple psuedo-browser, do not open if you configure only the **ip http secure-server** command. You should also configure the **ip http server** command.

Procedure

Step 1 Enable the HTTP server. The local web authentication feature uses the HTTP server to communicate with the hosts for user authentication.

Example:

```
Device(config)# ip http server
```

Step 2 Enable HTTPS.

Example:

```
Device(config)# ip http secure-server
```

You can configure custom authentication proxy web pages or specify a redirection URL for successful login.

Note
To ensure secure authentication when you enter the **ip http secure-server** command, the login page is always in HTTPS (secure HTTP) even if the user sends an HTTP request.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The controller is now configured with the HTTP or HTTPS or both. This enables local web authentication and secure browser access for users.

Allow special characters for serial port

Configure the serial port to support special characters for advanced device communication.

Use this procedure when the connected device or application must process special characters on the serial console port.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the primary terminal line number.

Example:

```
Device(config)# line console 0
```

Step 3 Configure the time to disconnect idle EXEC sessions using the **exec-timeout** *mins sec* command.

Example:

```
Device(config-line)# exec-timeout 12 0
```

Step 4 Configure login authentication checking using the **login authentication** *word* **default** command.

Example:

```
Device(config-line)# login authentication NO_LOGIN
```

You can configure an authentication list with a name or use the default authentication list

Step 5 Configure the character widths of EXEC command characters using the **exec-character-bit** {**7** | **8**} command.

Example:

```
Device(config-line)# exec-character-bit 8
```

Step 6 Configure the stop bits for the console port using the **stopbits** {**1** | **1.5** | **2**} command.

Example:

```
Device(config-line)# stopbits 1
```

Step 7 Return to privileged EXEC mode.

Example:

```
Device(config-line)# end
```

The serial port is now configured to support special characters according to your settings.

Allow special characters for VTY port

Enable the use of special (non-standard) characters in the banner text for Virtual Teletype (VTY) ports, which enhances customization options and supports global character sets.

You can allow special (non-standard) characters in the banner text for Virtual Teletype (VTY) ports. This lets you customize banners and support global character sets.

You may want to allow special characters in the banner displayed on the VTY port—for example, to include accented letters, non-English text, or symbols for branding or user communication.

Before you begin

Ensure you have determined the desired banner text and any required special characters.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a parameter map and enter parameter-map webauth configuration mode.

Example:

```
Device(config)# parameter-map type webauth global
```

Step 3 Create a custom banner using the **banner text** *text* command.

Example:

```
Device(config-params-parameter-map)# banner text #Hêllö#
```

You can create a custom banner (of up to 400 characters) by entering *c <banner-text> c*, where *c* is a delimiting character.

If the banner text exceeds 400 characters (400 characters is about 250 words), you see an error message and the configuration is rejected. The parser limits each line to 254 characters (about 150 words), including CLI keywords. If you need more than 254 characters, split the banner text into multiple lines.

The webauth login page displays only the default banner strings, if banner command is not configured.

Step 4 Return to privileged EXEC mode.

Example:

```
Device(config-params-parameter-map)# end
```

You can now use special characters in the VTY port banner. When users connect through VTY, they see your custom banner.

Create a parameter map (GUI)

Define criteria-based policies to control device and user access within the local policy framework.

Use this task to create a parameter map by specifying match criteria and associating service templates. This enables dynamic policy application based on device type, user role, and other attributes.

Before you begin

Ensure you have the required policy details and service templates ready.

Procedure

Step 1 Choose **Configuration** > **Security** > **Local Policy**.

Step 2 Click **Add**.

Step 3 Click **Policy Map**.

Step 4 Enter **Policy Map Name**.

Step 5 In the **Match Criteria List** settings, click **Add**.

Step 6 In the **Add Match Criteria** settings, choose the service template from the **Service Template** drop-down list.

Step 7 Choose the filters from **Device Type**, **User Role**, **User Name**, **OUI**, and **MAC Address** drop-down lists.

Step 8 Click **Add Criteria**.

Step 9 Click **Apply to Device**.

The parameter map is created and applied, enabling policy enforcement based on the selected criteria.

Configure the maximum web authentication request retries

Set the maximum number of web authentication request retries to define how many times the system attempts authentication before it stops.

Configure this setting to adjust the tolerance for failed web authentication attempts, which can improve network security and user experience.

Before you begin

Ensure you are in global configuration mode on your device.

Procedure

Step 1 Configure the maximum web authentication request retries.

Example:

```
Device(config)# wireless security web-auth retries  number
```

number is the maximum number of web authentication request retries. The valid range is 0-20.

Step 2 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

You have configured the specified maximum number of web authentication request retries.

Configure a local banner in web authentication page (GUI)

Present a custom banner to users on the web authentication page to meet organizational messaging or compliance requirements.

Use this task to configure a banner that will display on the login page for web authentication sessions.

Procedure

Step 1 Choose **Configuration** > **Security** > **Web Auth**.

Step 2 In the **Webauth Parameter Map** tab, click the parameter map name. The **Edit WebAuth Parameter** window is displayed.

Step 3 In the **General** tab and choose the required Banner Type:

- If you choose **Banner Text**, enter the required banner text to be displayed.
- If you choose **File Name**, specify the path of the file from which the banner text has to be picked up.

Step 4 Click **Update & Apply**.

The specified banner displays on the web authentication page as configured.

Configure a local banner in web authentication page (CLI)

Present a custom banner to users on the Web Authentication page to meet organizational messaging or compliance requirements.

Use this task to configure a banner that displays on the login page for web authentication sessions.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the web authentication parameters. Enters the parameter map configuration mode.

Example:

```
Device(config)# parameter-map type webauth param-map
```

Step 3 Enable the local banner using the **banner** [*file* | *banner-text* | *title*] command.

Example:

```
Device(config-params-parameter-map)# banner http C My Switch C
```

Create a custom banner by entering *C banner-text C* (where *C* is a delimiting character), or *file* that indicates a file (for example, a logo or text file) that appears in the banner, or *title* that indicates the title of the banner.

Step 4 Return to privileged EXEC mode.

Example:

```
Device(config-params-parameter-map)# end
```

The specified banner displays on the web authentication page as configured.

Configuration examples for local web authentication

Example: obtain a web authentication certificate

This example shows how to obtain web authentication certificate.

```
DeviceDevice# configure terminal
Device(config)# crypto pki import cert pkcs12 tftp://10.1.0.100/ldapserver-cert.p12 cisco
Device(config)# end
Device# show crypto pki trustpoints cert
 Trustpoint cert:
    Subject Name:
    e=rkannajr@cisco.com
    cn=sthaliya-lnx
    ou=WNBU
    o=Cisco
    l=SanJose
    st=California
    c=US
          Serial Number (hex): 00
    Certificate configured.
Device# show  crypto pki certificates cert
Certificate
  Status: Available
  Certificate Serial Number (hex): 04
  Certificate Usage: General Purpose
  Issuer:
    e=rkannajr@cisco.com
    cn=sthaliya-lnx
    ou=WNBU
    o=Cisco
    l=SanJose
    st=California
    c=US
  Subject:
    Name: ldapserver
    e=rkannajr@cisco.com
    cn=ldapserver
    ou=WNBU
    o=Cisco
    st=California
    c=US
  Validity Date:
```

```
    start date: 07:35:23 UTC Jan 31 2012
    end   date: 07:35:23 UTC Jan 28 2022
  Associated Trustpoints: cert ldap12
  Storage: nvram:rkannajrcisc#4.cer

CA Certificate
  Status: Available
  Certificate Serial Number (hex): 00
  Certificate Usage: General Purpose
  Issuer:
    e=rkannajr@cisco.com
    cn=sthaliya-lnx
    ou=WNBU
    o=Cisco
    l=SanJose
    st=California
    c=US
  Subject:
    e=rkannajr@cisco.com
    cn=sthaliya-lnx
    ou=WNBU
    o=Cisco
    l=SanJose
    st=California
    c=US
  Validity Date:
    start date: 07:27:56 UTC Jan 31 2012
    end   date: 07:27:56 UTC Jan 28 2022
  Associated Trustpoints: cert ldap12 ldap
  Storage: nvram:rkannajrcisc#0CA.cer
```

Example: display a web authentication certificate

This example shows how to display a web authentication certificate.

```
Device# show crypto ca certificate verb
     Certificate
     Status: Available
     Version: 3
     Certificate Serial Number (hex): 2A9636AC00000000858B
     Certificate Usage: General Purpose
     Issuer:
    cn=Cisco Manufacturing CA
    o=Cisco Systems
    Subject:
    Name: WS-C3780-6DS-S-2037064C0E80
    Serial Number: PID:WS-C3780-6DS-S SN:FOC1534X12Q
    cn=WS-C3780-6DS-S-2037064C0E80
    serialNumber=PID:WS-C3780-6DS-S SN:FOC1534X12Q
    CRL Distribution Points:
    http://www.cisco.com/security/pki/crl/cmca.crl
    Validity Date:
    start date: 15:43:22 UTC Aug 21 2011
    end   date: 15:53:22 UTC Aug 21 2021
    Subject Key Info:
    Public Key Algorithm: rsaEncryption
    RSA Public Key: (1024 bit)
    Signature Algorithm: SHA1 with RSA Encryption
    Fingerprint MD5: A310B856 A41565F1 1D9410B5 7284CB21
    Fingerprint SHA1: 04F180F6 CA1A67AF 9D7F561A 2BB397A1 0F5EB3C9
    X509v3 extensions:
    X509v3 Key Usage: F0000000
```

```
  Digital Signature
  Non Repudiation
  Key Encipherment
  Data Encipherment
X509v3 Subject Key ID: B9EEB123 5A3764B4 5E9C54A7 46E6EECA 02D283F7
X509v3 Authority Key ID: D0C52226 AB4F4660 ECAE0591 C7DC5AD1 B047F76C
Authority Info Access:
Associated Trustpoints: CISCO_IDEVID_SUDI
Key Label: CISCO_IDEVID_SUDI
```

Example: choose the default web authentication login page

This example shows how to choose a default web authentication login page.

```
Device# configure terminal
Device(config)# parameter-map type webauth test
This operation will permanently convert all relevant authentication commands to their CPL
control-policy equivalents. As this conversion is irreversible and will
disable the conversion CLI 'authentication display [legacy|new-style]', you are strongly
advised to back up your current configuration before proceeding.
Do you wish to continue? [yes]: yes
Device(config)# wlan wlan50
Device(config-wlan)# shutdown
Device(config-wlan)# security web-auth authentication-list test
Device(config-wlan)# security web-auth parameter-map test
Device(config-wlan)# no shutdown
Device(config-wlan)# end
Device# show running-config | section wlan50
wlan wlan50 50 wlan50
 security wpa akm wpa2
 security wpa wpa1
 security wpa wpa1 ciphers aes
 security wpa wpa1 ciphers tkip
 security web-auth authentication-list test
 security web-auth parameter-map test
 session-timeout 1800
 no shutdown

Device# show running-config | section parameter-map type webauth test
parameter-map type webauth test
 type webauth
```

Example: choosing a CWA login page from an IPv4 external web server

This example shows how to choose a customized web authentication login page from an IPv4 external web server.

```
Device# configure terminal
Device(config)# parameter-map type webauth global
Device(config-params-parameter-map)# virtual-ip ipv4 192.0.2.1.
Device(config-params-parameter-map)# parameter-map type webauth test
Device(config-params-parameter-map)# type webauth
Device(config-params-parameter-map)# redirect for-login http://9.1.0.100/login.html
Device(config-params-parameter-map)# redirect portal ipv4 9.1.0.100
Device(config-params-parameter-map)# end
Device# show running-config | section parameter-map
parameter-map type webauth global
virtual-ip ipv4 192.0.2.1.
parameter-map type webauth test
type webauth
```

```
redirect for-login http://10.1.0.100/login.html
redirect portal ipv4 10.1.0.100
security web-auth parameter-map rasagna-auth-map
security web-auth parameter-map test
```

Example: choose a customized web authentication login page from an IPv6 external web server

This example shows how to choose a customized web authentication login page from an IPv6 external web server.

```
Device# configure terminal
Device(config)# parameter-map type webauth global
Device(config-params-parameter-map)# virtual-ip ipv6 2001:DB8::/48
Device(config-params-parameter-map)# parameter-map type webauth test
Device(config-params-parameter-map)# type webauth
Device(config-params-parameter-map)# redirect for-login http://9:1:1::100/login.html
Device(config-params-parameter-map)# redirect portal ipv6 9:1:1::100
Device(config-params-parameter-map)# end
Device# show running-config | section parameter-map
parameter-map type webauth global
virtual-ip ipv6 2001:DB8::/48
parameter-map type webauth test
type webauth
redirect for-login http://10:1:1::100/login.html
redirect portal ipv6 10:1:1::100
security web-auth parameter-map rasagna-auth-map
security web-auth parameter-map test
```

Example: assigning login, login failure, and logout pages per WLAN

This example shows how to assign login, login failure and logout pages per WLAN.

```
Device# configure terminal
Device(config)# parameter-map type webauth test
Device(config-params-parameter-map)# custom-page login device flash:loginsantosh.html
Device(config-params-parameter-map)# custom-page login expired device flash:loginexpire.html
Device(config-params-parameter-map)# custom-page failure device flash:loginfail.html
Device(config-params-parameter-map)# custom-page success device flash:loginsucess.html
Device(config-params-parameter-map)# end
Device# show running-config | section parameter-map type webauth test
 parameter-map type webauth test
 type webauth
 redirect for-login http://10.1.0.100/login.html
 redirect portal ipv4 10.1.0.100
 custom-page login device flash:loginsantosh.html
 custom-page success device flash:loginsucess.html
 custom-page failure device flash:loginfail.html
 custom-page login expired device flash:loginexpire.html
```

Example: configure preauthentication ACL

This example shows how to configure preauthentication ACL.

```
Device# configure terminal
Device(config)# wlan fff
Device(config-wlan)# shutdown
Device(config-wlan)# ip access-group web preauthrule
```

```
Device(config-wlan)# no shutdown
Device(config-wlan)# end
Device# show wlan name fff
```

Example: configure webpassthrough

This example shows how to configure webpassthrough.

```
Device# configure terminal
Device(config)# parameter-map type webauth webparalocal
Device(config-params-parameter-map)# type consent
Device(config-params-parameter-map)# end
Device# show running-config | section parameter-map type webauth test
 parameter-map type webauth test
 type webauth
 redirect for-login http://10.1.0.100/login.html
 redirect portal ipv4 10.1.0.100
```

Verify web authentication type

To verify the web authentication type, run the command:

```
Device# show parameter-map type webauth all
Type Name
--------------------------------
Global global
Named webauth
Named ext
Named redirect
Named abc
Named glbal
Named ewa-2
```

```
Device# show parameter-map type webauth global
Parameter Map Name : global
Banner:
Text : CisCo
Type : webauth
Auth-proxy Init State time : 120 sec
Webauth max-http connection : 100
Webauth logout-window : Enabled
Webauth success-window : Enabled
Consent Email : Disabled
Sleeping-Client : Enabled
Sleeping-Client timeout : 60 min
Virtual-ipv4 : 10.0.2.1.
Virtual-ipv4 hostname :
Webauth intercept https : Disabled
Webauth Captive Bypass : Disabled
Webauth bypass intercept ACL :
Trustpoint name :
HTTP Port : 80
Watch-list:
Enabled : no
Webauth login-auth-bypass:
```

```
Device# show parameter-map type webauth name global
Parameter Map Name : global
Type : webauth
Auth-proxy Init State time : 120 sec
Webauth max-http connection : 100
Webauth logout-window : Enabled
Webauth success-window : Enabled
```

```
Consent Email : Disabled
Sleeping-Client : Disabled
Webauth login-auth-bypass:
```

External Web Authentication

Configure EWA with single WebAuth server address and default ports (80/443) (CLI)

Configure External Web Authentication (EWA) on your device to use a single WebAuth server address with default ports (80 or 443).

Use this procedure to redirect guest WLAN clients to a specific WebAuth portal using default HTTP or HTTPS ports.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Define the authentication method at login.

Example:

```
Device(config)# aaa authentication login WEBAUTH local
```

Step 3 Create the parameter map using the **parameter-map type webauth** *parameter-map-name* command.

Example:

```
Device(config)# parameter-map type webauth ISE-Ext-Webauth_IP
```

The *parameter-map-name* must not exceed 99 characters.

Step 4 Configure the webauth type parameter.

Example:

```
Device(config-params-parameter-map)# type webauth
```

Step 5 Configure the URL string for redirect during login using the **redirect for-login** *URL-String*command.

Example:

```
Device(config-params-parameter-map)#  redirect for-login
https://192.168.0.98:443/portal/PortalSetup.action?portal=ad64b062-1098-11e7-8591-005056891b52
```

Step 6 Configure the external portal IPv4 address.

Example:

```
Device(config-params-parameter-map)# redirect portal ipv4 192.168.0.98
```

Step 7 Return to global configuration mode.

Example:

```
Device(config-params-parameter-map)# exit
```

Step 8 Configure a WLAN using the **wlan** *wlan-name wlan-id SSID-name* command.

Example:

```
Device(config)#  wlan EWLC3-GUEST 3 EWLC3-GUEST
```

Step 9 Disable adaptive 11r.

Example:

```
Device(config-wlan)# no security ft adaptive
```

Step 10 Disable WPA security.

Example:

```
Device(config-wlan)# no security wpa
```

Step 11 Disable WPA2 security.

Example:

```
Device(config-wlan)# no security wpa wpa2
```

Step 12 Disable WPA2 ciphers for AES.

Example:

```
Device(config-wlan)# no security wpa wpa2 ciphers aes
```

Step 13 Disable security AKM for dot1x.

Example:

```
Device(config-wlan)# no security wpa akm dot1x
```

Step 14 Enable web authentication for WLAN.

Example:

```
Device(config-wlan)# security web-auth
```

Step 15 Enable authentication list for dot1x security using the **security web-auth authentication-list** *authenticate-list-name* command.

Example:

```
Device(config-wlan)# security web-auth authentication-list WEBAUTH
```

Step 16 Configure the parameter map using the **security web-auth parameter-map** *parameter-map-name* command.

Example:

```
Device(config-wlan)# security web-auth parameter-map ISE-Ext-Webauth_IP
```

Note
If parameter map is not associated with a WLAN, the configuration uses the global parameter map.

Step 17 Return to privileged EXEC mode.

Example:

```
Device(config-wlan)# end
```

Once enabled for the configured WLAN, web authentication redirects clients to the specified WebAuth portal using default ports.

Configure EWA with multiple web servers and/or ports different than default (80/443)

Configure an External Web Authentication (EWA) workflow to support multiple web servers and custom port numbers using CLI.

Enable guest access using EWA if there are multiple external web servers or if web authentication must use ports other than the default ports of 80 or 443.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Define an extended IPv4 access list using a name, and enters access-list configuration mode.

Example:

```
Device(config)# ip access-list extended preauth_ISE_Ext_WA
```

Step 3 Permit access from any host to the first external web server port number 8443.

Example:

```
Device(config)# access-list-number permit tcp any host external_web_server_ip_address1 eq
port-number
```

Example:

```
Device(config)# 10 permit tcp any host 192.168.0.98 eq 8443
```

Step 4 Permit access from any host to the second external web server port number 8443.

Example:

```
Device(config)# access-list-number permit tcp any host external_web_server_ip_address2 eq
port-number
```

Example:

```
Device(config)# 10 permit tcp any host 192.168.0.99 eq 8443
```

Step 5 Permit DNS UDP traffic.

Example:

```
Device(config)# access-list-number permit udp any eq domain
```

Example:

```
Device(config)# 20 permit udp any any eq domain
```

Step 6 Permit DHCP traffic using the **bootpc**.

Example:

```
Device(config)# 30 permit udp any any eq bootpc
```

Example:

```
Device(config)# access-list-number permit udp any any eq bootpc
```

Step 7 Permit DHCP traffic using **bootps**.

Example:

```
Device(config)# access-list-number permit udp any any eq bootps
```

Example:

```
Device(config)# 40 permit udp any any eq bootps
```

Step 8 Permit the access from the first external web server port 8443 to any host.

Example:

```
Device(config)# access-list-number permit tcp any host external_web_server_ip_address1 eq
port-number any
```

Example:

```
Device(config)# 50 permit tcp host 192.168.0.98 eq 8443 any
```

Step 9 Permit the access from the second external web server port 8443 to any host.

Example:

```
Device(config)# access-list-number permit tcp any host external_web_server_ip_address2 eq
port-number any
```

Example:

```
Device(config)# 50 permit tcp host 192.168.0.99 eq 8443 any
```

Step 10 Permit DNS TCP traffic.

Example:

```
Device(config)# access-list-number permit tcp any eq domain
```

Example:

```
Device(config)# 60 permit tcp any any eq domain
```

Step 11 Deny all the other traffic.

Example:

```
Device(config)# access-list-number deny ip any any
```

Example:

```
Device(config)# 70 deny ip any any
```

Step 12 Create the WLAN using the **wlan** *wlan-name wlan-id ssid* command.

Example:

```
Device(config)# wlan wlan-name wlan-id ssid
```

Example:

```
Device(config)# wlan EWLC3-GUEST 3 EWLC3-GUEST
```

Step 13 Configure the IPv4 WLAN web ACL

Example:

```
Device(config-wlan)# ip access-group web name
```

The variable *name* specifies the user-defined IPv4 ACL name

Step 14 Return to privileged EXEC mode.

Example:

```
Device(config-wlan)# end
```

This configuration allows EWA with multiple external web servers and ports. It supports DNS or DHCP traffic and blocks unauthorized traffic.

Configure wired guest EWA with multiple web servers, ports different than default (80/443)

Configure Wired Guest External Web Authentication (EWA) when using multiple web servers or ports other than the default ports of 80 or 443 using CLI.

Wired Guest LAN profiles do not allow manual ACL assignment directly. To support multiple web servers or custom ports, use the bypass ACL in the global parameter map.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Define an extended IPv4 access list using a name, and enter access-list configuration mode.

Example:

```
Device(config)# ip access-list extended BYPASS_ACL
```

Step 3 Allow the traffic to switch centrally.

Example:

```
Device(config)# 10 deny ip any host 192.168.0.45
```

Step 4 Allow the traffic to switch centrally

Example:

```
Device(config)# access-list-number  deny ip any host hostname
```

Example:

```
Device(config)# 20 deny ip any host 4.0.0.1
```

Step 5 Creates a parameter map and enter parameter-map webauth configuration mode.

Example:

```
Device(config)# parameter-map type webauth global
```

Step 6 Create a WebAuth bypass intercept using the ACL name.

Example:

```
Device(config-params-parameter-map)# webauth-bypass-intercept BYPASS_ACL
```

Note
You cannot manually apply an ACL to the wired guest profile to configure external web authentication with multiple IP addresses or different ports. To work around this, use the bypass ACL in the wired guest profile.

Step 7 Return to privileged EXEC mode.

Example:

```
Device(config-params-parameter-map)# end
```

The wired guest profile uses the bypass ACL, enabling external web authentication with multiple web servers or custom ports.

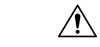
Authentication of Sleeping Client

Authenticating sleeping clients

A sleeping client is a wireless device that

- has completed web authentication and been granted guest access
- is allowed to enter sleep mode and wake up without reauthenticating through the login page, and
- the controller stores sleeping client information for a configurable duration before requiring reauthentication.

The valid range is 10 minutes to 43200 minutes, with the default being 720 minutes. You can also configure this duration on WebAuth parameter map that is mapped to a WLAN. The sleeping client timer is activated when conditions such as idle timeout, session timeout, WLAN disabling, or AP nonoperational status occur.



Caution If the MAC address of a client in sleep mode is spoofed, a fake device, such as a laptop, can be mistakenly authenticated.

Feature History

Feature Name	Release	Description
Webauth Sleeping Client Support	Cisco IOS XE 17.1.1s	The web authentication sleeping clients feature supports multiple combinations of authentications for a given client, which are configured on the WLAN profile.

Scenarios where sleeping clients do not need reauthentication

- Suppose there are two embedded wireless controller s in a mobility group. A client that is associated with one embedded wireless controller goes to sleep and then wakes up and gets associated with the other embedded wireless controller.
- Suppose there are three embedded wireless controller s in a mobility group. A client that is associated with the second embedded wireless controller that is anchored to the first controller goes to sleep, wakes up, and gets associated with the third embedded wireless controller.
- A client sleeps, wakes up and gets associated with the same or different export foreign embedded wireless controller that is anchored to the export anchor.

Guidelines for mobility scenarios

- This feature is supported on the FlexConnect scenario with local switching and central authentication.
- L2 roaming in the same subnet is supported.
- Anchor sleeping timer is applicable.
- The sleeping client information is shared between multiple auto anchors when a sleeping client moves from one anchor to another.

Restrictions on authenticating sleeping clients

- If the MAC address of a client in sleep mode is spoofed, a fake device, such as a laptop, can be mistakenly authenticated.
- The sleep client feature works only for WLAN configured with WebAuth security.
- You can configure the sleeping clients only on a per WebAuth parameter-map basis.
- The authentication of sleeping clients feature is supported only on WLANs that have Layer 3 security enabled.
- When Layer 3 security is enabled, the Authentication, Passthrough, and On MAC Filter failure web policies are supported. The Splash Page Web Redirect web policy is not supported.
- The central web authentication of sleeping clients is not supported.
- The authentication of sleeping clients feature is not supported on guest LANs and remote LANs.
- A guest access sleeping client that has a local user policy is not supported. In this case, the WLAN-specific timer is applied.

Configure authentication for sleeping clients (GUI)

Enable authentication for sleeping clients to ensure devices can maintain secure network access even after entering sleep mode.

Sleeping clients, such as laptops or mobile devices, periodically enter low-power states. You configure authentication to ensure they reconnect securely and seamlessly when they wake.

Procedure

Step 1 Choose **Configuration** > **Security** > **Web Auth**.

Step 2 In the **Webauth Parameter Map** tab, click the parameter map name. The **Edit WebAuth Parameter** window is displayed.

Step 3 Check **Sleeping Client Status** check box.

Step 4 Click **Update & Apply to Device**.

Authentication for sleeping clients is now enabled. Devices entering sleep mode will reconnect securely without manual intervention.

Configure authentication for sleeping clients (CLI)

Configure authentication parameters to manage sleeping wireless clients and control their session persistence on the device.

Sleeping clients are wireless devices that temporarily disconnect due to power-saving or roaming behaviors. Configuring authentication for sleeping clients ensures they are recognized and handled appropriately during these periods.

Procedure

Step 1 Create a parameter map and enters parameter-map webauth configuration mode.

Example:

```
Device(config)# parameter-map type webauth global
```

Step 2 Configure the sleeping client timeout to 100 minutes.

Example:

```
Device(config-params-parameter-map)# sleeping-client timeout 100
```

Valid range is between 10 minutes and 43200 minutes.

Note
If you do not use the timeout keyword, the sleeping client is configured with the default timeout value of 720 minutes.

Step 3 Exit parameter-map webauth configuration mode and returns to privileged EXEC mode.

Example:

```
Device# end
```

Step 4 (Optional) Show the MAC address of the clients and the time remaining in their respective sessions.

Example:

```
Device# show wireless client sleeping-client
```

Step 5 (Optional) Delete sleeping client entries from the sleeping client cache.

- **clear wireless client sleeping-client**—Deletes all sleeping client entries from the sleeping client cache.
- **clear wireless client sleeping-client mac-address** *mac-addr*—Deletes the specific MAC entry from the sleeping client cache.

Example:

```
Device# clear wireless client sleeping-client
mac-address 00e1.e1e1.0001
```

The device displays the global configuration prompt, allowing you to make configuration changes.

Multiple Authentication Combinations with 802.1X and LWA

Multiauthentication combinations with 802.1X authentication and local web authentication

A multiauthentication combination is a network access control strategy that

- allows multiple authentication methods (such as 802.1X and web authentication) to be used in sequence
- enables enforcement of security and user consent policies in wireless networks, and
- supports policy merging to maintain consistent access controls throughout device connections.

Expanded Explanation

In a wireless setup, for example, in a university, clients authenticate through 802.1X authentication. Because the 802.1X (dot1X) authentication process is secure and does not require user intervention, the end-users are unaware of the network that their devices are connected to. This could lead to serious concerns if they connect to the university's wireless network and post inappropriate content or access restricted content.

To avoid this situation, web authentication (webauth) and 802.1X authentication are configured in the network. End-user consent is used as a part of webauth to inform users that they are connected to the university's Wi-Fi network.

When the end-users accept the credentials for consent, AAA policies are not applied. The AAA policies that were applied earlier are deleted, resulting in a VLAN change and client disconnection.

A new command is introduced in Cisco IOS XE Dublin 17.11.1 to fix this issue. When you run the **consent activation-mode merge** command, the policy that is applied through consent is merged with the policy applied for 802.1X or MAC Authentication Bypass (MAB) authentication, thereby allowing clients to access the network. This command is available in parameter-map mode, which is configured with **type consent** command.

Feature History

Release	Feature	Feature Information
Cisco IOS XE Dublin 17.11.1	Multiauthentication Combination of 802.1X and Local Web Authentication	This feature supports the merging of applied policies during multiauthentication of 802.1X or MAC authentication bypass (MAB) and local web authentication (LWA).

Limitations for multi authentication combination of 802.1X and local web authentication

- It is not possible to configure this feature on the controller GUI.
- SNMP is not supported.
- When the **consent activation-mode merge** command is not configured on the webauth parameter map, the default activation mode is Replace. This means that the user profile for consent replaces all the user profile policies that were previously applied.

Enable the multiauthentication combinations of 802.1X authentication and local web authentication (CLI)

Configure multiauthentication by combining 802.1X authentication and local web authentication (LWA) on the device using CLI commands.

Use this procedure when you want to allow users to authenticate through both 802.1X and browser-based local web authentication. This is commonly needed for networks supporting multiple authentication types on a single interface.

Before you begin

Ensure that you have working knowledge of multiauthentication concepts, LWA (consent), and AAA override.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the webauth type parameter. Enters the parameter map configuration mode.

Example:

```
Device(config)# parameter-map type webauth parameter-map1
```

Step 3 Configure the type as **consent**.

Example:

```
Device(config-params-parameter-map)# type consent
```

Step 4 Enable policy activation mode and merges the previous policy using the **[no] consent** {**activation-mode merge** | **email**} command.

Example:

```
Device(config-params-parameter-map)# consent activation-mode merge
```

Run the **no** form of this command to disable the feature.

Multiauthentication combining 802.1X authentication and local web authentication is enabled on the device.

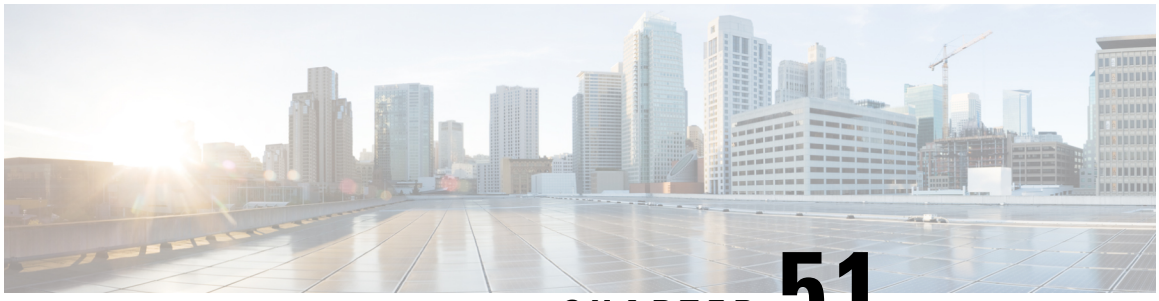
Verify multiauthentication combination with 802.1X authentication and local web authentication

To verify the multiauthentication combination with 802.1X authentication and LWA, run the command:

```
Device# show parameter-map type webauth lwa-consent
Parameter Map Name               : lwa_consent
  Banner Title                   : Consent Title
  Banner Text                    : Please accept the consent
  Type                           : consent
  Auth-proxy Init State time     : 300 sec
  Webauth max-http connection    : 200
  Webauth logout-window          : Enabled
  Webauth success-window         : Enabled
  Consent Email                  : Disabled
  Activation Mode                : Merge
  Sleeping-Client                : Disabled
  Webauth login-auth-bypass:
```

Title

Device



CHAPTER 51

Central Web Authentication

- Central web authentication, on page 437
- How to configure ISE, on page 439
- How to configure central web authentication on the controller, on page 441

Central web authentication

A central web authentication is a wireless security mechanism that

- delegates the user login webpage and credential processing to a centralized authentication server such as
- initiates user redirection and authentication at Layer 2, often in combination with MAC filtering or authentication, and
- uses RADIUS server attributes so that network controllers redirect web traffic to the authentication portal. This approach streamlines access and reduces delays.

- **ISE (Identity Services Engine)**: Cisco's centralized network access policy platform that delivers authentication, authorization, accounting, and guest access functionality.
- **ACL (Access control list)**: A set of rules used to control network traffic and enforce security policies, determining which clients can access which network resources.
- **Change of Authorization (CoA)**: A mechanism to reapply or update authorization parameters dynamically without requiring a new login.

Note Currently, Cisco Identity Services Engine (ISE) supports only one Attribute-Value Pair (AVP) for Access Control Lists (ACLs), either IPv4 or IPv6. This limitation prevents the simultaneous return of both ACLs within the same authentication profile. As a result, dual-stack clients (devices using both IPv4 and IPv6) can operate within a Central Web Authentication (CWA) flow, but only under specific configurations. To avoid issues, it is recommended to configure a default IPv6 ACL with a 'deny all' rule. This ensures that clients do not encounter connectivity problems while the limitation is addressed through a future feature enhancement

Prerequisite

Comparison with other authentication methods

Central web authentication (CWA) lets you manage web-based access for wireless clients through a dedicated authentication portal (typically). Unlike traditional local web authentication, CWA performs core security and redirection at Layer 2, working with authentication mechanisms such as MAC filtering or . The RADIUS server sends specific attributes to the controller, which then redirects web traffic for portal-based login. This approach helps streamline authentication, reduce delays, and improve policy enforcement.

There are multiple methods of web authentication used in wireless environments.

- **Local web authentication (LWA)**: Local web authentication (LWA) is Layer 3 security configured on the controller. The authentication page and pre-authentication ACL are configured locally. The controller intercepts HTTP(S) traffic from the client and redirects the client to an internal authentication web page. The controller authenticates credentials locally or through RADIUS or LDAP.
- **External web authentication (EWA)**: Also configured as Layer 3 security on the controller. The controller intercepts HTTP(S) traffic and redirects the client to a login page hosted on an external web server. Credentials are authenticated by the controller locally or through a RADIUS or LDAP server. The pre-authentication ACL is statically configured on the controller.
- **Central web authentication (CWA)**: Typically configured as Layer 2 security, with the redirection URL and pre-authentication ACL residing on . During Layer 2 authentication, pushes the redirection attributes to the controller. The controller redirects all web traffic from the client to the login page. then validates the credentials entered by the client through HTTPS and authenticates the user.

This table compares different types of authentication methods used in wireless environments.

Table 29: Difference from other authentication types

Method	Layer	Portal	Credential processing	Key attributes
Local web authentication	Layer 3	Controller	Locally or through RADIUS or LDAP	Controller intercepts traffic
External web authentication	Layer 3	External server	Locally or through RADIUS or LDAP	Static ACLs and external portal
Central web authentication	Layer 2		Through (HTTPS)	

Analogy: concert tickets

Imagine a concert venue with several ways to check tickets and admit guests. You can have ticket booths at every entrance (local authentication), ticket checkers who send guests to a special desk outside (external authentication), or one main VIP booth at the heart of the venue that handles everyone’s tickets and access (central authentication). Let’s use this concert analogy to understand central web authentication and other methods.

At your concert venue, central web authentication (CWA) is what happens when, instead of letting every entrance or gate have their own ticket booth, you create one exclusive VIP booth—like —that manages all ticketing for everyone. Instead of waiting until a guest actually tries to enter through a particular door (the

way local booth might do), the venue's security starts checking guests' tickets as soon as they enter the red carpet. The VIP booth can give the gatekeepers special instructions: "If you don't recognize someone's ticket, redirect them straight to me!" This means the main ticketing process is handled efficiently and quickly by one central authority.

Let's look at all the ticketing strategies you could use at your concert:

Local Ticket Booth (Local Web Authentication, LWA): Every entrance has its own mini ticket booth and rules. Guards at the door check tickets and can ask guests for their info. Ticket validation is handled locally at each gate, sometimes via a backstage manager or external system.

External Ticket Desk (External Web Authentication, EWA): Instead of ticket checks at the gate, guests are sent to a desk outside the stadium. The desk is run by another company. The security at the entrance gates redirects guests and the validation can still interact with the backstage manager if needed. Rules for who gets through are set upfront.

VIP Central Ticket Booth (Central Web Authentication, CWA): The gates just check basic details (like guest's wristband color), and anyone who isn't recognized is sent straight to the main VIP booth () to have their ticket or credentials checked and get access granted for the whole event.

How to configure ISE

To configure ISE, follow these tasks:

1. Create an authorization profile.
2. Create an authentication rule.
3. Create an authorization rule.

Create an authorization profile

Define an authorization profile for central web authentication with required redirect attributes.

Before you begin

Ensure you have the required access and know the ACL name for redirection.

Procedure

Step 1	Click **Policy**, and click **Policy Elements**.
Step 2	Click **Results**.
Step 3	Expand **Authorization**, and click **Authorization Profiles**.
Step 4	Click **Add** to create a new authorization profile for central web authentication.
Step 5	In the **Name** field, enter a name for the profile. For example, CentralWebAuth.
Step 6	Choose **ACCESS_ACCEPT** from the **Access Type** drop-down list.
Step 7	Check the **Web Redirection (CWA, MDM, NSP, CPP)** check box, and choose **Centralized Web Auth** from the drop-down list.
Step 8	In the **ACL** field, enter the name of the ACL that defines the traffic to be redirected. For example, redirect.

Step 9 In the **Value** field, choose the default or customized values.

This field defines whether the displays the default or a custom web portal that the admin created.

Step 10 Click **Save**.

The authorization profile is created and is available for use in your central web authentication policies.

Create an authentication rule

Define an authentication rule to control network access based on specified conditions.

Use authentication rules to specify how users or devices are authenticated in your policy system. This rule determines which authentication methods and identity sources are applied when network access is requested.

Procedure

Step 1 In the **Policy** > **Authentication** page, click **Authentication**.

Step 2 Enter a name for your authentication rule. For example, MAB.

Step 3 In the If condition field, select the plus (+) icon.

Step 4 Choose **Compound condition**, and choose **Wireless_MAB**.

Step 5 Click the arrow next to **and ...** in order to expand the rule further.

Step 6 Click the + icon in the **Identity Source** field, and choose **Internal endpoints**.

Step 7 Choose **Continue** from the **If user not found** drop-down list.

A device can be authenticated even if its MAC address is not known when you select this option.

Step 8 Click **Save**.

Your new authentication rule is added to the authentication policy.

Create an authorization rule

Define and enforce policies to control access to network resources for users and devices.

Use authorization rules to allow or deny access based on user, device, or authentication attributes in .

You can configure many rules in the authorization policy, such as the *MAC not known*.

Procedure

Step 1 Click **Policy** > **Authorization**.

Step 2 In the **Rule Name** field, enter a name. For example: *Mac not known*.

Step 3 In the **Conditions** field, click the plus (+) icon.

Step 4 Choose **Compound Conditions**, and choose **Wireless_MAB**.

Step 5 From the settings icon, select **Add Attribute/Value** from the options.

Step 6 In the **Description** field, choose **Network Access** > **AuthenticationStatus** as the attribute from the drop down list.

Step 7 Choose the **Equals** operator.

Step 8 From the right hand field, choose **UnknownUser**.

Step 9 In the **Permissions** field, choose the name of the authorization profile you had created earlier.

The continues even though the user (or MAC) is not known.

Unknown users now see the login page. When they enter their credentials, the sends another authentication request. To support guest users, configure a rule to check if the user is in the guest group. For instance, if UseridentityGroup Equals Guest is used, all guests are included in this group.

Step 10 In the **Conditions** field, click the plus (+) icon.

Step 11 Choose **Compound Conditions**, and choose to create a new condition.

Place the new rule so it is evaluated prior to the *MAC not known* rule.

Step 12 From the settings icon, select **Add Attribute/Value** from the options.

Step 13 In the **Description** field, choose **Network Access** > **UseCase** as the attribute from the drop-down list.

Step 14 Choose the **Equals** operator.

Step 15 From the right hand field, choose **GuestFlow**.

Step 16 In the **Permissions** field, click the plus (+) icon to select a result for your rule.

You can choose **Standard** > **PermitAccess** option or create a custom profile to return the attributes that you like.

When the user is authorized on the login page, the triggers a Change of Authorization (COA). This process restarts Layer 2 authentication. If the user is identified as a guest, the user is authorized.

---

evaluates user or device access requests against these rules and enforces the appropriate policy. Unknown users see the login page and, if identified as guests, receive guest access upon authentication.

How to configure central web authentication on the controller

To configure central web authentication on the controller, proceed with these tasks.

1. Configure WLAN.
2. Configure policy profile.
3. Configure redirect ACL.
4. Configure AAA for central web authentication.
5. Configure redirect ACL in Flex profile.

Configure WLAN (GUI)

Set up a new WLAN on your wireless controller using the GUI.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 In the **WLANs** window, click the name of the **WLAN** or click **Add** to create a new one.
The **Add/Edit WLAN** window is displayed.

Step 3 In the **Add/Edit WLAN** window, click the **General** tab to configure these parameters.

- In the **Profile Name** field, enter or edit the name of the profile.
- In the **SSID** field, enter or edit the SSID name.

  The SSID name is alphanumeric and can be up to 32 characters in length.
- In the **WLAN ID** field, enter or edit the ID number. The valid range is between one and 512.
- Select the **802.11** radio band from the **Radio Policy** drop-down list.
- Using the **Broadcast SSID** toggle button, change the status to either **Enabled** or **Disabled**.
- Using the **Status** toggle button, change the status to either **Enabled** or **Disabled**.

Step 4 Click the **Security** tab, and then select the **Layer 2** tab to configure these parameters:

- Select **None** from the **Layer 2 Security Mode** drop-down list. This setting disables Layer 2 security.
- Enter the **Reassociation Timeout** value, in seconds. This value specifies the duration before a fast transition reassociation times out.
- Check the **Over the DS** check box to enable Fast Transition over a distributed system.
- Choose **OWE**. Opportunistic Wireless Encryption (OWE) provides data confidentiality with encryption over the air between an AP radio and a wireless client. OWE Transition Mode ensures backwards compatibility.
- Choose Fast Transition (802.11r), the IEEE standard for fast roaming. This standard allows the initial handshake with a new AP to occur before the client roams to the target AP. This method is known as Fast Transition.
- Check the check box to enable MAC filtering in the WLAN.

Step 5 Click **Save & Apply to Device**.

Configure WLAN (CLI)

Set up a new WLAN on your wireless controller using the CLI.

Before you begin

Enable MAC filtering for Layer 2 authentication to download the redirect URL and ACL.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN.

Example:

```
Device(config)# wlan wlan-name wland-id SSID-name
```

- **wlan-name** is the name of the configured WLAN.
- **wlan-id** is the WLAN identifier. The range is one to 512.
- **SSID-name** is the SSID name which can have up to 32 alphanumeric characters.

If you have already created and configured the WLAN, use the **wlan** *wlan-name* command.

Step 3 Enable MAC filtering on a WLAN.

Example:

```
Device(config-wlan)# mac-filtering name
```

If the authentication list is not already configured, the default authentication list is used when configuring MAC filtering.

Step 4 Disable WPA security.

Example:

```
Device(config-wlan)# no security wpa
```

Step 5 Enable the WLAN.

Example:

```
Device(config-wlan)# no shutdown
```

Step 6 Return to privileged EXEC mode.

Example:

```
Device(config-wlan)# end
```

The new WLAN is available and active on the controller.

After completing the WLAN configuration, if the changes are not pushed to all the APs, a syslog message appears.

```
2021/01/06 16:20:00.597927186 {wncd_x_R0-4}{1}: [wlanmgr-db] [20583]: UUID: 0, ra: 0, TID:
 0
```

```
(note): Unable to push WLAN config changes to all APs, cleanup required for WlanId: 2,
profile: wlan1 state: Delete pending
```

If this syslog message appears for more than six minutes, reload the controller

If the controller does not reload and the syslog message continues to appear, collect the archive logs and wncd core file. Then, raise a case by clicking the link: Support Case Manager.

```
Device# config terminal
            Device(config)# wlan wlanProfileName 1 ngwcSSID
            Device(config-wlan)# mac-filtering default
            Device(config-wlan)# no security wpa
            Device(config-wlan)# no shutdown
            Device(config-wlan)# end
```

Configure policy profile (CLI)

Define and activate a policy profile to control WLAN behavior using the CLI.

Use the CLI to set up policy profiles that govern AAA, NAC, and VLAN assignment for wireless clients on Cisco devices. Apply this procedure when building new WLAN policies or adjusting network admission controls.

Before you begin

- Both NAC and AAA override must be configured in the policy profile for proper CWA operation.
- You need a AAA override to apply policies coming from the AAA or ISE servers. When a redirect URL and redirect ACL is received from the ISE server, NAC is used to trigger the Central Web Authentication (CWA).
- The default policy profile is used for APs not associated with a specific policy.
- Clients may experience VLAN assignment during the final RADIUS access-accept following successful authentication.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN.

Example:

```
Device(config)# wlan wlan-name wland-id SSID-name
```

- **wlan-name** is the name of the configured WLAN.
- **wlan-id** is the WLAN identifier. The range is one to 512.
- **SSID-name** is the SSID name which can have up to 32 alphanumeric characters.

If you have already created and configured the WLAN, use the **wlan** *wlan-name* command.

Step 3 Set the policy profile.

Example:

```
Device(config)# wireless profile policy default-policy-profile
```

Step 4 Map the VLAN to a policy profile.

Example:

```
Device(config-wireless-policy)# vlan vlan-id
```

If vlan-id is not specified, the default native vlan one is applied. The valid range for vlan-id is one to 4096.

Management VLAN is applied if no VLAN is configured on the policy profile.

Step 5 Configure AAA override to apply policies coming from the AAA or ISE servers.

Example:

```
Device(config-wireless-policy)# aaa-override
```

Step 6 Configure Network Access Control in the policy profile. NAC is used to trigger the Central Web Authentication (CWA).

Example:

```
Device(config-wireless-policy)# nac
```

Step 7 Enable the WLAN.

Example:

```
Device(config-wireless-policy)# no shutdown
```

Step 8 Return to privileged EXEC mode.

Example:

```
Device(config-wlan)# end
```

The policy profile is configured and active, applying the desired AAA, NAC, and VLAN parameters to WLAN clients.

```
Device# configure terminal
Device(config)# wireless profile policy default-policy-profile
Device(config-wireless-policy)# vlan 41
Device(config-wireless-policy)# aaa-override
Device(config-wireless-policy)# nac
Device(config-wireless-policy)# no shutdown
Device(config-wireless-policy)# end
```

Configure a policy profile (GUI)

Create and apply a new policy profile using the GUI.

Use this task to define access and traffic management settings by configuring a policy profile in the system's GUI.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 On the **Policy Profile** page, click **Add**.

Step 3 In the **Add Policy Profile** window, in General Tab, enter a name and description for the policy profile.

Step 4 To enable the policy profile, set **Status** as Enabled.

Step 5 Use the slider to enable or disable **Passive Client** and **Encrypted Traffic Analytics** .

Step 6 (Optional) In the **CTS Policy** section, choose the appropriate status for the following:

- Inline Tagging—a transport mechanism using which a embedded wireless controller, controller, or AP understands the source SGT.
- SGACL Enforcement

Step 7 Specify a default **SGT**. The valid range is from two to 65519.

Step 8 In the **WLAN Switching Policy** section, choose as required:

- Central Switching
- Central Authentication
- Central DHCP
- Central Association Enable
- Flex NAT/PAT

Step 9 Click **Save & Apply to Device**.

The new policy profile is created and applied to the device using your configured settings.

Create redirect ACL

Create a redirect access control list (ACL). Direct unauthenticated HTTP and HTTPS traffic to the login page. Allow traffic to and block other traffic

The redirect ACL is a punt ACL that must be predefined on the controller. For FlexConnect local switching, the ACL must be predefined on the AP. The Authentication, authorization, and accounting (AAA) server server returns only the name of the ACL, not its definition.

The redirect ACL defines traffic matching "deny" statements, allowing this traffic to pass through the data plane. Traffic matching "permit" statements is sent to the control plane for further processing, which includes web interception and redirection.

The redirect ACL includes implicit statements that allow DHCP and DNS traffic to all IP addresses, similar to LWA.

It also ends with an implicit deny statement in the security ACL.

Before you begin

Ensure you have the IP address of your deployment.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create an extended access list.

Example:

```
Device(config)# ip access-list extended redirect
```

If users are not authenticated, HTTP and HTTPS browsing fails because uses a redirect ACL (named **redirect**).

Step 3 Permit traffic to and block all other traffic.

Example:

```
Device(config)# deny ip any host ISE-IP-address
```

Step 4 Permit traffic to and all other traffic is blocked.

Example:

```
Device(config)# deny ip host ISE-IP-add any
```

Note
This ACL is applicable for both local and flex mode.

Step 5 Redirect all HTTP or HTTPS access to the ISE login page. Port number 80 is used for HTTP, and port number 443 is used for HTTPS, configured with the **permit TCP any any eq web address/port-number** command.

Example:

In case of HTTP:

```
Device(config)# permit TCP any any eq www
Device(config)# permit TCP any any eq 80
```

Example:

In case of HTTPS:

```
Device(config)# permit TCP any any eq 443
```

To allow traffic to , configure before the HTTP or HTTPS ACE entry.

Step 6 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

HTTP

```
Device# configure terminal
Device(config)# ip access-list extended redirect
Device(config)# deny ip any host 123.123.134.112
Device(config)# deny ip host 123.123.134.112 any
Device(config)# permit TCP any any eq www
Device(config)# permit TCP any any eq 80
Device(config)# end
```

HTTPS

```
Device# configure terminal
Device(config)# ip access-list extended redirect
Device(config)# deny ip any host 123.123.134.112
Device(config)# deny ip host 123.123.134.112 any
Device(config)# permit TCP any any eq 443

Device(config)# end
```

Configure AAA for CWA

Set up AAA to support Central Web Authentication using CLI.

Central Web Authentication requires proper AAA configuration to enable Change of Authorization (CoA) functions using a RADIUS (Remote Authentication Dial-In User Service) server.

Before you begin

Ensure AAA authentication is configured on your device. For more details, see the *Configuring AAA Authentication* documentation.

Procedure

Step 1 Configure the Change of Authorization (CoA) on the .

Example:

```
Device(config)# aaa server radius dynamic-author
```

Step 2 Specify a RADIUS client and configure the RADIUS key that is shared between the device and the RADIUS client.

Example:

```
Device(config-locsvr-da-radius)# client ISE-IP-add server-key
radius-shared-secret
```

ISE-IP-add is the IP address of the RADIUS client.

server-key is the radius client server-key.

radius-shared-secret can have these values:

- **0**—Specifies unencrypted key.
- **6**—Specifies encrypted key.
- **7**—Specifies HIDDEN key.

- **Word**—Unencrypted (cleartext) server key.

When configuring WSMA data in GUI, ensure that the RADIUS shared secret does not exceed 240 characters.

AAA is configured to support Central Web Authentication with dynamic CoA, enabling secure device communication with the RADIUS server.

```
Device# config terminal
Device(config)# aaa server radius dynamic-author
Device(config-locsvr-da-radius)# client 123.123.134.112 server-key 0 SECRET
Device(config-locsvr-da-radius)# end
```

Configure redirect ACL in flex profile (GUI)

Set up a redirect ACL within a flex profile so that APs enforce specified access control and web authentication policies.

The redirect ACL definition must be sent to the AP in the FlexConnect profile. The redirect ACL associated with an AP must be configured in the FlexConnect profile that hosts the client. If an AP is not configured with a FlexConnect profile, it is associated with the default FlexConnect profile.

Before you begin

- Identify the FlexConnect profile to be updated or verify if a new Flex profile needs to be created.
- Prepare the ACL details, central web authentication requirements, and any preauthentication URL filters.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Flex**.

Step 2 On the **Flex Profile** page, click the name of the FlexConnect profile or click **Add** to create a new FlexConnect profile.

Step 3 In the **Add/Edit Flex Profile** window that is displayed, click the **Policy ACL** tab.

Step 4 Click **Add** to map an ACL to the FlexConnect profile.

Step 5 Choose the ACL name, enable central web authentication, and specify the preauthentication URL filter.

Step 6 Click **Save**.

Step 7 Click **Update & Apply to Device**.

The AP applies the configured redirect ACL parameters for client traffic as specified in the flex profile.

Configure redirect ACL in flex profile (CLI)

Set up a redirect ACL within a flex profile so that APs enforce specified access control and web authentication policies.

The redirect ACL definition must be sent to the AP in the FlexConnect profile. The redirect ACL associated with an AP must be configured in the FlexConnect profile that hosts the client. If an AP is not configured with a FlexConnect profile, it is associated with the default FlexConnect profile.

Before you begin

- Ensure you have the required ACL policy created on the controller.
- Confirm that AP is operating in FlexConnect mode.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a new flex policy.

Example:

```
Device(config)# wireless profile flex default-flex-profile
```

The default flex profile name is **default-flex-profile**.

Step 3 Configure an ACL policy.

Example:

```
Device(config-wireless-flex-profile)# acl-policy
                        acl-policyname
```

Step 4 Configure central web authentication.

Example:

```
Device(config-wireless-flex-profile-acl)# central-webauth
```

Step 5 Return to privileged EXEC mode.

Example:

```
Device(config-wireless-flex-profile-acl)# end
```

The AP in flex profile has the redirect ACL configured. The ACL is now applied and used for client redirection during centralized web authentication.

Troubleshoot CWA

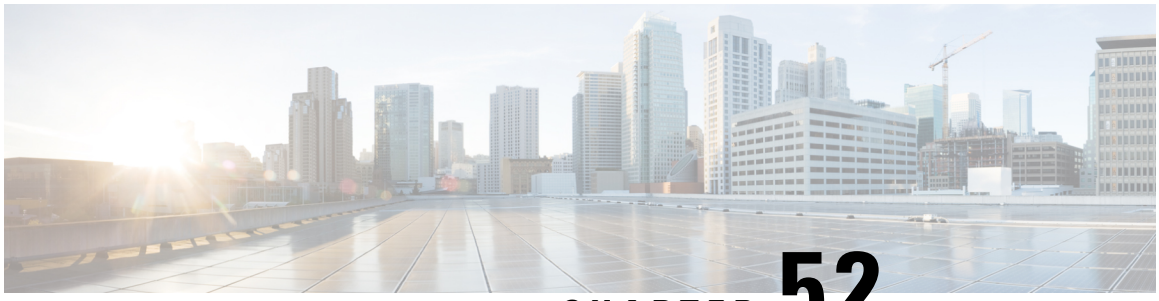
Init-State timer running out

Problem Issue: The client devices are deauthenticated by the controller if users fail to enter their credentials in a limited time interval. The clients are deauthenticated after three times the time configured for the init-state timeout in the controller.

Problem Explanation: This is expected behavior. For central web authentication, the init-state timeout does not apply directly. The reap timer—three times the init-state timeout plus five seconds (3 × init-state timeout + 5)—determines when your device deauthenticates in seconds.

Problem For example, if you have configured the init-state timeout as 10 seconds, then the client devices are deauthenticated if users fail to enter their credentials after 35 seconds; that is (3*10 + 5) = 35 seconds.

Problem For example, if you set the init-state timeout to 10 seconds, your device deuathenticates after 35 seconds if you do not enter your credentials. (This calculation is: 3 × 10 + 5 = 35 seconds.)



CHAPTER 52

ISE Simplification and Enhancements

- Security utilities configuration options, on page 453
- Captive bypassing, on page 456
- DHCP option 55 and 77 parameters, on page 458
- Captive portals, on page 462

Security utilities configuration options

You can set up the RADIUS server using this simplified method:

wireless-default radius server *ip* **key** *secret*

- Configures AAA authorization for network services, including authentication for web authentication and Dot1x.
- Enables local authentication with default authorization.
- Applies the default redirect ACL for Central Web Authentication (CWA).
- Creates a global parameter map with a virtual IP and enables captive bypass portal.
- Configures all default AAA settings required when configuring a RADIUS server.
- Sets method-list configuration and enables RADIUS accounting by default.
- Disables RADIUS aggressive failovers by default and sets the RADIUS request timeout to five seconds.
- Implements a default access control list (ACL) for CWA URL redirect.

```
aaa new-model
               aaa authentication webauth default group radius
               aaa authentication dot1x default group radius
               aaa authorization network default group radius
               aaa accounting identity default start-stop group radius
               !
               aaa server radius dynamic-author
               client <IP> server-key cisco123
               !
               radius server RAD_SRV_DEF_<IP>
               description Configured by wireless-default
               address ipv4 <IP> auth-port 1812 acct-port 1813
               key <key>
               !
```

```
aaa local authentication default authorization default
aaa session-id common
!
ip access-list extended CISCO-CWA-URL-REDIRECT-ACL-DEFAULT
remark " CWA ACL to be referenced from ISE "
deny udp any any eq domain
deny tcp any any eq domain
deny udp any eq bootps any
deny udp any any eq bootpc
deny udp any eq bootpc any
deny ip any host <IP>
permit tcp any any eq www
!
parameter-map type webauth global
captive-bypass-portal
virtual-ip ipv4 192.0.2.1
virtual-ip ipv6 2001:DB8::1
!
wireless profile policy default-policy-profile
aaa-override
local-http-profiling
local-dhcp-profiling
accounting
```

Key benefits

- Simplifies deployment of RADIUS server configuration for wireless controllers.
- Eliminates the need for step-by-step manual configuration across multiple CLI commands.
- Ensures consistent and secure default settings for AAA and authentication services.

Configure multiple RADIUS servers

To configure multiple RADIUS servers for authentication in a network.

Before you begin

Ensure you have the necessary IP addresses and shared secrets for the RADIUS servers.

Procedure

Step 1 Enter global configuration mode

Example:

```
Device# configure terminal
```

Step 2 Configure a RADIUS server

Example:

```
Device(config)# wireless-default radius server ip key secret
```

Example:

```
Device(config)# wireless-default radius server 192.2.58.90 key cisco123
```

You can configure up to ten RADIUS servers.

Step 3 Return to privileged EXEC mode

Example:

```
Device(config)# end
```

Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Multiple RADIUS servers are now configured and ready for use in the network.

Verify AAA and Radius server configurations

To view details of AAA server, use these command:

```
Device# show run aaa
!
aaa new-model
aaa authentication webauth default group radius
aaa authentication dot1x default group radius
aaa authorization network default group radius
aaa accounting Identity default start-stop group radius
!
aaa server radius dynamic-author
 client 192.0.2.10 server-key cisco123
!
radius server RAD_SRV_DEF_192.0.2.10
 description Configured by wireless-default
 address ipv4 192.0.2.10 auth-port 1812 acct-port 1813
 key cisco123
!
aaa local authentication default authorization default
aaa session-id common
!
!
ip access-list extended CISCO-CWA-URL-REDIRECT-ACL-DEFAULT
remark " CWA ACL to be referenced from ISE "
deny udp any any eq domain
deny tcp any any eq domain
deny udp any eq bootps any
deny udp any any eq bootpc
deny udp any eq bootpc any
deny ip any host 192.0.2.10
permit tcp any any eq www
!
parameter-map type webauth global
  captive-bypass-portal
  virtual-ip ipv4 192.0.2.1
  virtual-ip ipv6 2001:DB8::1
!
wireless profile policy default-policy-profile
   aaa-override
   local-http-profiling
   local-dhcp-profiling
   accounting
```

Note The **show run aaa** output may change when new commands are added to this utility.

Captive bypassing

A captive bypass is a network behavior that

- enables client devices to automatically determine Internet connectivity and initiate authentication flows,
- may enable users to bypass captive portal splash pages through protocols such as WISPr.
- involves interaction between devices (such as Apple iOS) and Embedded Wireless Controllers, affecting web redirection and authentication.

Additional reference information

WISPr is a draft protocol that enables users to roam between different wireless service providers. Devices like Apple iOS use HTTP WISPr requests to check if they are connected to the Internet.

When direct Internet connectivity is not detected, these mechanisms prompt the device to open a web browser so the user can enter credentials for Internet access. Authentication occurs in the background whenever the device connects to a new SSID.

When an Apple iOS device connects, it sends a WISPr request to the Embedded Wireless Controller, which checks the user agent details and then triggers an HTTP request with web authentication interception. After verifying the iOS version and browser details, the Embedded Wireless Controller allows the client device to bypass captive portal settings and access the Internet.

This HTTP request triggers web authentication interception on the Embedded Wireless Controller just as any other page requests do. This leads to the standard web authentication process. If web authentication uses splash page features (such as a URL from a configured RADIUS server), the splash page might not appear for the user because WISPr requests occur at short intervals. Once a query reaches the server, web redirection or splash page display running in the background is cancelled, and the device processes the page request, which may prevent the splash page from being displayed as intended.

Example

For instance, Apple introduced an iOS feature that detects captive portals by sending a web request upon connecting to a wireless network. On iOS 6 and earlier, the request is sent to http://www.apple.com/library/test/success.html. On iOS 7 and later, multiple possible URLs are used. If a response is received, Internet access is assumed and no further interaction occurs. If no response is received, Internet access is assumed to be blocked and the device's Captive Network Assistant (CNA) auto-launches a pseudo-browser to prompt for portal login. The CNA may not function properly if it is redirected to an ISE captive portal. The Embedded Wireless Controller can suppress the pop-up of the pseudo-browser. Network administrators can configure the Embedded Wireless Controller to bypass WISPr detection. In this configuration, web authentication interception only occurs when a user intentionally requests a web page, ensuring the splash page is loaded in the user's browser context and not triggered by background connectivity probes.

Analogy: Sneaking into an amusement park

Captive bypassing is like someone sneaking into an amusement park through a side door, instead of showing their ticket at the main entrance. Some devices use automated checks to find shortcuts and access the internet without going through the intended login page, just as clever visitors might bypass security by finding an

easier way in. Network controls are needed to make sure everyone enters through the main gate and checks in properly.

Configure captive bypassing for WLAN in LWA and CWA (GUI)

Enable client devices to bypass captive portal authentication on the selected WLAN.

Before you begin

Use this task when you need certain clients to connect without passing through the captive portal, typically for pre-authorized devices.

Ensure you have administrative access to the device and the parameter map is appropriately configured.

Procedure

Step 1 Choose **Configuration** > **Security** > **Web Auth** .

Step 2 In the **Webauth Parameter Map** tab, click the parameter map name. The **Edit WebAuth Parameter** window is displayed.

Step 3 Select **Captive Bypass Portal** check box.

Step 4 Click **Update & Apply to Device** .

The selected WLAN now allows captive bypass in accordance with your configuration.

Configure captive bypassing for WLAN in LWA and CWA

Enable captive bypassing for WLAN to allow users to bypass the captive portal.

This configuration is applicable in environments where users need to access the network without going through a captive portal.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create the parameter map.

Example:

```
Device(config)# parameter-map type webauth parameter-map-name
```

The *parameter-map-name* must not exceed 99 characters.

Step 3 Configure captive bypassing.

Example:

```
Device(config)# captive-bypass-portal
```

Step 4 Specify the WLAN name and ID.

Example:

```
Device(config)# wlan profile-name wlan-id ssid-name
```

- *profile-name* is the WLAN name which can contain 32 alphanumeric characters.
- *wlan-id* is the wireless LAN identifier. The valid range is from 1 to 512.
- *ssid-name* is the SSID which can contain 32 alphanumeric characters.

Step 5 Enable the web authentication for the WLAN.

Example:

```
Device(config-wlan)# security web-auth
```

Step 6 Map the parameter map.

Example:

```
Device(config-wlan)# security web-auth parameter-map parameter-map-name
```

If the parameter map is not associated with a WLAN, the configuration is considered from the global parameter map.

Step 7 (Optional) Return to privileged EXEC mode.

Example:

```
Device(config-wlan)# end
```

Alternatively, you can also press *Ctrl-Z* to exit global configuration mode.

The WLAN is now configured with captive bypassing enabled, allowing users to bypass the captive portal.

DHCP option 55 and 77 parameters

The DHCP sensors use these DHCP options on the ISE for both native and remote device profiling:

- Option 12: Hostname
- Option 6: Class Identifier

These options must also be sent to ISE for accurate profiling:

- Option 55: Parameter Request List
- Option 77: User Class

Configure the DHCP options 55 and 77 to ISE using the GUI

Ensure DHCP options 55 and 77 are sent to ISE to enable device profiling and policy enforcement

These options allow ISE to collect device-specific DHCP information for accurate profiling on wireless networks.

Before you begin

Confirm that your network devices are compatible with ISE profiling features.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 On the **Policy Profile** page, click **Add** to view the **Add Policy Profile** window.

Step 3 Click **Access Policies** tab, choose the **RADIUS Profiling** and **DHCP TLV Caching** check boxes to configure radius profiling and DHCP TLV Caching on a WLAN.

Step 4 Click **Save & Apply to Device**

he network device now sends DHCP options 55 and 77 to ISE, enabling accurate device profiling and network access policy enforcement.

Configure the device to send DHCP options 55 and 77 to ISE (CLI)

Enable the device to send specific DHCP options to ISE for improved client profiling.

This configuration is essential for environments where client profiling is necessary for network access control and monitoring.

Before you begin

Ensure that the device is running a compatible version of the software that supports DHCP options 55 and 77.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure WLAN policy profile and enters the wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy profile-policy
```

The *profile-policy* is the name of the WLAN policy profile being configured.

Step 3 Configure DHCP TLV caching on a WLAN.

Example:

```
Device(config-wireless-policy)# dhcp-tlv-caching
```

Enables caching of DHCP TLV information for better profiling.

Step 4 Configure client radius profiling on a WLAN.

Example:

```
Device(config-wireless-policy)# radius-profiling
```

Enables RADIUS profiling to enhance client identification.

Step 5 (Optional) Return to privileged EXEC mode.

Example:

```
Device(config-wireless-policy)# end
```

Alternatively, you can also press *Ctrl-Z* to exit global configuration mode.

The device is configured to include DHCP options 55 and 77 in client profiling information sent to Cisco ISE.

Configure the EAP request timeout using the GUI

Use the steps to configure the EAP request timeout through the GUI:

Procedure

Step 1 Choose **Configuration** > **Security** > **Advanced EAP**.

Step 2 In the **EAP-Identity-Request Timeout** field, specify the amount of time (in seconds) in which the device attempts to send an EAP identity request to wireless clients using local EAP.

Step 3 In the **EAP-Identity-Request Max Retries** field, specify the maximum number of times that the device attempts to retransmit the EAP identity request to wireless clients using local EAP.

Step 4 Set **EAP Max-Login Ignore Identity Response** to **Enabled** state to limit the number of clients that can be connected to the device with the same username. You can log in up to eight times from different clients (PDA, laptop, IP phone, and so on) on the same device. The default state is **Disabled**.

Step 5 In the **EAP-Request Timeout** field, specify the amount of time (in seconds) in which the device attempts to send an EAP request to wireless clients using local EAP.

Step 6 In the **EAP-Request Max Retries** field, specify the maximum number of times that the device attempts to retransmit the EAP request to wireless clients using local EAP.

Step 7 In the **EAPOL-Key Timeout** field, specify the amount of time (in seconds) in which the device attempts to send an EAP key over the LAN to wireless clients using local EAP.

Step 8 In the **EAPOL-Key Max Retries** field, specify the maximum number of times that the device attempts to send an EAP key over the LAN to wireless clients using local EAP.

Step 9 In the **EAP-Broadcast Key Interval** field, specify the time interval between rotations of the broadcast encryption key used for clients and click **Apply**.

Note
After configuring the EAP-Broadcast key interval to a new time period, you must shut down or restart the WLAN for the changes to take effect. Once the WLAN is shut down or restarted, the M5 and M6 packets are exchanged when the configured timer value expires.

Configure EAP request timeout

Set the timeout for EAP requests to manage client exclusion effectively.

This configuration is useful in environments where EAP authentication is used, and it is necessary to handle clients that do not respond in a timely manner.

Before you begin

Ensure you have access to the device and are in the appropriate configuration mode.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable exclusion on timeout and no response.

Example:

```
Device(config)# wireless wps client-exclusion dot1x-timeout
```

By default, this feature is enabled. To disable, append a *no* at the beginning of the command.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press *Ctrl-Z* to exit global configuration mode.

The EAP request timeout is now configured, allowing for better management of client exclusions.

Configure the EAP request timeout in wireless security

Set the EAP request timeout to ensure timely authentication in wireless security.

This configuration is essential in environments where EAP is used for authentication, as it affects the responsiveness of the authentication process.

Before you begin

Ensure you have access to the device and are in privileged EXEC mode.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 2 Configure the EAP request retransmission timeout value in seconds.

Example:

```
Device(config)# wireless security dot1x request timeout timeout
```

Configures the EAP request retransmission timeout value in seconds.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Returns to privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

The EAP request timeout is now configured, which will help in managing the authentication process in wireless security.

Captive portals

A captive portal is a network authentication mechanism that

- intercepts and redirects user web requests to a designated login or acceptance page,
- allows administrators to enforce authentication or policy acceptance before granting network access, and
- supports configuration of multiple web authentication URLs based on access point (AP), WLAN, or global scope.

Order of precedence

Captive portal configurations let you define different web authentication URLs—including external URLs—for the same SSID, based on the specific access point or WLAN. By default, the system uses a global URL for user authentication, but administrators may override this at the WLAN or AP level to customize user experience.

Order of precedence

1. AP-level configuration (highest priority)
2. WLAN-level configuration
3. Global configuration (default)

Restrictions

- This feature is supported on standalone controllers only.
- Export-Anchor configurations are not supported.

Configure captive portal (GUI)

Configure a secure WLAN that uses captive portal authentication for guest or user access.

Configure a captive portal when you require user authentication on your Wi-Fi network for guests or employees.

Before you begin

Confirm the web authentication parameter map and necessary authentication lists are already created.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Click **Add**.

Step 3 In the **General** tab, enter the **Profile Name**, the **SSID**, and the **WLAN ID**.

Step 4 In the **Security** > **Layer2** tab, uncheck the **WPA Policy**, **AES** and **802.1x** check boxes.

Step 5 In the **Security** > **Layer3** tab, choose the parameter map from the **Web Auth Parameter Map** drop-down list and authentication list from the **Authentication List** drop-down list.

Step 6 In the **Security** > **AAA** tab, choose the Authentication list from the **Authentication List** drop-down list.

Step 7 Click **Apply to Device**.

Step 8 Choose **Configuration** > **Security** > **Web Auth**.

Step 9 Choose a **Web Auth Parameter Map**.

Step 10 In the **General** tab, enter the **Maximum HTTP connections**, **Init-State Timeout(secs)** and choose **webauth** from the **Type** drop-down list.

Step 11 In the **Advanced** tab, under the **Redirect to external server** settings, enter the **Redirect for log-in** server.

Step 12 Click **Update & Apply**.

The captive portal WLAN is available, and users associating with this SSID will be redirected for authentication as defined in the parameter map.

Configure captive portal

Set up a captive portal to manage user access to the network.

The captive portal is used to authenticate users before granting them access to the network, typically in public Wi-Fi environments.

Before you begin

Ensure that the WLAN is properly configured and that you have the necessary access rights.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 2 Configure the WLAN profile.

Example:

```
Device(config)# wlan profile-name
```

Enables or disables all WLANs and creates the WLAN identifier. The *profile-name* and the SSID network name should be up to 32 alphanumeric characters.

Step 3 Configure the WLAN web ACL.

Example:

```
Device(config-wlan)# ip access-group web IPv4-ACL-Name
```

WLAN needs to be disabled before performing this operation.

Step 4 Disable WPA security.

Example:

```
Device(config-wlan)# no security wpa
```

Step 5 Disable security AKM for dot1x.

Example:

```
Device(config-wlan)# no security wpa akm dot1x
```

Disables security AKM for dot1x.

Step 6 Disable WPA2 ciphers for AES.

Example:

```
Device(config-wlan)# no security wpa wpa2 ciphers aes
```

Disables WPA2 ciphers for AES.

Step 7 Enable web authentication for WLAN.

Example:

```
Device(config-wlan)# security web-auth authentication-list authentication-list-name
Device(config-wlan)# security web-auth parameter-map parameter-map-name
```

Enables web authentication for WLAN. Here,

- **authentication-list**

  authentication-list-name : Sets the authentication list for IEEE 802.1x.

- **authorization-list**

  authorization-list-name : Sets the override-authorization list for IEEE 802.1x.

- **on-macfilter-failure** : Enables Web authentication on MAC filter failure.

- **parameter-map**

  parameter-map-name : Configures the parameter map.

Note
When **security web-auth** is enabled, you get to map the default **authentication-list** and global **parameter-map** . This is applicable for authentication-list and parameter-map that are not explicitly mentioned.

Step 8 (Optional) Enable the WLAN.

Example:

```
Device(config-wlan)# no shutdown
```

Step 9 Exit from the WLAN configuration.

Example:

```
Device(config-wlan)# exit
```

Step 10 Create a parameter map and enter parameter-map webauth configuration mode.

Example:

```
Device(config)# parameter-map type webauth parameter-map-name
```

Creates a parameter map and enters parameter-map webauth configuration mode.

Step 11 Configure the webauth type parameter.

Example:

```
Device(config-params-parameter-map)# type webauth parameter-map-name
```

Step 12 Configure the WEBAUTH timeout in seconds.

Example:

```
Device(config-params-parameter-map)# timeout init-state sec <timeout-seconds>
```

Valid range for the time in sec parameter is 60 seconds to 3932100 seconds.

Step 13 Configure the URL string for redirect during login.

Example:

```
Device(config-params-parameter-map)# redirect for-login <URL-String>
```

Example:

```
Device(config-params-parameter-map)# redirect for-login
https://172.16.100.157/portal/login.html
```

Configures the URL string for redirect during login.

Step 14 Exit the parameters configuration.

Example:

```
Device(config-params-parameter-map)# exit
```

Step 15 Configure policy tag and enter policy tag configuration mode.

Example:

```
Device(config)# wireless tag policy policy-tag-name
```

Step 16 Attach a policy profile to a WLAN profile.

Example:

```
Device(config-policy-tag)# wlan wlan-profile-name policy policy-profile-name
```

Step 17 Save the configuration and exit configuration mode.

Example:

```
Device(config-policy-tag)# end
```

The captive portal is now configured and ready to manage user access to the network.

Example: Captive portal configuration

The example shows how you can have APs at different locations, broadcasting the same SSID but redirecting clients to different redirect portals:

Configuring multiple parameter maps pointing to different redirect portal:

```
parameter-map type webauth parMap1
type webauth
timeout init-state sec 21600
redirect for-login
https://172.16.12.3:8080/portal/PortalSetup.action?portal=cfdbce00-2ce2-11e8-b83c-005056a06b27
redirect portal ipv4 172.16.12.3
!
!
parameter-map type webauth parMap11
type webauth
timeout init-state sec 21600
redirect for-login
https://172.16.12.4:8443/portal/PortalSetup.action?portal=094e7270-3808-11e8-9797-02421e4cae0c
redirect portal ipv4 172.16.12.4
!
```

Associating these parameter maps to different WLANs:

```
wlan edc1 1 edc
ip access-group web CPWebauth
no security wpa
no security wpa akm dot1x
no security wpa wpa2 ciphers aes
security web-auth
security web-auth authentication-list cp-webauth
security web-auth parameter-map parMap11
no shutdown
wlan edc2 2 edc
ip access-group web CPWebauth
no security wpa
no security wpa akm dot1x
no security wpa wpa2 ciphers aes
security web-auth
security web-auth authentication-list cp-webauth
security web-auth parameter-map parMap1
no shutdown
```



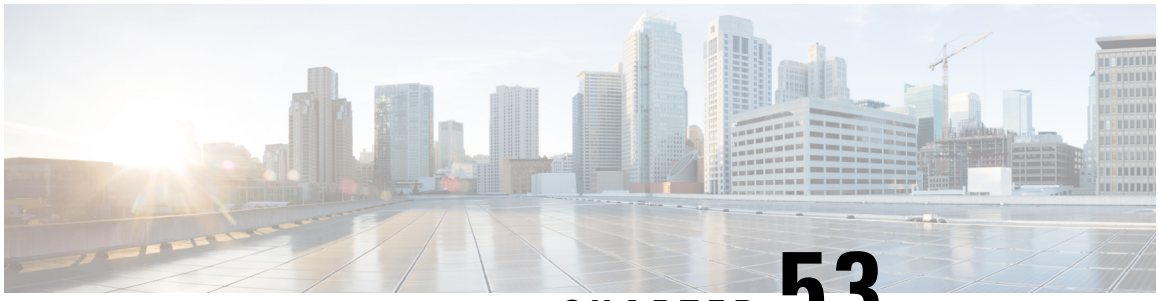
Note All WLANs have identical SSIDs.

Associating WLANs to different policy tags:

```
wireless tag policy policy_tag_edc1
wlan edc1 policy policy_profile_flex
wireless tag policy policy_tag_edc2
wlan edc2 policy policy_profile_flex
```

Assigning these policy tags to the desired APs:

```
ap E4AA.5D13.14DC
policy-tag policy_tag_edc1
site-tag site_tag_flex
ap E4AA.5D2C.3CAC
policy-tag policy_tag_edc2
site-tag site_tag_flex
```



CHAPTER 53

Authentication and Authorization Between Multiple RADIUS Servers

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- Configuring 802.1X security for WLAN with split authentication and authorization servers, on page 468
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Authentication and authorization between multiple RADIUS servers

A RADIUS authentication and authorization role is a function within a RADIUS-based wireless controller configuration that:

- allows authentication and authorization duties to be carried out by a single RADIUS server or split between different servers
- enables the controller to relay authentication attributes to a separate authorization server, and
- in a split configuration, requires both servers to return ACCESS-ACCEPT for a client session to be established.

Cisco Embedded Wireless Controller on Catalyst Access Points use a request and response transaction with a single RADIUS server that combines both authentication and authorization.

A RADIUS server can assume the role of either an authentication server, authorization server, or both. In cases where there are separate RADIUS servers for authentication and authorization, the Session Aware Networking (SANet) component on the embedded wireless controller allows authentication on one server and authorization on another when a client joins embedded wireless controller.

Authentication can be performed using Cisco ISE, Cisco Catalyst Center, Free RADIUS, or any third-party RADIUS Server. After the authentication server successfully authenticates a user, the embedded wireless controller relays attributes received from the authentication server to another RADIUS server designated as the authorization server.

The authorization server then performs these:

- Processes received attributes with the other policies or rules defined on the server.
- Derives attributes as part of the authorization response and returns them to the embedded wireless controller.

Note The Authentication/Authorization list created through Cisco Catalyst Center provisioning supports a maximum of 100 entries. Entries beyond 100 can be created, but they do not function.

Configuring 802.1X security for WLAN with split authentication and authorization servers

Configure explicit authentication and authorization server list (GUI)

Set up and customize authentication and authorization server lists to control network access and user verification methods using the GUI.

Designate specific authentication and authorization servers, such as RADIUS, TACACS+, or LDAP, to handle AAA (Authentication, Authorization, and Accounting) operations on your device.

Procedure

Step 1 Choose **Configuration** > **Security** > **AAA**. On the **Authentication Authorization and Accounting** page, click the **Servers/Groups** tab. Click the type of AAA server you want to configure from these options:

- RADIUS
- TACACS+
- LDAP

In this procedure, the RADIUS server configuration is described.

Step 2 With the **RADIUS** option selected, click **Add** and enter a name for the RADIUS server and the IPv4 or IPV6 address of the server.

Step 3 Enter the authentication and encryption key to be used between the device and the key string RADIUS daemon running on the RADIUS server. You can choose to use either a PAC key or a non-PAC key.

Step 4 Enter the server timeout value; the valid range is 1 to 1000 seconds. Enter a retry count; the valid range is 0 to 100.

Step 5 Leave the **Support for CoA** field in **Enabled** state and click **Save & Apply to Device**.

Step 6 On the **Authentication Authorization and Accounting** page, with **RADIUS** option selected, click the **Server Groups** tab. In the **Create AAA RADIUS Server Group** window that is displayed, enter a name for the RADIUS server group.

Step 7 From the **MAC-Delimiter** drop-down list, select the delimiter to be used in the MAC addresses that are sent to the RADIUS servers. From the **MAC Filtering** drop-down list, select a value based on which to filter MAC addresses.

Step 8 To configure dead time for the server group and direct AAA traffic to alternative groups of servers that have different operational characteristics, in the **Dead-Time** field, enter the amount of time, in minutes, after which a server is assumed to be dead.

Step 9 Choose the servers that you want to include in the server group from the **Available Servers** list and move them to the **Assigned Servers** list. Click **Save & Apply to Device**.

Configure explicit authentication server list (GUI)

Set up and manage RADIUS authentication servers and server groups to control authentication and accounting within your network environment using the GUI.

Use this task when you need to explicitly designate which RADIUS servers and groups are available for authentication in your AAA configuration, using the device's graphical interface.

Procedure

Step 1 Choose **Configuration** > **Security** > **AAA** > **Servers/Groups**.

Step 2 Choose **RADIUS** > **Servers** tab.

Step 3 Click **Add** to add a new server or click an existing server.

Step 4 Enter the **Name**, the **Server Address**, **Key**, **Confirm Key**, **Auth Port** and **Acct Port**. Check the **PAC Key** checkbox and enter the **PAC key** and **Confirm PAC Key**.

Step 5 Click **Apply to Device**.

Step 6 Choose **RADIUS** > **Server Groups** and click **Add** to add a new server group or click an existing server group.

Step 7 Enter the **Name** of the server group and choose the servers that you want to include in the server group, from the **Available Servers** list and move them to the **Assigned Servers** list.

Step 8 Click **Apply to Device**.

Configure explicit authentication server list (CLI)

Set up an authentication server list by explicitly defining RADIUS server parameters using commands.

Use this procedure on Cisco devices when you require explicit configuration of authentication server parameters for AAA.

Procedure

Step 1 Enable the privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Specify the RADIUS server name.

Example:

```
Device(config)# radius server server name
```

Step 4 Specify the RADIUS server parameters.

Example:

```
Device(config-radius-server)# address ipv4 192.0.2.56 auth-port 1812 acct-port 1813
```

Step 5 Specify the authentication and encryption key used between the device and the key string RADIUS daemon running on the RADIUS server.

Example:

```
Device(config-radius-server)# pac key key
```

Step 6 Return to the configuration mode.

Example:

```
Device(config-radius-server)# exit
```

Step 7 Create a radius server-group identification.

Example:

```
Device(config)# aaa group server radius server-group
```

server-group refers to the server group name. The valid range is from 1 to 32 alphanumeric characters.

If the IP address of the RADIUS server is not added to the routes defined for the controller, the default route is used. We recommend that you define a specific route to source the traffic from the defined SVI in the AAA server group.

Step 8 Configure the server name.

Example:

```
Device(config)# server name server-name
```

Step 9 Return to privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Example:

```
Device(config)# end
```

For more information, see *Configuring AAA for External Authentication*.

Configure explicit authorization server list (GUI)

Set up and organize RADIUS authorization servers and groups for secure network authentication and accounting using the GUI.

Configuring an explicit authorization server list ensures that devices can authenticate users and account activity through specified RADIUS servers. This centralized management helps enforce access policies and simplifies administration.

Procedure

Step 1 Choose **Configuration** > **Security** > **AAA** > **Servers/Groups**.

Step 2 Choose **RADIUS** > **Servers** tab.

Step 3 Click **Add** to add a new server or click an existing server.

Step 4 Enter the **Name**, the **Server Address**, **Key**, **Confirm Key**, **Auth Port** and **Acct Port.** Check the **PAC Key** checkbox and enter the **PAC key** and **Confirm PAC Key**.

Step 5 Click **Apply to Device**.

Step 6 Choose **RADIUS** > **Server Groups** and click **Add** to add a new server group or click an existing server group.

Step 7 Enter the **Name** of the server group and choose the servers that you want to include in the server group, from the **Available Servers** list and move them to the **Assigned Servers** list.

Step 8 Click **Apply to Device**.

Configure explicit authorization server list (CLI)

You must direct AAA validation access requests to a specific server. Otherwise, the wireless controller selects any available AAA server from the configured pool to validate access requests. Because the controller cannot target a specific server for validation, you may face inefficiencies and potential security vulnerabilities.

To address this, an authorization method list is created to allow administrators to explicitly direct the controller to use a specific AAA server or the local database for validation. This configuration ensures a streamlined and secure validation process by eliminating randomness in server selection.

Benefits of this approach are:

- **Improved Control**: You can explicitly define which AAA server handles validation requests and ensure precise control over server selection.
- **Flexibility**: You can configure either an external AAA server or a local database based on the network's requirements.
- **Enhanced Security**: By specifying the AAA server, you can ensure that only trusted servers are used for validation, reducing the risk of unauthorized access.

Follow these steps to configure an explicit authorization server list using commands:

Procedure

Step 1 Enable privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Set up the security framework by enabling AAA features for authentication, authorization, and accounting.

Example:

```
Device# aaa new-model
```

Step 4 Configure a RADIUS server to enable centralized authentication, authorization, and accounting for secure and scalable network access control.

a) Specify the RADIUS server name.
b) Specify the RADIUS server parameters.
c) Specify the authorization and encryption key used between the device and the RADIUS daemon running on the RADIUS server by key string encryption.

Example:

```
Device(config)# radius server server-name
Device(config)# address ipv4 address auth-port auth_port_number acct-port acct_port_number
Device(config)# pac key key
Device(config)# end
```

Step 5 Configure the RADIUS group.

a) Create a radius server-group identification.

Example:

```
Device(config)# aaa group server radius server-name
Device(config-sg-radius)# server name server-name
Device(config-sg-radius)# exit
```

Step 6 Define a network-level authorization policy for access control using the previously specified server group.

Example:

```
Device(config)# aaa authorization network rogued group group-name
```

Step 7 Create an attribute list to apply custom authentication or authorization attributes.

a) Create an attribute list to specify policies for rogue AP detection and control and enter the attribute list configuration mode.
b) Identify the device with a specific rogue state for network policies.
c) Identify the device with a specific rogue class for network policies.

Example:

```
Device(config)# aaa attribute list aaa-attribute-list-name
Device(config-attr-list)# attribute type rogue-ap-state {alert | contain | threat }
Device(config-attr-list)# attribute type rogue-ap-class {unclassified | malicious | friendly
 }
Device(config-attr-list)# exit
```

Step 8 Define a client with a specific MAC address as a *username* and associate it with the previously defined AAA attribute list. This allows for controlled access or applies policy decisions for that specific client.

Important
For rogue validation, the *username* must be a MAC address in the semicolon format.

Example:

Define a client with a specific MAC address (00:00:00:00:00:00) as a *username* and associate it with an AAA attribute list named **rogue-attributes**. This allows for the use of specific AAA (authentication, authorization, and accounting) attributes to be applied to this MAC address, typically to control access or apply policy decisions for that client.

```
Device(config)# username 00:00:00:00:00:00 mac aaa attribute list aaa-attribute-list-name
```

Step 9 Display the AAA running configuration for review.

Example:

```
Device(config)# show running-config | include aaa
```

Setting up these configurations ensure that only authorized clients can access the network, and any suspicious activity is flagged and handled appropriately.

Configure authentication and authorization list for 802.1X security (GUI)

Set up 802.1X security by specifying authentication and authorization lists through the GUI.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Click **Add**.

Step 3 In the **General** tab, enter the **Profile Name** , the **SSID** , and the **WLAN ID**.

Step 4 In the **Security** > **AAA** tab, select an authentication list from the **Authentication List** drop-down list.

Step 5 Click **Apply to Device**.

Configure authentication and authorization list for 802.1X security (CLI)

Configure 802.1X authentication and authorization on a WLAN using commands.

Use this procedure when you need to enforce 802.1X security for a specific wireless network on your device.

Procedure

Step 1 Enable privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Enter the WLAN configuration sub-mode.

Example:

```
Device(config)# wlan wlan-name wlan-id ssid name
```

- *wlan-name* : is the name of the configured WLAN.
- *wlan-id* : is the wireless LAN identifier. The valid range is from 1 to 512.
- *SSID-name* : is the SSID name which can contain 32 alphanumeric characters.

Note
If you have already configured this command, enter **wlan** *wlan-name* command.

Step 4 Enable authentication list for 802.1x security.

Example:

```
Device(config-wlan)# security dot1x authentication-list authenticate-list-name
```

Step 5 Specify authorization list for 802.1x security.

Example:

```
Device(config-wlan)# security dot1x authorization-list authorize-list-name
```

For more information on the Cisco Catalyst Center, see the Cisco Catalyst Center documentation.

Step 6 Return to privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Example:

```
Device(config-wlan)# end
```

Configure web authentication for WLAN with split authentication and authorization servers

Configure authentication and authorization list for web authentication (GUI)

Configure authentication and authorization lists to secure web authentication on WLANs using the GUI.

This task ensures only authorized users can access the WLAN, and that access policies are applied during web authentication by assigning the correct authentication and authorization lists.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Click **Add**.

Step 3 In the **General** tab, enter the **Profile Name**, the **SSID**, and the **WLAN ID**.

Step 4 In the **Security** > **Layer2** tab, uncheck the **WPAPolicy**, **AES** and **802.1x** check boxes.

Step 5 Check the **MAC Filtering** check box to enable the feature. With MAC Filtering enabled, select the authorization list from the **Authorization List** drop-down list.

Step 6 In the **Security** > **AAA** tab, select the authentication list from the **Authentication List** drop-down list.

Step 7 Click **Apply to Device**.

Configure authentication and authorization list for web authentication (CLI)

Enable web-based authentication and authorization for users connecting to a specified WLAN using commands.

Web authentication allows users to be authenticated through a web browser before gaining access to network resources.

Procedure

Step 1 Enable privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Enter the WLAN configuration sub-mode.

Example:

```
Device(config)# wlan wlan-name wlan-id ssid-name
```

- *wlan-name* : is the name of the configured WLAN.
- *wlan-id* : is the wireless LAN identifier.
- *SSID-name* : is the SSID name which can contain 32 alphanumeric characters.

Note
If you have already configured this command, enter **wlan** *wlan-name* command.

Step 4 Disable WPA security.

Example:

```
Device(config-wlan)# no security wpa
```

Step 5 Disable security AKM for 802.1x.

Example:

```
Device(config-wlan)# no security wpa akm dot1x
```

Step 6 Disable WPA2 security.

Example:

```
Device(config-wlan)# no security wpa wpa2
```

Step 7 Enable authentication or authorization list for 802.1x security.

Example:

```
Device(config-wlan)# security web-auth { authentication-list authenticate-list-name |
authorization-list authorize-list-name }
```

Note
When the WPA security, AKM for 802.1x, and WPA2 security settings are not disabled, the system displays the error:

% switch-1:dbm:wireless:web-auth cannot be enabled. Invalid WPA/WPA2 settings.

Step 8 Return to the privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Example:

```
Device(config-wlan)# end
```

Verify split authentication and authorization configuration

To view the WLAN details, use this command:

```
Device# show run wlan

wlan wlan-foo 2 foo-ssid
security dot1x authentication-list authc-server-group
security dot1x authorization-list authz-server-group
wlan wlan-bar 3 bar-ssid
security web-auth authentication-list authc-server-group
security web-auth authorization-list authz-server-group
```

To view the AAA authentication and server details, use this command:

```
Device# show run aaa

!
aaa authentication dot1x default group radius
username cisco privilege 15 password 0 cisco
!
!
radius server free-radius-authc-server
 address ipv4 9.2.62.56 auth-port 1812 acct-port 1813
 key cisco
!
radius server cisco-catalyst-center-authz-server
 address ipv4 9.4.62.32 auth-port 1812 acct-port 1813
 pac key cisco
!
!
aaa new-model
aaa session-id common
!
```

To view the authentication and authorization list for 802.1X security, use this command:

```
Device# show wlan name wlan-foo | sec 802.1x

802.1x authentication list name                : authc-server-group
802.1x authorization list name                 : authz-server-group
            802.1x                             : Enabled
```

To view the authentication and authorization list for web authentication, use this command:

```
Device# show wlan name wlan-bar | sec Webauth

Webauth On-mac-filter Failure              : Disabled
Webauth Authentication List Name           : authc-server-group
Webauth Authorization List Name            : authz-server-group
Webauth Parameter Map                      : Disabled
```

Configuration examples

Configure Cisco Embedded Wireless Controller on Catalyst Access Points for authentication with a third-party RADIUS server: example

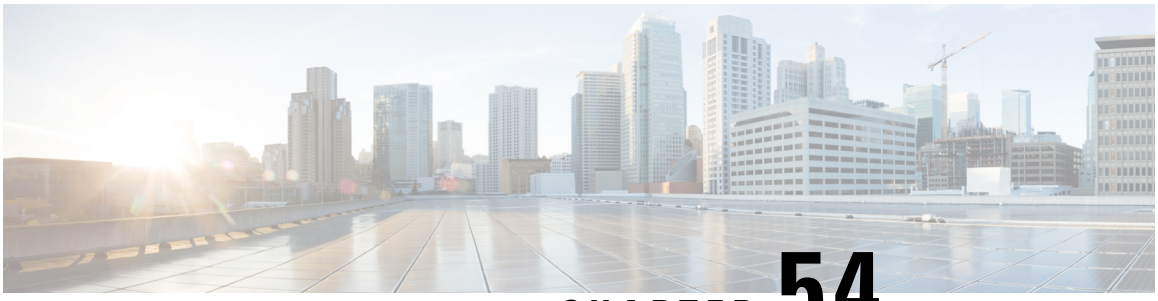
This example shows how to configure Cisco Embedded Wireless Controller on Catalyst Access Points for authentication with a third-party RADIUS server:

```
Device(config)# radius server free-radius-authc-server
Device(config-radius-server)# address ipv4 9.2.62.56 auth-port 1812 acct-port 1813
Device(config-radius-server)# key cisco
Device(config-radius-server)# exit
Device(config)# aaa group server radius authc-server-group
Device(config)# server name free-radius-authc-server
Device(config)# end
```

Configure Cisco Embedded Wireless Controller on Catalyst Access Points for authorization with Cisco ISE or Cisco Catalyst Center: example

This example shows how to configure Cisco Embedded Wireless Controller on Catalyst Access Points for authorization with Cisco ISE or Cisco Catalyst Center:

```
Device(config)# radius server cisco-catalyst-center-authz-server
Device (config-radius-server)# address ipv4 9.4.62.32 auth-port 1812 acct-port 1813
Device (config-radius-server)# pac key cisco
Device (config-radius-server)# exit
Device(config)# aaa group server radius authz-server-group
Device(config)# server name cisco-catalyst-center-authz-server
Device(config)# end
```



CHAPTER 54

Secure LDAP

This chapter guides administrators through configuring secure LDAP on Cisco wireless controllers, detailing prerequisites, restrictions, TLS certificate requirements, CLI and GUI steps for server and AAA group setup, search/bind options, attribute mapping, and verification.

- Lightweight Directory Access Protocol (LDAP), on page 479

Lightweight Directory Access Protocol (LDAP)

A Lightweight Directory Access Protocol (LDAP) is a client-server protocol that

- allows clients to access and manage directory information stored on servers
- supports user authentication and authorization using operations such as bind and search, and
- operates over TCP/IP on port 389, optionally using Transport Layer Security (TLS) for secure communications.

Transport Layer Security (TLS)

Transport Layer Security (TLS) is an application-level protocol that enables secure data transactions by providing privacy, authentication, and data integrity. TLS relies on certificates, public keys, and private keys to prove the identity of clients.

Certificate Authorities (CAs) issue the certificates.

Each certificate includes these:

- The name of the authority that issued it.
- The name of the entity to which the certificate was issued.
- The public key of the entity.
- The timestamps indicating the expiration date of the certificate.

TLS support for LDAP is described in RFC 2830, which is an extension to the LDAP protocol.

LDAP Operations

Bind

The bind operation authenticates a user to the server and starts a connection with the LDAP server. LDAP is a connection-oriented protocol. The client specifies the protocol version and authentication information.

LDAP supports these binds:

- Authenticated bind: An authenticated bind is performed when a root Distinguished Name (DN) and password are available.
- Anonymous bind: An anonymous bind is performed when no root DN and password are provided.

In LDAP deployments, the search operation is commonly performed before the bind operation. If a password attribute is returned as part of the search operation, the LDAP client can verify the password locally, eliminating the need for an extra bind operation. If the password attribute is not returned, the bind operation can occur later. Another advantage of performing the search operation first is that the LDAP client can use the DN received in the search result as the user DN, instead of constructing it by prefixing the username (cn attribute) with the base DN. All entries stored in an LDAP server have a unique DN.

The DN consists of two parts:

- Relative Distinguished Name (RDN)
- Location in the LDAP server where the record resides.

Most of the entries that you store in an LDAP server will have a name, and the name is frequently stored in the Common Name (cn) attribute. Because every object has a name, most objects stored in an LDAP server use their cn value as the basis for their RDN.

Search

A search operation is used to search the LDAP server. The client specifies the starting point (base DN) of the search, the search scope (either the object, its children, or the subtree rooted at the object), and a search filter.

For authorization requests, the search operation is performed without a bind operation. The LDAP server must be configured with sufficient privileges for the search operation to succeed. These privileges are established during the bind operation.

An LDAP search operation can return multiple entries for a specific user. When this occurs, the LDAP client returns an error code to AAA. To prevent these errors, configure search filters to match only a single entry.

Compare

The compare operation replaces a bind request for authentication and helps maintain the initial bind parameters for the connection.

LDAP Dynamic Attribute Mapping

The Lightweight Directory Access Protocol (LDAP) is a powerful and flexible protocol for communication with AAA servers. LDAP attribute maps provide a method to cross-reference attributes retrieved from a server with Cisco attributes supported by security appliances.

When a user authenticates to a security appliance, the appliance authenticates the server and uses LDAP to retrieve the user's record. The record consists of LDAP attributes associated with fields displayed on the server's user interface. Each attribute retrieved includes a value entered by the administrator responsible for updating user records.

SLDAP prerequisite

This section lists the prerequisite for setting up SLDAP on a wireless controller and describes when to configure certificates.

- If you are using a Transport Layer Security (TLS) secure connection, you must configure X.509 certificates.

SLDAP restrictions

- LDAP referrals are not supported.
- The LDAP server's unsolicited messages or notifications are not handled.
- LDAP authentication is not supported for interactive terminal sessions.

Configure SLDAP (CLI)

Set up Secure LDAP (SLDAP) for authentication and directory queries on the wireless controller using commands.

Before you begin

Ensure you have administrator access to the controller. Gather LDAP server details (IP address, base DN, credentials).

Procedure

Step 1 Enable privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Define a Lightweight Directory Access Protocol (LDAP) server and enter the LDAP server configuration mode.

Example:

```
Device(config)# ldap server server-name
```

Step 4 Specify the LDAP server IP address using IPv4.

Example:

```
Device(config-ldap-server)# ipv4 ipv4-address
```

Step 5 Specify the number of seconds the or the embedded wireless controller waits for a reply to a LDAP request before retransmitting the request.

Example:

```
Device(config-ldap-server)# timeout retransmit seconds
```

Step 6 Specify a shared secret text string used between the or the embedded wireless controller and a LDAP server.

Example:

```
Device(config-ldap-server)# bind authenticate root-dn
CN=ldapipv6user,CN=Users,DC=ca,DC=ssh2,DC=com password Cisco12345
```

Use the **0** line option to configure an unencrypted shared secret.

Use the **7** line option to configure an encrypted shared secret.

Step 7 Specify the base Distinguished Name (DN) of the search.

Example:

```
Device(config-ldap-server)# base-dn string CN=Users,DC=ca,DC=ssh2,DC=com
```

Step 8 Configure LDAP to initiate the TLS connection and specify the secure mode.

Example:

```
Device(config-ldap-server)# mode secure no- negotiation
```

Step 9 Return to the privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Example:

```
Device(config-ldap-server)# end
```

Configure a AAA server group (GUI)

Configure a AAA server group using the GUI for RADIUS, TACACS+, or LDAP server hosts using the GUI.

Configuring a device to use AAA server groups helps you group existing server hosts, select a subset of those hosts, and assign them for a particular service. A server group is used with a global server-host list. The server group lists the IP addresses of the selected server hosts.

You can create these server groups:

Before you begin

Procedure

Step 1 RADIUS

a) Choose **Services** > **Security** > **AAA** > **Server Groups** > **RADIUS**.
b) Click the **Add** button. The **Create AAA Radius Server Group** dialog box appears.
c) Enter a name for the RADIUS server group in the **Name** field.
d) Select a desired delimiter from the **MAC-Delimiter** drop-down list. The available options are colon, hyphen, and single-hyphen.
e) Select a desired filter from the **MAC-Filtering** drop-down list. The available options are mac and Key.

f) Enter a value in the **Dead-Time (mins)** field to make a server non-operational. You must specify a value between 1 and 1440.
g) Choose any of the available servers from the **Available Servers** list and move them to the **Assigned Servers** list by clicking the **>** button.
h) Click the **Save & Apply to Device** button.

Step 2 TACACS+

a) Choose **Services** > **Security** > **AAA** > **Server Groups** > **TACACS+**.
b) Click the **Add** button. The **Create AAA Tacacs Server Group** dialog box appears.
c) Enter a name for the TACACS server group in the **Name** field.
d) Choose any of the available servers from the **Available Servers** list and move them to the **Assigned Servers** list by clicking the **>** button.
e) Click the **Save & Apply to Device** button.

Step 3 LDAP

a) Choose **Services** > **Security** > **AAA** > **Server Groups** > **LDAP**.
b) Click the **Add** button. The **Create AAA Ldap Server Group** dialog box appears.
c) Enter a name for the LDAP server group in the **Name** field.
d) Choose any of the available servers from the **Available Servers** list and move them to the **Assigned Servers** list by clicking the **>** button.
e) Click the **Save & Apply to Device** button.

Configure a AAA server group (CLI)

Establish a AAA server group for centralized authentication, authorization, and accounting using commands.

AAA server groups allow you to centrally manage user access and policy enforcement with protocols such as LDAP, RADIUS, or TACACS+.

Procedure

Step 1 Enable the privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Enable AAA.

Example:

```
Device(config)# aaa new-model
```

Step 4 Define the AAA server group with a group name and enter the LDAP server group configuration mode.

Example:

```
Device(config)# aaa group server ldap group-name
```

All members of a group are of the same type: RADIUS, LDAP, or TACACS+.

Step 5 Associate a particular LDAP server with the defined server group.

Example:

```
Device(config-ldap-sg)# server server-name
```

Each security server is identified by its IP address and UDP port number.

Step 6 Exit the LDAP server group configuration mode.

Example:

```
Device(config-ldap-sg)# exit
```

Configure search and bind operations for authentication requests (CLI)

Enable LDAP-based authentication by defining how the controller searches and binds user credentials during authentication requests using commands.

Configuring search and bind operations determines whether the LDAP server first binds the user and then performs a search, or compares credentials without binding. This affects how authentication requests are processed on the controller.

Procedure

Step 1 Enable the privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Enable AAA.

Example:

```
Device(config)# aaa new-model
```

Step 4 Define a Lightweight Directory Access Protocol (LDAP) server and enter the LDAP server configuration mode.

Example:

```
Device(config)# ldap server server-name
```

Step 5 Configure the sequence of search and bind operations for an authentication request.

Example:

```
Device(config-ldap-server)# authentication bind-first
```

Step 6 Replace the bind request with the compare request for authentication.

Example:

```
Device(config-ldap-server)# authentication compare
```

Step 7 Exit the LDAP server group configuration mode.

Example:

```
Device(config-ldap-server)# exit
```

Configure a dynamic attribute map on a SLDAP server (CLI)

Configure dynamic LDAP attribute maps to ensure seamless interoperability between user-defined attribute names and Cisco attribute requirements on a wireless controller using commands.

You must create LDAP attribute maps that map your existing user-defined attribute names and values to Cisco attribute names and values that are compatible with the security appliance. You can then bind these attribute maps to LDAP servers or remove them as required.



Note To use the attribute mapping features correctly, make sure you understand Cisco LDAP and user-defined attribute names and values.

Before you begin

Procedure

Step 1 Enable privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Configure a dynamic LDAP attribute map and enter the attribute-map configuration mode.

Example:

```
Device(config)# ldap attribute-map map-name
```

Step 4 Define an attribute map.

Example:

```
Device(config-attr-map)# map type ldap-attr-type aaa-attr-type
```

Step 5 Exit the attribute-map configuration mode.

Example:

```
Device(config-attr-map)# exit
```

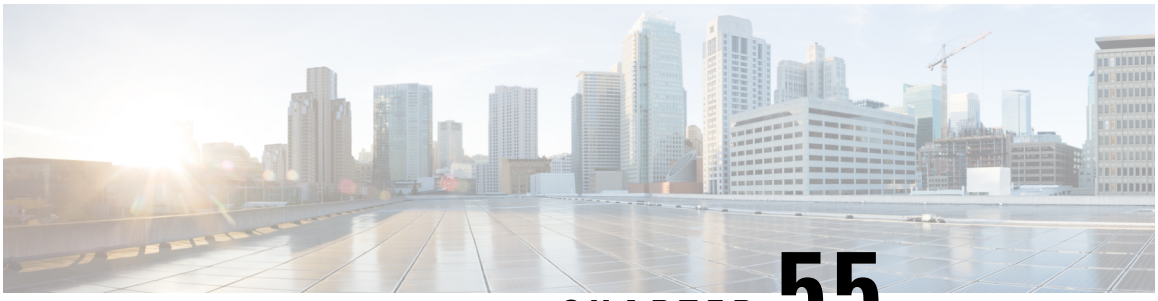
Verify the SLDAP configuration

To view details about the default LDAP attribute mapping, use this command:

```
Device# show ldap attributes
```

To view the LDAP server state information and various other counters for the server, use this command:

```
Device# show ldap server
```



CHAPTER 55

RADIUS DTLS

- Information About RADIUS DTLS, on page 487
- Prerequisites, on page 489
- Configuring RADIUS DTLS Server, on page 489
- Configuring DTLS Dynamic Author, on page 494
- Enabling DTLS for Client, on page 495
- Verifying the RADIUS DTLS Server Configuration, on page 498
- Clearing RADIUS DTLS Specific Statistics, on page 498

Information About RADIUS DTLS

The Remote Authentication Dial-In User Service (RADIUS) is a client or server protocol that provides centralized security for users attempting to gain management access to a network. The RADIUS protocol is a widely deployed authentication and authorization protocol that delivers a complete Authentication, Authorization, and Accounting (AAA) solution.

RADIUS DTLS Port

The RADIUS port (DTLS server) is used for authentication and accounting. The default DTLS server port is 2083.

You can change the RADIUS DTLS port number using **dtls port** *port_number*. For more information, see the Configuring RADIUS DTLS Port Number section.

Shared Secret

You can use **radius/dtls** as the shared secret, if you have enabled DTLS for a specific server.

Handling PAC for CTS Communication

You can download PAC from ISE for CTS communication. Once the PAC is downloaded, you need to encrypt all the CTS attributes with the PAC key instead of the shared secret.

The ISE then decrypts these attributes using PAC.

Session Management

The RADIUS client purely depends on the response from the DTLS server. If the session is ideal for ideal timeout, then the session must be closed.

In case of invalid responses, the sessions must be deleted.

If you need to send the radius packets over DTLS, the DTLS session needs to be re-established with the specific server.

Load Balancing

Multiple DTLS servers and load balancing methods are configured.

You need to select the AAA server to which the request needs to be sent. Then use the DTLS context of the specific server to encrypt the RADIUS packet and send it back.

Connection Timeout

After the encrypted RADIUS packet is sent, you need to start the retransmission timer. If you do not get a response before the retransmission timer expires, the packet is re-encrypted and re-transmitted.

You can continue for number of times as per the **dtls retries** configuration or till the default value. Once the number of tries exceeds the limit, the server becomes unavailable and responses are sent back to the AAA clients.

Note The default connection timeout is 5 seconds.

Connection Retries

As the RADIUS DTLS is UDP based, you need to retry the connection after a specific timeout interval for a specific number of retries.

RADSEC consists of two types: RADIUS-over-TLS (using TCP) and RADIUS-over-DTLS (using UDP). Cisco IOS-XE support RADIUS-over-DTLS (UDP) but does not support RADIUS-over-TLS (TCP), as outlined in RFC 7360.

After all retries are exhausted, the DTLS connection performs the following:

- Is marked as unsuccessful.
- Looks up for the next available server for processing the RADIUS requests.

Note The default connection retries is 5.

Idle Timeout

When the idle timer expires and no transactions exists since the last idle timeout, the DTLS session remains closed.

After you establish the DTLS session, you can start the idle timer. If you start the idle timer for 30 seconds and one of the RADIUS DTLS packet is sent, then after 30 seconds, the idle timer expires and checks for number of RADIUS DTLS transactions.

If the idle timer value exceeds zero, the idle timer resets the transaction counter and restarts the timer.

Note The default idle timeout is 60 seconds.

Handling Server and Server Group Failover

You can configure RADIUS servers with and without DTLS. It is recommended to create AAA server groups with DTLS enabled servers and non-DTLS servers. However, you will not find any such restriction while configuring AAA server groups.

Suppose you choose a DTLS server, the DTLS server establishes connection and RADIUS request packet is sent to the DTLS server. If the DTLS server does not respond after all RADIUS retries, it would fall over to the next configured server in the same server group. If the next server is a DTLS server, the processing of the RADIUS request packet continues with the next server. If the next server is a non-DTLS server, the processing of RADIUS request packet does not happen in that server group. Then the server group failover occurs and the same sequence continues with the next server group, if the next server group is available.

Note You need to use either only DTLS or non-DTLS servers in a server group.

Prerequisites

Support for IOS and BINOS AAA

The AAA server runs in IOS and BINOS platforms. Once you complete the RADIUS DTLS support in IOS, the same needs to be ported to BINOS.

Configuring RADIUS DTLS Server

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
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 R1`	Specifies the RADIUS server name.
Step 4	**dtls** **Example:** `Device(config-radius-server)# dtls`	Configures DTLS parameters.
Step 5	**end** **Example:** `Device(config-radius-server)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring RADIUS DTLS Connection Timeout

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters 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 R1`	Specifies the RADIUS server name.
Step 4	**dtls connectiontimeout** *timeout* **Example:** `Device(config-radius-server)# dtls connectiontimeout 1`	Configures RADIUS DTLS connection timeout. Here, *timeout* refers to the DTLS connection timeout value. The valid range is from 1 to 65535.
Step 5	**end** **Example:** `Device(config-radius-server)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring RADIUS DTLS Idle Timeout

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters 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 R1`	Specifies the RADIUS server name.
Step 4	**dtls idletimeout** *idle_timeout* **Example:** `Device(config-radius-server)# dtls idletimeout 2`	Configures RADIUS DTLS idle timeout. Here, *idle_timeout* refers to the DTLS idle timeout value. The valid range is from 1 to 65535.
Step 5	**end** **Example:** `Device(config-radius-server)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring Source Interface for RADIUS DTLS Server

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters 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 R1`	Specifies the RADIUS server name.

	Command or Action	Purpose
Step 4	**dtls ip** {**radius source-interface Ethernet-Internal** *interface_number* **Example:** `Device(config-radius-server)# dtls ip radius source-interface Ethernet-Internal 0`	Configures source interface for RADIUS DTLS server. Here, • *interface_number* refers to the Ethernet-Internal interface number. The default value is 0.
Step 5	**end** **Example:** `Device(config-radius-server)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring RADIUS DTLS Port Number

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters 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 R1`	Specifies the RADIUS server name.
Step 4	**dtls port** *port_number* **Example:** `Device(config-radius-server)# dtls port 2`	Configures RADIUS DTLS port number. Here, *port_number* refers to the DTLS port number.
Step 5	**end** **Example:** `Device(config-radius-server)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring RADIUS DTLS Connection Retries

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters 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 R1`	Specifies the RADIUS server name.
Step 4	**dtls retries** *retry_number* **Example:** `Device(config-radius-server)# dtls retries 3`	Configures RADIUS connection retries. Here, *retry_number* refers to the DTLS connection retries. The valid range is from 1 to 65535.
Step 5	**end** **Example:** `Device(config-radius-server)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring RADIUS DTLS Trustpoint

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters 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 R1`	Specifies the RADIUS server name.

	Command or Action	Purpose

Step 4	**dtls trustpoint** {**client** *LINE* **dtls** | **server** *LINE* **dtls**}
	Example:
	`Device(config-radius-server)# dtls trustpoint client client1 dtls`
	`Device(config-radius-server)# dtls trustpoint server server1 dtls`
		Configures trustpoint for client and server.

Step 5	**end** **Example:** `Device(config-radius-server)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring RADIUS DTLS Match-Server-Identity

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `dtls match-server-identity hostname <name>`	Configure the RADSEC certification validation parameters.
Step 2	**enable** **Example:** `dtls match-server-identity ip-address <IPv4 or IPv6>`	Configure the RADSEC certification validation parameters.

Configuring DTLS Dynamic Author

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**aaa server radius dynamic-author** **Example:** `Device(config)# aaa server radius dynamic-author`	Configures local server profile for RFC 3576 support.
Step 4	**dtls** **Example:** `Device(config-locsvr-da-radius)# dtls`	Configures DTLS source parameters.
Step 5	**end** **Example:** `Device(config-locsvr-da-radius)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Enabling DTLS for Client

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa server radius dynamic-author** **Example:** `Device(config)# aaa server radius dynamic-author`	Configures local server profile for RFC 3576 support.
Step 4	**client** *IP_addr* **dtls** **Example:** `Device(config-locsvr-da-radius)# client 10.104.49.14 dtls`	Enables DTLS for the client.
Step 5	**end** **Example:** `Device(config-locsvr-da-radius)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring Client Trustpoint for DTLS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa server radius dynamic-author** **Example:** `Device(config)# aaa server radius dynamic-author`	Configures local server profile for RFC 3576 support.
Step 4	**client** *IP_addr* **dtls** {**client-tp** *client-tp-name* | **server-tp** *server-tp-name*} **Example:** `Device(config-locsvr-da-radius)# client 10.104.49.14 dtls client-tp client_tp_name`	Configures client trustpoint for DTLS.
Step 5	**end** **Example:** `Device(config-locsvr-da-radius)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring DTLS Idle Timeout

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 3	**aaa server radius dynamic-author** **Example:** `Device(config)# aaa server radius dynamic-author`	Configures local server profile for RFC 3576 support.
Step 4	**client** *IP_addr* **dtls idletimeout** *timeout-interval* {**client-tp** *client_tp_name* | **server-tp** *server_tp_name*} **Example:** `Device(config-locsvr-da-radius)# client 10.104.49.14 dtls idletimeout 62 client-tp dtls_ise`	Configures DTLS idle time. Here, *timeout-interval* refers to the idle timeout interval. The valid range is from 60 to 600.
Step 5	**end** **Example:** `Device(config-locsvr-da-radius)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring Server Trustpoint for DTLS

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**aaa server radius dynamic-author** **Example:** `Device(config)# aaa server radius dynamic-author`	Configures local server profile for RFC 3576 support.
Step 4	**client** *IP_addr* **dtls server-tp** *server_tp_name* **Example:** `Device(config-locsvr-da-radius)# client 10.104.49.14 dtls server-tp dtls_client`	Configures server trust point.
Step 5	**end** **Example:** `Device(config-locsvr-da-radius)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Verifying the RADIUS DTLS Server Configuration

To view information about the DTLS enabled servers, use the following command:

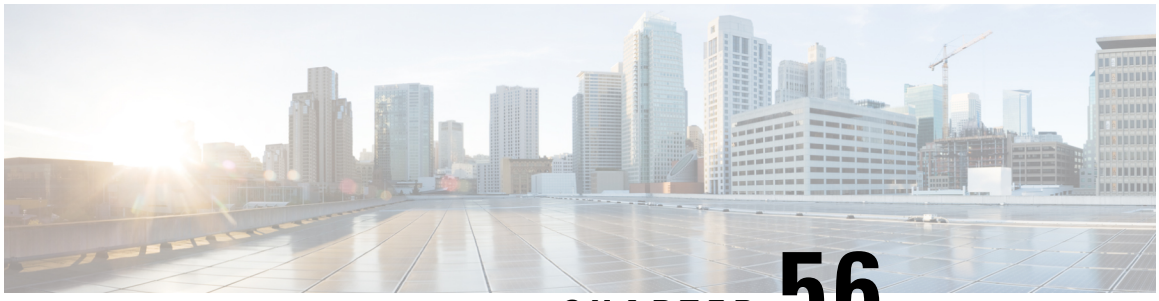
```
Device# show aaa servers
DTLS: Packet count since last idletimeout 1,
Send handshake count 3,
Handshake Success 1,
Total Packets Transmitted 1,
Total Packets Received 1,
Total Connection Resets 2,
Connection Reset due to idle timeout 0,
Connection Reset due to No Response 2,
Connection Reset due to Malformed packet 0,
```

Clearing RADIUS DTLS Specific Statistics

To clear the radius DTLS specific statistics, use the following command:

```
Device# clear aaa counters servers radius {<server-id> | all}
```

Note Here, *server-id* refers to the server ID displayed by **show aaa servers**. The valid range is from 0 to 2147483647.



CHAPTER 56

MAC Filtering

- MAC Filtering, on page 499
- Configuring MAC Filtering for Local Authentication (CLI), on page 500
- Configuring MAC Filtering (GUI), on page 502
- Configuring MAB for External Authentication (CLI), on page 502

MAC Filtering

You can configure the embedded wireless controller to authorize clients based on the client MAC address by using the MAC filtering feature.

When MAC filtering is enabled, the embedded wireless controller uses the MAC address as the client identity. The authentication server has a database of client MAC addresses that are allowed network access. The embedded wireless controller sends the authentication server a RADIUS-access/request frame with a username and password based on the client MAC address as soon as it gets the association request from the client. If authorization succeeds, the embedded wireless controller sends a successful association response to the client. If authorization fails, the embedded wireless controller rejects the client association.

Clients that were authorized with MAC filtering can be re-authenticated through the WLAN session timeout feature.

MAC Filtering Configuration Guidelines

- MAC filtering authentication occurs at the 802.11 association phase and delays the association response until authentication is done. If you use a RADIUS server for MAC filtering, it is advised to keep a low latency between the controller and the RADIUS server. When latency is too high, the client might timeout while waiting for the association response.
- MAC filtering can be combined with other authentication methods such as 802.1X, Pre-Shared Key or it can be used alone.
- MAC addresses can be spoofed and MAC filtering does not consist in a security measure.
- Many clients can use a private MAC address to connect and change it at every session, therefore making it harder to identify devices through their MAC address.

Note If wlan-profile-name is configured for a user, guest user authentication is allowed only from that WLAN.

If wlan-profile-name is not configured for a user, guest user authentication is allowed on any WLAN.

If you want the client to connect to SSID1, but not to SSID2 using mac-filtering, ensure that you configure **aaa-override** in the policy profile.

In the following example, when a client with MAC address 112233440001 tries to connect to a WLAN, the request is sent to the local RADIUS server, which checks the presence of the client MAC address in its attribute list (FILTER_1 and FILTER_2). If the client MAC address is listed in an attribute list (FILTER_1), the client is allowed to join the WLAN (WLAN_1) that is returned as *ssid attribute* from the RADIUS server. The client is rejected, if the client MAC address is not listed in the attribute list.

Local RADIUS Server Configuration

```
!Configures an attribute list as FILTER_2
aaa attribute list FILTER_2
!Defines an attribute type that is to be added to an attribute list.
attribute type ssid "WLAN_2"

!Username with the MAC address is added to the filter
username 112233440001 mac aaa attribute list FILTER_2

!
aaa attribute list FILTER_1
attribute type ssid "WLAN_1"
username 112233440001 aaa attribute list FILTER_1
```

Controller Configuration

```
! Sets authorization to the local radius server
aaa authorization network MLIST_MACFILTER local

!A WLAN with the SSID WLAN_2 is created and MAC filtering is set along with security
parameters.
wlan WLAN_2 2 WLAN_2
mac-filtering MLIST_MACFILTER
no security wpa
no security wpa wpa2 ciphers

!WLAN with the SSID WLAN_1 is created and MAC filtering is set along with security parameters.
wlan WLAN_1 1 WLAN_1
mac-filtering MLIST_MACFILTER
no security wpa
no security wpa wpa2 ciphers aes
no security wpa akm dot1x
security web-auth
security web-auth authentication-list WEBAUTH

! Policy profile to be associated with the above WLANs
wireless profile policy MAC_FILTER_POLICY
aaa-override
vlan 504
no shutdown
```

Configuring MAC Filtering for Local Authentication (CLI)

Follow the procedure given below to configure MAB for local authentication.

Before you begin

Configure AAA local authentication.

Configure the username for WLAN configuration (local authentication) using **username** *mac-address* **mac** command.



Note The mac-address must be in the following format: *abcdabcdabcd*

Procedure

	Command or Action	Purpose
Step 1	**wlan** *profile-name wlan-id* **Example:** `wlan CR1_SSID_mab-local-default 1 CR1_SSID_mab-local-default`	Specifies the WLAN name and ID.
Step 2	**mac-filtering default** **Example:** `Device(config-wlan)# mac-filtering default`	Sets MAC filtering support for the WLAN.
Step 3	**no security wpa** **Example:** `Device(config-wlan)# no security wpa`	Disables WPA secuirty.
Step 4	**no security wpa akm dot1x** **Example:** `Device(config-wlan)# no security wpa akm dot1x`	Disables security AKM for dot1x.
Step 5	**no security wpa wpa2** **Example:** `Device(config-wlan)# no security wpa wpa2`	Disables WPA2 security.
Step 6	**no security wpa wpa2 ciphers aes** **Example:** `Device(config-wlan)# no security wpa wpa2 ciphers aes`	Disables WPA2 ciphers for AES.
Step 7	**no shutdown** **Example:** `Device(config-wlan)# no shutdown`	Enables the WLAN.

Configuring MAC Filtering (GUI)

Before you begin

Configure AAA external authentication.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **WLANs**.
Step 2 On the **Wireless Networks** page, click the name of the WLAN.
Step 3 In the **Edit WLAN** window, click the **Security** tab.
Step 4 In the **Layer2** tab, check the **MAC Filtering** check box to enable the feature.
Step 5 With MAC Filtering enabled, choose the **Authorization List** from the drop-down list.
Step 6 Save the configuration.

Configuring MAB for External Authentication (CLI)

Follow the procedure given below to configure MAB for external authentication.

Before you begin

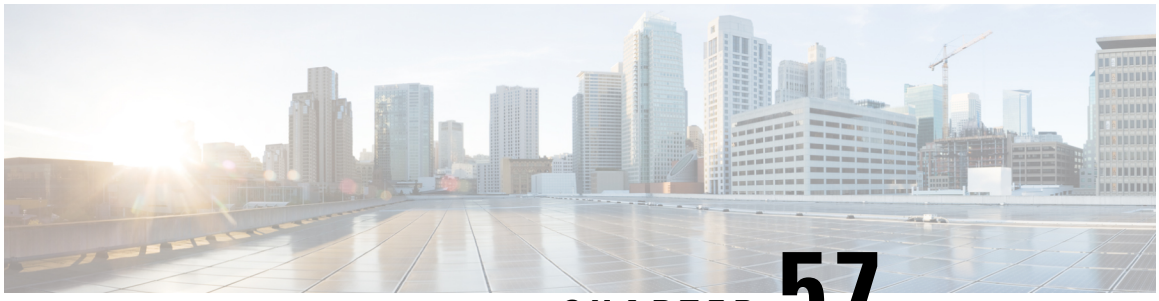
Configure AAA external authentication.

Procedure

	Command or Action	Purpose
Step 1	**wlan** *wlan-name wlan-id ssid-name* **Example:** `wlan CR1_SSID_mab-ext-radius 3 CR1_SSID_mab-ext-radius`	Specifies the WLAN name and ID.
Step 2	**mac-filtering** *list-name* **Example:** `Device(config-wlan)# mac-filtering ewlc-radius`	Sets the MAC filtering parameters. Here, *ewlc-radius* is an example for the *list-name*
Step 3	**no security wpa** **Example:** `Device(config-wlan)# no security wpa`	Disables WPA secuirty.

	Command or Action	Purpose
Step 4	**no security wpa akm dot1x** **Example:** `Device(config-wlan)# no security wpa akm dot1x`	Disables security AKM for dot1x.
Step 5	**no security wpa wpa2** **Example:** `Device(config-wlan)# no security wpa wpa2`	Disables WPA2 security.
Step 6	**mab request format attribute** {**1 groupsize** *size* **separator** *separator* [**lowercase** | **uppercase**] | **2** {**0** | **7** | **LINE**} **LINE** *password* | **32 vlan access-vlan**} **Example:** `Device(config)# mab request format attribute 1 groupsize 4 separator`	Optional. Configures the delimiter while using MAC filtering in a WLAN. Here, **1**- Specifies the username format used for MAB requests. **groupsize** *size*- Specifies the number of hex digits per group. The valid values range from 1 to 12. **separator** *separator*- Specifies how to separate groups. The separators are comma, semicolon, and full stop. **lowercase**- Specifies the username in lowercase format. **uppercase**- Specifies the username in uppercase format. **2**- Specifies the global password used for all the MAB requests. **0**- Specifies the unencrypted password. **7**- Specifies the hidden password. **LINE**- Specifies the encrypted or unencrypted password. *password*- LINE password. **32**- Specifies the NAS-Identifier attribute. **vlan**- Specifies a VLAN. **access-vlan**- Specifies the configured access VLAN.
Step 7	**no security wpa wpa2 ciphers aes** **Example:** `Device(config-wlan)# no security wpa wpa2 ciphers aes`	Disables WPA2 ciphers for AES.

	Command or Action	Purpose
Step 8	**no shutdown** **Example:** `Device(config-wlan)# no shutdown`	Enables the WLAN.



CHAPTER 57

Dynamic Frequency Selection

- Information About Dynamic Frequency Selection, on page 505
- Configuring Dynamic Frequency Selection (GUI), on page 505
- Configuring Dynamic Frequency Selection, on page 505
- Verifying DFS, on page 506

Information About Dynamic Frequency Selection

Dynamic Frequency Selection (DFS) is the process of detecting radar signals and automatically setting the frequency on a DFS-enabled 5.0-GHz (802.11a/h) radio to avoid interference with the radar signals. Radios configured for use in a regulatory domain must not interfere with radar systems.

In normal DFS, when a radar signal is detected on any of the channels in the 40-MHz or 80-MHz bandwidth, the whole channel is blocked. With Flex DFS, if the radar signals are not detected on the secondary channel, the AP is moved to a secondary channel with a reduction in the bandwidth, usually, by half.

Configuring Dynamic Frequency Selection (GUI)

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**

Step 2 Choose a profile.

Step 3 In **General** tab, check the **Full sector DFS status** check box.

Step 4 Click **Update & Apply to Device**.

Configuring Dynamic Frequency Selection

Follow the procedure given below to configure DFS:

Before you begin

- The corresponding AP must be on one of the DFS channels.
- Shut down the radio before applying the configuration changes.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**no ap dot11 5ghz dtpc** **Example:** `Device(config)# no ap dot11 5ghz dtpc`	Disables the 802.11a Dynamic Transmit Power Control (DTPC) setting.
Step 3	**ap dot11 5ghz channelswitch mode** *mode-num* **Example:** `Device(config)# ap dot11 5ghz channelswitch mode 1`	Configures the 802.11h channel switch mode.
Step 4	**ap dot11 5ghz power-constraint** *value* **Example:** `Device(config)# ap dot11 5ghz power-constraint 12`	Configures the 802.11h power-constraint value.
Step 5	**ap dot11 5ghz smart-dfs** **Example:** `Device(config)# ap dot11 5ghz smart-dfs`	Configures nonoccupancy time for the radar interference channel.

Verifying DFS

Use the following commands to verify the DFS configuration:

To display the 802.11h configuration, use the following command:

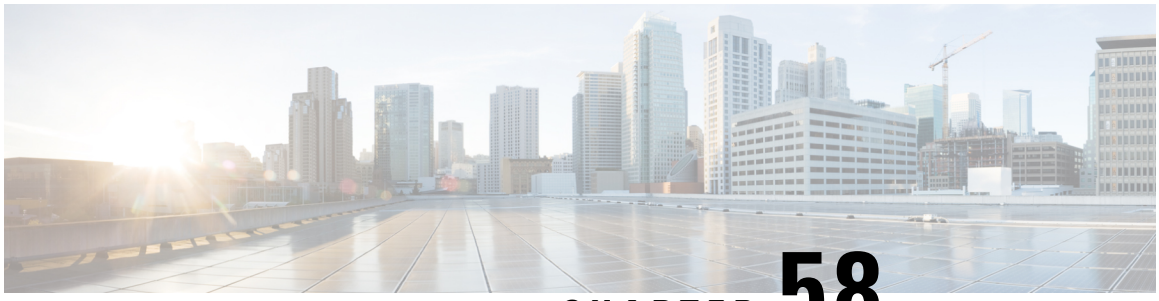
```
Device# show wireless dot11h
```

To display the auto-rF information for 802.11h configuration, use the following command:

```
Device# show ap auto-rf dot11 5ghz
```

To display the auto-rF information for a Cisco AP, use the following command:

```
Device# show ap name ap1 auto-rf dot11 5gh
```



CHAPTER 58

Managing Rogue Devices

- Rogue devices and detection, on page 507
- Rogue Location Discovery Protocol (RLDP), on page 522
- Wireless Service Assurance (WSA) rogue events, on page 529

Rogue devices and detection

A rogue device is any unauthorized network device.

A rogue device can:

- disrupt wireless LAN operations by hijacking legitimate clients,
- facilitate attacks such as plaintext, denial-of-service, and man-in-the-middle attacks on wireless networks, and
- pose serious security risks by allowing unauthorized access, interception, and breaches inside the corporate firewall.

Risks and impact on network security

Rogue access points are a common form of rogue devices. Hackers can use rogue access points to capture sensitive information such as usernames and passwords. By transmitting a series of Clear to Send (CTS) frames, a rogue access point can mimic a legitimate access point. This action instructs a specific client to transmit while forcing other clients to wait, which prevents legitimate clients from accessing network resources.

Ban rogue access points from the air space to protect users and maintain network integrity.

Because rogue access points are inexpensive and available, staff may connect unauthorized access points to existing LANs. This can create ad hoc wireless networks without approval from IT departments.

These rogue access points can create serious security risks because they may connect inside the corporate firewall. If security settings are disabled on these devices, unauthorized users can intercept network traffic and hijack client sessions. When wireless users connect to rogue access points within the enterprise network, the risk of a security breach increases.

Rogue client status change

The controller marks the rogue client as a threat if a wireless client in the RUN state has the same MAC address.

Restrictions on rogue detection

- Rogue containment is not supported on DFS channels.

Rogue AP containment and attack signatures

A rogue AP containment and attack signature is a set of wireless network security mechanisms that

- detect and contain unauthorized rogue wireless APs,
- use automated or manual methods to select the best access point for containment actions, and
- define specific attack signatures, including behaviors of rogue AP impersonators and new threats based on beacon frames.

Containment operation

A rogue access point is moved to a contained state either automatically or manually. The controller selects the best available access point (AP) for containment and pushes the containment information to it. Each AP stores its list of containments per radio.

For auto-containment, you can configure the controller to use only APs in monitor mode. Containment operations occur through two primary methods:

- The container AP periodically reviews its containment list and sends unicast containment frames. For rogue AP containment, these are sent only if a rogue client is associated.
- When the system detects contained rogue activity, the AP immediately transmits containment frames.

Individual rogue containment involves sending a sequence of unicast disassociation and deauthentication frames.

Attack signature examples

These signatures help identify sophisticated attack methods targeting wireless networks and support more effective containment and remediation strategies.

- **Beacon DS Attack** —When managed and rogue APs use the same BSSID, the rogue APs are termed as impersonators. An attacker can add the Direct-Sequence parameter set information element with any channel number. If the added channel number is different from the channel number used by the managed AP, the attack is termed as Beacon DS Attack.
- **Beacon Wrong Channel** —When managed and rogue APs use the same BSSID, the rogue APs are termed as AP impersonators. If an AP impersonator uses a channel number that is different from the one used by the managed AP with the same BSSID, the attack is termed as Beacon Wrong Channel. In such a case, the Direct-Sequence Information Element might not even be present in the Beacon frame.

Cisco Prime Infrastructure interaction and rogue detection

A rogue access point classification rule is a network security mechanism that

- applies predefined criteria to evaluate and categorize access points detected on the network,

- determines the current state of each detected access point (such as Friendly, Malicious, Internal, or External), and
- defines when and how the controller communicates rogue events to Cisco Prime Infrastructure.

How Cisco Prime Infrastructure interacts with the controller for rogue detection

Cisco Prime Infrastructure interacts with controllers to detect and manage rogue access points according to the classification rules set on the controllers. The rule-based classification enables Cisco Prime Infrastructure to receive detailed trap notifications when rogue access point events occur. Key interactions and behaviors include:

- The controller uses its configured classification rules to determine the state of each rogue access point.
- When certain rogue access point events occur (such as state changes or rogue entry removal), the controller sends traps (notifications) to Cisco Prime Infrastructure.
- Trap notifications depend on both the rogue state and the event type, including these cases:
  - If an unknown access point moves to the Friendly state for the first time and the rogue state is Alert, a trap is sent.
  - No trap is sent if the rogue state is Internal or External.
  - If a rogue entry is removed after timeout, the controller sends a trap for entries classified as Malicious (Alert, Threat) or Unclassified (Alert).
  - The controller does not remove rogue entries with the following states: Contained, Contained Pending, Internal, and External.
- When a new, unknown access point is detected and moves to the Friendly state under Alert, Cisco Prime Infrastructure receives a notification.
- If a rogue entry with a Malicious or Unclassified (Alert) state is removed after a timeout, a trap is generated and sent to Cisco Prime Infrastructure.
- Rogue entries in Contained, Contained Pending, Internal, and External states are retained by the controller and not removed automatically, so no removal trap is sent for them.

Rogue containment (Protected Management Frames (PMF) enabled)

Starting with Cisco IOS XE 17.3.1, the system does not contain rogue devices enabled with 802.11w Protected Management Frames (PMF). Instead, the system marks the rogue device as *Contained Pending*, and raises a Web Security Appliance (WSA) alarm for the *Contained Pending* event. Skipping device containment prevents unnecessary use of AP resources.

Run the **show wireless wps rogue ap detailed** command to verify device containment when PMF is enabled on a rogue device.



Note This feature is supported only on Wave 2 APs.

AP impersonation detection

An AP impersonation is a wireless security attack that

- allows a rogue device to masquerade as a legitimate AP
- enables attackers to intercept and manipulate wireless communication between client devices and the network, and
- threatens the confidentiality, integrity, and security of wireless network traffic.

Detection methods

The various methods to detect AP impersonation are:

- You can detect AP impersonation if a managed AP reports itself as Rogue. This method is always enabled and does not require configuration.
- AP impersonation detection uses Management Frame Protection (MFP).
- AP impersonation detection uses AP authentication.

Management Frame Protection (MFP)-based detection

Infrastructure MFP protects 802.11 session management by adding Message Integrity Check (MIC) elements to management frames sent by APs (not clients). Other APs in the network then validate these management frames.

- If infrastructure MFP is enabled, managed APs check whether the MIC elements are present and valid.
- If either condition is not met, the managed AP sends rogue AP reports with an updated AP authentication failure counter field.

AP authentication-based detection

When you enable AP authentication, the controller creates an AP domain secret and shares it with all APs in the same network. This process enables APs to authenticate each other.

- An AP authentication information element is attached to beacon and probe response frames.
- If the AP authentication information element has an incorrect signature, an off timestamp, or the information element is missing, the AP that detects the condition increments the **AP authentication failure count** field.
- An impersonation alarm is raised after the **AP authentication failure count** field exceeds its threshold.
- The rogue AP is classified as **Malicious** with the state **Threat**.

Run the **show wireless wps rogue ap detail** command to see when AP impersonation is detected as a result of authentication errors.

Configuration notes

- Run the **CCX Aironet-IESupport** command in all WLAN procedures to prevent the BSSID from being detected as a rogue.

- For AP impersonation detection, Network Time Protocol (NTP) must be enabled under the AP profile. CAPWAP-based time is not sufficient.

Rogue detection security level

A rogue detection security level is a configuration preset that

- determines the sensitivity and scope of rogue wireless device detection
- restricts or allows configuration of specific detection parameters, and
- provides predefined or customizable options for different deployment needs.
- Rogue detection: identifies unauthorized or unknown wireless devices in a network environment.
- Security level: specifies a preset combination of parameters for rogue detection.

The system provides four rogue detection security levels.

- Critical: Provides basic rogue detection for highly sensitive deployments. Fixed configuration parameters ensure maximum security and consistency.
- High: Provides basic rogue detection suitable for medium-scale environments. Several parameters are fixed to balance protection and operational simplicity.
- Low: Provides basic rogue detection suitable for small-scale deployments. Fixed parameters provide easy management.
- Custom: The default security level. You can fully configure all rogue detection parameters to suit any environment.



Note To modify all parameters, select the Custom security level. The critical, high, and low levels have fixed settings.

Table 30: Rogue Detection: Predefined Levels

Parameter	Critical	High	Low
Cleanup Timer	3600 seconds (1 hour)	1200 seconds (20 minutes)	240 seconds (4 minutes)
AAA Validate Clients	Disabled	Disabled	Disabled
Adhoc Reporting	Enabled	Enabled	Enabled
Monitor Mode Report Interval	10 seconds (0:10)	30 seconds (0:30)	60 seconds (1:00)
Minimum RSSI	-128 dBm	-80 dBm	-80 dBm
Transient Interval	600 seconds (10 minutes)	300 seconds (5 minutes)	120 seconds (2 minutes)

Parameter	Critical	High	Low
Auto Contain **This feature works only on Monitor Mode APs.**	Disabled	Disabled	Disabled
Auto Contain Level	1	1	1
Auto Contain Same SSID	Disabled	Disabled	Disabled
Auto Contain Valid Clients on Rogue AP	Disabled	Disabled	Disabled
Auto Contain Adhoc	Disabled	Disabled	Disabled
Containment Auto Rate	Enabled	Enabled	Enabled
Validate Clients with Cisco Connected Mobile Experiences (CMX)	Enabled	Enabled	Enabled
Containment FlexConnect	Enabled	Enabled	Enabled
Rogue Location Discovery Protocol (RLDP)	The device functions as a monitor mode AP if RLDP scheduling is disabled.	The device functions as a monitor mode AP if RLDP scheduling is disabled.	Disabled
Auto Contain RLDP	Disabled	Disabled	Disabled

You can configure all these parameters in the Custom security level.

- A hospital implements the Critical security level to maintain rigorous control over rogue detection with fixed settings.
- A small business chooses the Low security level for straightforward rogue detection with minimal configuration.
- An enterprise IT team uses the Custom security level to tailor all rogue detection parameters to their unique requirements.

Set rogue detection security level (CLI)

Set the wireless rogue detection security level for your network deployment.

Before you begin

Use these steps to set the rogue detection security level.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the rogue detection security level to custom.

Example:

```
Device(config)# wireless wps rogue security-level custom
```

Step 3 Configure the rogue detection security level for small-scale deployments.

Example:

```
Device(config)# wireless wps rogue security-level low
```

Step 4 Configure the rogue detection security level for medium-scale deployments.

Example:

```
Device(config)# wireless wps rogue security-level high
```

Step 5 Configure the rogue detection security level for highly sensitive deployments.

Example:

```
Device(config)# wireless wps rogue security-level critical
```

The device applies the selected rogue detection security level to enhance wireless intrusion protection for your deployment.

Configuring rogue detection (GUI)

Enable rogue access point detection and set parameters in the GUI.

Use rogue detection to identify and manage unauthorized or suspicious APs in your network. Complete this task when you establish or update your wireless security policies.

Before you begin

Use these steps to configure rogue detection using the GUI:

Procedure

Step 1 Choose Configuration, then Tags and Profiles, then AP Join.

Step 2 Click the **AP Join Profile Name** to edit the access point (AP) join profile properties.

Step 3 In the **Edit AP Join Profile** window, click the **Rogue AP** tab.

Step 4 Check the **Rogue Detection** check box to enable rogue detection.

Step 5 In the **Rogue Detection Minimum RSSI** field, enter the RSSI value.

Step 6 In the **Rogue Detection Transient Interval** field, enter the interval in seconds (minutes).

Step 7 In the **Rogue Detection Report Interval** field, enter the report interval value in seconds (minutes).

Step 8 In the **Rogue Detection Client Number Threshold** field, enter the threshold for rogue client detection.

Step 9 Check the **Auto Containment on FlexConnect Standalone** check box to enable auto containment.

Step 10 Click **Update and Apply to Device**.

The rogue-detection feature is activated with your configured parameters. This helps you identify and contain unauthorized access points (APs) in the network.

Configure rogue detection (CLI)

You enable and customize rogue detection on Cisco wireless access points using specific CLI commands.

Use these commands to detect and contain unauthorized access points (APs) and improve wireless network security.

Before you begin

Use these steps to configure rogue detection.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Set how often APs consistently scan for rogues after the initial detection.

Example:

```
Device(config)# ap profile profile-name
Device(config)# rogue detection min-transient-time time in seconds
```

You can enter a time between two minutes (120 seconds) and thirty minutes (1,800 seconds). The default is zero.

Note
You can use this feature with any AP mode.

Use the transient interval to control how often APs scan for rogues. APs can also filter rogues based on this value.

This feature provides these advantages:

- Rogue reports from APs to the controller are shorter.
- Transient rogue entries are avoided in the controller.

The system avoids unnecessary memory allocation for transient rogues.

Step 3 Choose a rogue containment option.

Example:

```
Device(config)# ap profile profile-name
Device(config)# rogue detection containment flex-rate
```

The **auto-rate** option contains rogues automatically. The **flex-rate** option contains standalone FlexConnect APs.

Step 4 Turn on rogue detection for all APs.

Example:

```
Device(config)# ap profile profile-name
```

Step 5 Set the interval for rogue reports on monitor mode APs.

Example:

```
Device(config)# ap profile profile-name
Device(config)# rogue detection report-interval time in seconds
```

The valid range for the reporting interval is 10 to 300 seconds.

If the controller detects thousands of rogue APs, the PUBD (Public Utility Bulletin Daemon) process may cause sustained high CPU usage. Increase the Rogue Detection Report Interval to a value higher than the default of 10 to resolve this issue.

Rogue detection is active using your specified parameters on the AP profile. This improves security by monitoring and containing unauthorized devices.

Configure RSSI deviation notification threshold for rogue APs (CLI)

Set the signal strength deviation threshold to trigger notifications for rogue access points on your network.

Before you begin

Use these steps to configure the RSSI deviation notification threshold for rogue APs.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the RSSI deviation notification threshold for rogue APs.

Example:

```
Device(config)# wireless wps rogue ap notify-rssi-deviation
```

Step 3 Return the system to privileged EXEC mode.

Example:

```
Device(config)# end
```

You can press Ctrl and Z to exit global configuration mode.

The system notifies you when a rogue APs RSSI deviation exceeds the set threshold.

Configure management frame protection (GUI)

Enable and configure management frame protection (MFP) to secure wireless network communications against attacks such as rogue AP impersonation.

Before you begin

Use these steps to configure management frame protection.

Procedure

Step 1 Choose **Configuration**, then **Security**, then **Wireless Protection Policies**.

Step 2 In the **Rogue Policy** tab, under the **MFP Configuration** section, check the **Global MFP State** check box to enable the global MFP state.

Step 3 Check the **AP Impersonation Detection** check box to enable AP impersonation detection.

Step 4 In the **MFP Key Refresh Interval** field, specify the refresh interval in hours.

Step 5 Click **Apply**.

Management frame protection is enabled and configured, providing enhanced security for wireless management frames.

Configure Management Frame Protection (CLI)

Configure Management Frame Protection (MFP) on a device using the command-line interface (CLI).

Before you begin

Use these steps to configure management frame protection.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure management frame protection.

Example:

```
Device(config)# wireless wps mfp
```

Step 3 Configure AP impersonation detection or set the MFP key refresh interval in hours.

Example:

```
Device(config)# wireless wps mfp ap-impersonation
Device(config)# wireless wps mfp key-refresh-interval
```

key-refresh-interval: Set sthe MFP key refresh interval in hours.

The valid range is one to 24 hours. The default value is 24 hours.

Step 4 Save the configuration, exit configuration mode, and return to privileged **EXEC** mode.

Example:

```
Device(config)# end
```

The device protects wireless management traffic according to the configured settings.

Enable AP authentication

Set up AP authentication on a wireless controller. This enhances network security by authenticating APs and by configuring threshold values for authentication failures.

Before you begin

Use these steps to enable AP authentication.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the wireless Wi-Fi Protected Setup (WPS) AP authentication.

Example:

```
Device(config)# wireless wps ap-authentication
```

Step 3 Configure AP neighbor authentication and set the threshold for AP authentication failures.

Example:

```
Device(config)# wireless wps ap-authentication threshold threshold
```

Step 4 Configure a WLAN.

Example:

```
Device(config)# wlan wlan-namewlan-idSSID-name
```

Step 5 Enable support for Aironet information elements on this Wireless Local Area Network (WLAN).

Example:

```
Device(config-wlan)# ccx aironet-iesupport
```

Step 6 Return to privileged EXEC mode.

Example:

```
Device# end
```

AP authentication is enabled on the wireless controller. Authentication thresholds and Aironet IE support are configured for the specified WLAN.

Verify management frame protection

To verify if the Management Frame Protection (MFP) feature is enabled or not, use this command:

```
Device# show wireless wps summary
Client Exclusion Policy
  Excessive 802.11-association failures   : unknown
  Excessive 802.11-authentication failures: unknown
  Excessive 802.1x-authentication         : unknown
  IP-theft                                : unknown
  Excessive Web authentication failure    : unknown
  Failed Qos Policy                       : unknown

Management Frame Protection
  Global Infrastructure MFP state : Enabled
  AP Impersonation detection      : Disabled
  Key refresh interval            : 15
```

To view the MFP details, use this command:

```
Device# show wireless wps mfp summary
Management Frame Protection
  Global Infrastructure MFP state : Enabled
  AP Impersonation detection      : Disabled
  Key refresh interval            : 15
```

Verify rogue detection

This section describes the new command for rogue detection.

These commands can be used to verify rogue detection on the device.

Table 31: Verifying Adhoc rogues information

Command	Purpose
show wireless wps rogue adhoc detailed *mac_address*	Displays the detailed information for an Adhoc rogue.
show wireless wps rogue adhoc summary	Displays a list of all Adhoc rogues.

Table 32: Verifying rogue AP information

Command	Purpose
show wireless wps rogue ap clients *mac_address*	Displays the list of all rogue clients associated with a rogue.

show wireless wps rogue ap custom summary	Displays the custom rogue AP information.
show wireless wps rogue ap detailed *mac_address*	Displays the detailed information for a rogue AP.
show wireless wps rogue ap friendly summary	Displays the friendly rogue AP information.
show wireless wps rogue ap list *mac_address*	Displays the list of rogue APs detected by a given AP.
show wireless wps rogue ap malicious summary	Displays the malicious rogue AP information.
show wireless wps rogue ap summary	Displays a list of all Rogue APs.
show wireless wps rogue ap unclassified summary	Displays the unclassified rogue AP information.

Table 33: Verifying Rogue Auto-Containment Information

Command	Purpose
show wireless wps rogue auto-contain	Displays the rogue auto-containment information.

Table 34: Verifying Classification Rule Information

Command	Purpose
show wireless wps rogue rule detailed *rule_name*	Displays the detailed information for a classification rule.
show wireless wps rogue rule summary	Displays the list of all rogue rules.

Table 35: Verifying Rogue Statistics

Command	Purpose
show wireless wps rogue stats	Displays the rogue statistics.

Table 36: Verifying Rogue Client Information

Command	Purpose
show wireless wps rogue client detailed *mac_address*	Displays detailed information for a Rogue client.
show wireless wps rogue client summary	Displays a list of all the Rogue clients.

Table 37: Verifying Rogue Ignore List

Command	Purpose
show wireless wps rogue ignore-list	Displays the rogue ignore list.

Examples: rogue detection onfiguration

This example shows how to configure the minimum RSSI that a detected rogue AP needs to be at, to have an entry created in the device:

```
Device# wireless wps rogue ap notify-min-rssi 100
```

This example shows how to configure the classification interval:

```
Device# configure terminal
Device(config)#
Device(config)#
Device(config)# end
Device# show wireless wps rogue client /show wireless wps rogue ap summary
```

Configure rogue policies (GUI)

Use this task to define and customize rogue wireless protection policies. These policies help the system detect and respond to unauthorized wireless activity.

Before you begin

Perform the steps in this section to configure rogue policies.

Procedure

Step 1	Choose **Configuration**, then **Security**, then **Wireless Protection Policies**.
Step 2	In the **Rogue Policies** tab, select the security level from the **Rogue Detection Security Level** drop-down.
Step 3	In the **Expiration timeout for Rogue APs** field, enter the timeout value in seconds.
Step 4	Select the **Validate Rogue Clients against AAA** check box to validate rogue clients using the AAA server.
Step 5	Select the **Validate Rogue APs against AAA** check box to validate rogue access points using the AAA server.
Step 6	In the **Rogue Polling Interval** field, enter the interval in seconds at which the system polls the AAA server for rogue information.
Step 7	Select the **Detect and Report Adhoc Networks** check box to enable detection of rogue ad hoc networks.
Step 8	In the **Rogue Detection Client Number Threshold** field, enter the number of clients at which the system generates an SNMP trap.
Step 9	In the **Auto Contain** section, enter these details.
Step 10	Select the containment level from the **Auto Containment Level** drop-down.
Step 11	Select the **Auto Containment only for Monitor Mode APs** check box to limit automatic containment to monitor-mode APs.
Step 12	Select the **Using our SSID** check box to limit automatic containment to rogue APs that use an SSID that is configured on the controller.
Step 13	Select the **Adhoc Rogue AP** check box to enable automatic containment for ad hoc rogue APs.
Step 14	Click **Apply**.

The system updates rogue policies to enhance detection and containment of unauthorized wireless threats according to your configuration.

Configure rogue policies (CLI)

Establish rogue policies to enhance network security by managing rogue access points and clients.

This configuration is essential in environments where rogue devices may pose a security threat to the network.

Before you begin

Ensure you have access to the device's global configuration mode.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 2 Configure the expiration time for rogue entries.

Example:

```
Device(config)# wireless wps rogue ap timeout timout-in-seconds
```

Valid range for the time in seconds is 240 seconds to 3600 seconds.

Step 3 Configure the minimum RSSI notification threshold for rogue clients.

Example:

```
Device(config)# wireless wps rogue client notify-min-rssi RSSI-threshold
```

Valid range for the RSSI threshold in dB is -128 dB to -70 dB.

Step 4 Configure the RSSI deviation notification threshold for rogue clients.

Example:

```
Device(config)# wireless wps rogue client notify-min-deviation RSSI-threshold-value
```

Valid range for the RSSI threshold in dB is 0 dB to 10 dB.

Step 5 Configure rogue AP AAA validation interval.

Example:

```
Device(config)# wireless wps rogue ap aaa polling-interval AP-AAA-interval-value
```

The valid range for the AP AAA interval in seconds is 60 seconds to 86400 seconds.

Step 6 Enable detecting and reporting adhoc rogue (IBSS).

Example:

```
Device(config)# wireless wps rogue adhoc
```

Enables detecting and reporting adhoc rogue (IBSS).

Step 7 Configure the rogue client per a rogue AP SNMP trap threshold.

Example:

```
Device(config)# wireless wps rogue client client-threshold threshold-value
```

The valid range for the threshold is 0 to 256.

The rogue policies are now configured, enhancing the network's security against rogue devices.

Rogue Location Discovery Protocol (RLDP)

A rogue location discovery protocol is a network security protocol that

- detects rogue access points by actively investigating their presence
- enables authorized access points to associate with rogue devices and communicate findings to network controllers, and
- enhances wireless network protection by identifying open and NATed rogue APs.

How RLDP Works

Rogue Location Discovery Protocol (RLDP) operates when a rogue access point uses open authentication (lacks password protection). RLDP instructs an authorized AP to temporarily disconnect its clients, switch to the rogue channel, and attempt to join the rogue AP as a client.

Once associated, the AP requests an IP address from the rogue AP and sends a UDP packet (port 6352) containing connection details to the controller. If the controller receives this packet, it triggers an alarm to alert administrators about the presence of a rogue AP on the wired network.

RLDP offers high accuracy in rogue AP detection, especially for open and NAT-enabled rogue devices. However, RLDP packets may be blocked if filtering rules exist between the controller network and the rogue network.

Note The RLDP packets are unable to reach the embedded wireless controller if filtering rules are placed between the embedded wireless controller 's network and the network where the rogue device is located.

Guidelines to manage RLDP

- Use Rogue Location Discovery Protocol (RLDP) to detect rogue access points configured for open-authentication.
- Use RLDP to detect rogue access points that broadcast a Basic Service Set Identifier (BSSID). In this case, the access point broadcasts its Service Set Identifier in beacons.
- You can use RLDP to detect only rogue access points on the same network. RLDP does not function if an access list in the network blocks RLDP traffic from the rogue access point to the embedded wireless controller.
- You cannot use RLDP on 5-GHz (5-gigahertz) Dynamic Frequency Selection (DFS) channels.

- If you enable RLDP on mesh APs and they perform RLDP tasks, the mesh APs will be dissociated from the embedded wireless controller. To prevent this, disable RLDP on mesh APs.
- If you enable RLDP on non-monitor APs, clients may experience connectivity outages while RLDP runs.

Best practices for RLDP initiation commands and configuration

Your embedded wireless controller collects information about rogue access points and clients from nearby APs.

When your embedded wireless controller discovers a rogue AP, it uses Rogue Location Discovery Protocol (RLDP) (if enabled and the rogue detector mode AP is connected) to determine whether the rogue is attached to your network.

The Embedded Wireless Controller initiates RLDP on rogue devices that use open .

If RLDP uses FlexConnect or local mode access points, clients disconnect briefly and reconnect after RLDP completes.

When a rogue access point appears , RLDP starts automatically.

You can configure the embedded wireless controller to use RLDP on all access points or only on those set to monitor (listen-only) mode.

Monitoring-mode access points let you detect rogue access points automatically in crowded RF spaces without creating interference or affecting data access point functionality.

If both monitor and local (data) access points are nearby, the embedded wireless controller selects the monitor access point for RLDP.

If RLDP determines that the rogue is on your network, choose to contain the rogue manually or automatically.

RLDP checks whether rogue access points that use open authentication are present on the wire only once by default.

You can configure the number of retries using the .

Use these best practices to initiate and configure RLDP on the embedded wireless controller.

1. Initiate RLDP manually from the controller CLI.
2. Schedule RLDP from the controller CLI.
3. Configure auto RLDP on your controller from the CLI or GUI after setting the correct security level.

Additional guidance

- You can configure auto RLDP only when the rogue detection security level is set to custom.
- Enable either auto RLDP or scheduled RLDP, but not both at the same time.

Restrictions for RLDP

- You can use Rogue Location Discovery Protocol (RLDP) only with open rogue APs that broadcast their SSID with authentication and encryption disabled.
- Ensure the managed AP acting as a client can obtain an IP address using DHCP on the rogue network.

- You can use manual RLDP to run an RLDP trace on a rogue device multiple times.
- During the RLDP process, the AP cannot serve clients, which reduces performance and connectivity for local mode APs. To prevent this issue, enable RLDP only on Monitor Mode APs.
- RLDP does not connect to rogue APs operating in 5GHz DFS channels.
- You can use RLDP only on Cisco IOS APs.

Rogue Location Discovery Protocol (RLDP) process

Summary

Use Rogue Location Discovery Protocol (RLDP) to help Unified APs identify and verify whether a rogue device is connected to the network.

RLDP associates with the rogue device, obtains network parameters, and reports the results to controllers.

Workflow

1. Identify the closest Unified AP to the rogue using signal strength values.
2. The AP then connects to the rogue as a WLAN client, attempting three associations before timing out.
3. If association is successful, the AP then uses DHCP to obtain an IP address.
4. If an IP address is obtained, the AP (acting as a WLAN client) sends a UDP packet to each of the embedded wireless controller's IP addresses.
5. If the embedded wireless controller receives even one RLDP packet from the client, the system marks the rogue as on-wire.

Result

You can use RLDP to automatically detect and confirm rogue devices connected to your enterprise wired network.

RLDP supports rapid security response.

Configuring RLDP for Generating Alarms (GUI)

Procedure

Step 1 Choose **Configuration > Security > Wireless Protection Policies**.

Step 2 In the **RLDP** tab, use the **Rogue Location Discovery Protocol** drop-down to select one of the following options:

a) **Disable**: Disables RLDP on all the access points. **Disable** is the default option.
b) **All APs**: Enables RLDP on all APs.
c) **Monitor Mode APs**: Enables RLDP only on APs in the monitor mode.

Note

The **Schedule RLDP** check box is enabled only if the **Disable** option is selected. The Schedule RLDP check box remains disabled when you select the **All APs** option or the **Monitor Mode APs** option.

Step 3 In the **Retry Count** field, specify the number of retries that should be attempted. The range allowed is between 1 and 5.

Step 4 Click **Apply**.

Configure RLDP to generate alarms (CLI)

Enable the Rogue Location Discovery Protocol (RLDP) to generate alarms using CLI commands.

Before you begin

Follow these steps to configure RLDP to create alarms.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable RLDP to generate alarms.

Example:

```
Device(config)# wireless wps rogue ap rldp alarm-only
Device(config)# wireless wps rogue ap rldp alarm-only monitor-ap-only
```

In this method, RLDP is always enabled.

The **monitor-ap-only** keyword is optional.

The command with only the **alarm-only** keyword enables RLDP without restrictions on AP mode.

The command with the "alarm-only monitor-ap-only" keyword enables RLDP only in monitor-mode access points.

Step 3 Go to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can press **Ctrl-Z** to exit global configuration mode.

RLDP generates alarms when the system detects rogue access points, according to your configuration.

Configure a schedule for RLDP (GUI)

Define and apply a scheduled operation for the Rogue Location Discovery Protocol (RLDP) to automate rogue device detection on your wireless network.

Before you begin

Use these steps to configure a schedule for RLDP.

Procedure

Step 1 Choose **Configuration > Security > Wireless Protection Policies**.

Step 2 In the **RLDP** tab, choose these options from the **Rogue Location Discovery Protocol** drop-down list.

Disable (default): Disables RLDP on all access points.

Step 3 In the **Retry Count** field, enter a value between 1 and 5 for the number of retries.

Step 4 Select the **Schedule RLDP** check box, and then specify the days, start time (for example, 8:00 a.m. [0800]), and end time (for example, 5:00 p.m. [1700]) for the process.

Step 5 Click **Apply**.

The system schedules RLDP based on your configuration and automatically detects rogue APs during the specified periods.

Configure a schedule for RLDP (CLI)

Set up a scheduled Rogue Location Discovery Protocol (RLDP) scan to run at specific days and times using CLI.

Before you begin

Use these steps to configure an RLDP schedule using CLI.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable Rogue Location Discovery Protocol (RLDP) based on a scheduled day, start time, and end time.

Example:

```
Device(config)# wireless wps rogue ap rldp schedule day Monday start start-time end end-time
```

day is the day when the RLDP scheduling can be done. The values are Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday.

start-time is the start time for scheduling RLDP for the day. You need to enter start time in **HH:MM:SS** format.

end-time is the end time for scheduling RLDP for the day. You need to enter end time in **HH:MM:SS** format.

Step 3 Enable the schedule.

Example:

```
Device(config)# wireless wps rogue ap rldp schedule
```

Step 4 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

The RLDP schedule runs automatically on the specified days and times, enabling periodic rogue AP detection.

Configure an RLDP for auto-contain (GUI)

Enable RLDP-based automatic containment of rogue devices detected on the wired network.

Before you begin

Use these steps to configure RLDP for auto-contain.

Procedure

Step 1 Choose **Configuration > Security > Wireless Protection Policies** .

Step 2 In the **Rogue Policies** tab, under the **Auto Contain** section, check the **Rogue on Wire** checkbox.

Step 3 Click **Apply** .

The system will automatically contain rogue devices detected through RLDP on the wired network.

Configure an RLDP for auto-contain (CLI)

Enable Rogue Location Discovery Protocol (RLDP) auto-contain mode on a wireless LAN controller using CLI.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable RLDP to perform auto-contain. This method always keeps RLDP enabled.

Example:

```
Device config)# wireless wps rogue ap rldp auto-contain
```

```
Device (config)# wireless wps rogue ap rldp auto-contain monitor-ap-only
```

The **monitor-ap-only** keyword is optional.

Using the command with only **auto-contain** keyword enables RLDP without any restriction on the AP mode.

The command with **auto-contain <monitor-ap-only>** keyword enables RLDP in monitor mode access points only.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

RLDP is enabled for auto-contain. Rogue APs matching the configured behavior are automatically contained by the controller.

Configure RLDP retry times on rogue APs (GUI)

Set the number of RLDP retry attempts on rogue wireless APs.

Before you begin

Use these steps to configure RLDP retry times for rogue APs.

Procedure

Step 1 Choose **Configuration** > **Security** > **Wireless Protection Policies** .

Step 2 On the **Wireless Protection Policies** page, click the **RLDP** tab.

Step 3 Enter the RLDP retry attempt value for rogue access points in the **Retry Count** field.

The valid range is between 1 to 5.

Step 4 Save the configuration.

The RLDP retry count value for rogue APs are updated and applied on the network controller.

Configure RLDP retry times on rogue APs (CLI)

Set the number of RLDP (Rogue Location Discovery Protocol) retry attempts for rogue APs.

Before you begin

Use these steps to configure RLDP retry times on rogue APs.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable RLDP retry times on rogue APs.

Example:

```
Device(config)# wireless wps rogue ap rldp retries num-entries
```

Here, *num-entries* is the number of RLDP retry times for each of the rogue APs.

The valid range is 1 to 5.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

The device updates the RLDP retry times for rogue AP as specified, affecting future rogue AP RLDP attempts.

Verify rogue AP RLDP

These commands can be used to verify rogue AP RLDP.

Table 38: Verify rogue AP information

Command	Purpose
show wireless wps rogue ap rldp detailed *mac_address*	Displays the RLDP details for a rogue AP.
show wireless wps rogue ap rldp in progress	Displays the list of in-progress RLDP.
show wireless wps rogue ap rldp summary	Displays the summary of RLDP scheduling information.

Wireless Service Assurance (WSA) rogue events

Wireless Service Assurance (WSA) rogue events are telemetry notifications that replicate the information of corresponding SNMP traps. Support is available in Release 16.12.x, where x denotes a release version.

- You receive details such as the MAC address of the rogue AP.
- You receive information about the managed AP and the radio that detected the rogue AP with the strongest RSSI.
- You receive event-specific data, such as SSID; channel for potential honeypot events; and MAC address of the impersonating AP for impersonation events.

WSA Rogue Events: Details and Support

For all exported events, these details are provided to the wireless service assurance (WSA) infrastructure:

- MAC address of the rogue AP
- Details of the managed AP and the radio that detected the rogue AP with the strongest RSSI
- Event-specific data such as SSID; channel for potential honeypot events; and MAC address of the impersonating AP for impersonation events.

You can scale the WSA rogue events feature up to four times the maximum number of supported access points (APs). You can also scale it to one-half of the maximum number of supported clients.

The WSA rogue events feature is supported on Cisco Catalyst Center and other third-party infrastructure.

Wireless service assurance rogue events

Configure your wireless device to send service assurance rogue event data to the event queue.

Before you begin

To configure wireless service assurance for rogue events, complete these steps.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable wireless service assurance.

Example:

```
Device# network-assurance enable
```

Step 3 Enable wireless service assurance for rogue devices.

Example:

```
Device# wireless wps rogue network-assurance enable
```

This ensures that the wireless service assurance (WSA) rogue events are sent to the event queue.

Your device sends wireless service assurance rogue events to the event queue for enhanced monitoring.

Monitor wireless service assurance rogue events

View wireless service assurance (WSA) rogue event statistics and details.

Before you begin

Use these steps to monitor wireless service assurance rogue events.

Procedure

Step 1 **show wireless wps rogue stats**

Example:

```
Device# show wireless wps rogue stats
            WSA Events
            Total WSA Events Triggered          : 9
            ROGUE_POTENTIAL_HONEYPOT_DETECTED   : 2
            ROGUE_POTENTIAL_HONEYPOT_CLEARED    : 3
            ROGUE_AP_IMPERSONATION_DETECTED     : 4
            Total WSA Events Enqueued           : 6
            ROGUE_POTENTIAL_HONEYPOT_DETECTED   : 1
            ROGUE_POTENTIAL_HONEYPOT_CLEARED    : 2
            ROGUE_AP_IMPERSONATION_DETECTED     : 3
```

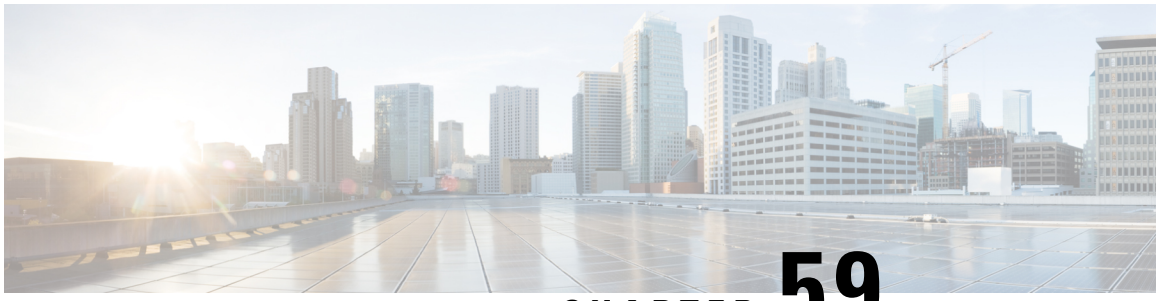
In this example, nine events occurred, but only six events were enqueued. Three events occurred before you enabled the WSA rogue feature.

Step 2 **show wireless wps rogue stats internal**

show wireless wps rogue ap detailed *rogue-ap-mac-addr*

These commands display information about WSA events in the event history.

You can track WSA rogue event activity, investigate event history, and verify system responsiveness to rogue threats.



CHAPTER 59

Classifying Rogue Access Points

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- Rogue containment methods, on page 535
- Guidelines and restrictions for classifying Rogue APs, on page 536
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Rogue AP classifications

A rogue AP classification is a wireless security mechanism that

- enables administrators to group rogue APs as Friendly, Malicious, , or Unclassified,
- uses configurable rules to automate the categorization and state assignment of unauthorized APs, and
- allows both automatic and manual reclassification of rogues based on network security requirements.

Additional reference information

- By default, no classification rules are active, so all unknown access points are assigned the Unclassified state. Administrators must enable classification rules to begin organizing rogue access points.
- When rules are enabled, all rogue access points in the Alert state are reclassified automatically based on the latest conditions and rule configurations.
- Changing or adding a rule triggers reclassification of all applicable rogue access points that are in the Alert state.
- You can manually move any rogue or ad hoc rogue access point to Unclassified and state, which represents the default state. Manually moved rogues are subject to rule-based reclassification.
- Rule-based classification does not apply to ad hoc rogues and rogue clients.
- You can configure up to 64 rogue classification rules per embedded wireless controller .
-

How the controller classifies rogue access points

When the controller software receives a rogue report from one of its managed access points, it follows this process:

- If the unknown access point is listed in the friendly MAC address list, the embedded wireless controller classifies it as Friendly.
- If it is not on the friendly MAC list, the embedded wireless controller applies the configured rogue classification rules.
-
- If a rogue matches the criteria in a classification rule, the embedded wireless controller assigns the classification type specified in that rule.
- If a rogue does not match any configured rules, it remains Unclassified.
- If a rogue access point is detected on the same wired network, the embedded wireless controller marks its state as Threat and classifies it as Malicious automatically (regardless of rules). You can manually contain such rogues, changing their state to Contained. If the rogue becomes unavailable, the embedded wireless controller moves it to the Alert state until you manually contain it.
- Administrators can always manually change the classification type and state of an access point as needed.

Examples: Classification mapping

Rule-Based Classification Type	Rogue State
Friendly	• Internal—If the unknown AP poses no threat to WLAN security, you can manually configure it as Friendly, Internal. An example of this would be the APs in your lab network. • External—If the unknown AP is outside the network and poses no threat to WLAN security, you can manually configure it as Friendly, External. An example of this would be the AP in your neighboring coffee shop. • Alert—
Malicious	• Alert— • Threat—The unknown AP is found to be on the network and poses a threat to WLAN security. • Contained—The unknown AP is contained.
Unclassified	• Alert— • Contained—The unknown AP is contained.

As mentioned earlier, the embedded wireless controller can automatically change the classification type and rogue state of an unknown AP based on user-defined rules. Alternatively, you can manually move the unknown AP to a different classification type and rogue state.

Allowable classification type and rogue state transitions

Assigning rogue APs classifications is like sorting emails automatically into spam or inbox based on filters (rules), while still allowing the user to manually move an email to a different folder when needed.

Rogue containment methods

A rogue containment method is a wireless security approach that

- detects unauthorized access points in the network environment,
- applies different containment strategies including manual, rule-based, and auto-containment, and
- prioritizes and restricts the actions of access points based on containment configuration and AP operating mode.

Containment methods and priorities

- **Manual rogue containment (Priority 1):** Administrators manually designate which rogue APs to contain, offering the highest control and flexibility. Containment levels can range from 1 to 4 APs participating.
- **Rule-based rogue containment (Priority 2):** The controller automatically contains rogue APs based on predefined rules, always using 1 AP for containment.
- **Auto-containment (Priority 3):** The controller automatically contains rogue APs, but only when specific options (such as "Using our SSID", "A valid client on the Rogue AP", or "Ad-hoc Rogue AP") are enabled.

Auto-containment for monitor mode APs

- When you enable 'Auto Containment only for Monitor Mode APs', only monitor mode APs perform auto-containment. Local or FlexConnect mode APs do not.
- This option applies only to auto-containment. It does not affect your manual or rule-based methods.
- Other AP modes (local or FlexConnect) still enforce rogue containment actions outside the scope of this auto-containment setting.

Containment prioritization and exceptions

- Manual containment always takes highest priority, followed by rule-based, with auto-containment last.
- If a rogue AP matches both manual or rule-based configurations, auto-containment does not occur for that AP.

Example

An ad-hoc rogue AP detected with a valid client connected triggers auto-containment by monitor mode APs only if the corresponding option is enabled. If manual containment is also configured for this rogue AP, manual containment takes precedence and disables auto-containment for that case.

Guidelines and restrictions for classifying Rogue APs

Classifying Custom type rogues is tied to rogue rules. Therefore, it is not possible to manually classify a rogue as Custom. Custom class change can occur only when rogue rules are used.

Some are sent for containment by rule and every 30 minutes for rogue classification change.

Rogue rules are applied on every incoming new rogue report in the embedded wireless controller in the order of their priority.

After a rogue satisfies a rule and is classified, it does not move down the priority list for the same report.

Previously classified rogue gets re-classified on every new rogue report with the following restrictions:

- Rogues which are classified as friendly by rule and whose state is set to ALERT, go through re-classification on receiving the new rogue report.
- If a rogue is classified as friendly by the administrator manually, then the state is INTERNAL and it does not get re-classified on successive rogue reports.
- If rogue is classified as malicious, irrespective of the state it does not get re-classified on subsequent rogue reports.

If a rogue AP is classified as friendly

Until the controller discovers all the APs through neighbor reports from APs, the rogue APs are kept in unconfigured state for three minutes after they are detected. After 3 minutes, the rogue policy is applied on the rogue APs and the APs are moved to unclassified, friendly, malicious, or custom class. Rogue APs kept in unconfigured state means that no rogue policy has yet been applied on them.

When a rogue BSSID is submitted for a containment on Cisco Catalyst 9800 Series Wireless Controller, if the controller has enough resources, it will contain. The APs that detect the particular contained rogue AP starts broadcasting the DEAUTH packets.

Wireless client connected to the contained rogue BSSID will disconnect once DEAUTH packets are received. However, when the client assumes being in a connected state, repeatedly tries to reconnect and the wireless client's user browsing experience would be badly affected.

Also, in a high RF environment like that of a stadium, though DEAUTH packets are broadcasted, client does not receive all of them because of RF disturbance. In this scenario, the client may not be fully disconnected but will be affected badly.

The rouge AP manual classification limit has been enhanced from 625 to 10,000 configurations at a time. The rouge client manual classification limit has been enhanced from 625 to 10,000 configurations at a time.

How to Classify Rogue Access Points

Classify a rogue AP manually (GUI)

Set the correct classification for rogue access points to maintain wireless network security and compliance.

Use this task after the system detects unclassified APs and you need to determine their status.

Procedure

Step 1 Choose **Monitoring > Wireless** > **Rogues**.

Step 2 In the **Unclassified** tab, select an AP to view the detail in the lower pane.

Step 3 Use the **Class Type** drop-down to set the status.

Step 4 Click **Apply**.

The AP is reclassified and removed from the unclassified list; its status is updated accordingly.

Classify rogue APs and clients manually (CLI)

Classify rogue access points and clients to enhance network security.

This procedure is used in environments where rogue access points and clients need to be identified and managed to prevent unauthorized access to the network.

Before you begin

Ensure you have the necessary permissions to configure the device.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Detect and report the ad hoc rogue.

Example:

```
Device(config)# wireless wps rogue adhoc alert mac-addr
```

Enter one of these options after you enter the **adhoc** keyword:

- **alert**—Sets the ad hoc rogue access point to alert mode. If you choose this option, enter the MAC address for the *mac-addr* parameter.
- **auto-contain**—Sets the automatically containing ad hoc rogue to auto-contain mode.
- **contain**—Sets the containing ad hoc rogue access point to contain mode. If you choose this option, enter the MAC address for the *mac-addr* parameter and containment level for the *containment-level* parameter. The valid range for *containment-level* is from 1 to 4.
- **external**—Sets the ad hoc rogue access point as **external**. If you choose this option, enter the MAC address for the *mac-addr* parameter.
- **internal**—Sets the ad hoc rogue access point as **internal**. If you choose this option, enter the MAC address for the *mac-addr* parameter.

Step 3 Configure the rogue APs.

Example:

```
Device(config)# wireless wps rogue ap malicious mac-addr state contain containment-level
```

Example:

```
Device(config)# wireless wps rogue ap malicious 74a0.2f45.c520 state contain 3
```

Enter one of the following options after the **ap** keyword:

- **friendly**—Configures the friendly rogue access points. If you choose this option, enter the MAC address for the *mac-addr* parameter. After that enter the **state** keyword followed by either of these options: **internal** or **external**.
- **malicious**—Configures the malicious rogue access points. If you choose this option, enter the MAC address for the *mac-addr* parameter. After that enter the **state** keyword followed by either of these options: **alert** or **contain**.
- **alert**—Sets the malicious rogue access point to **alert** mode.
- **contain**—Sets the malicious rogue access point to **contain** mode. If you choose this option, enter the containment level for the *containment-level* parameter. The valid range is from 1 to 4.

Step 4 Configure the rogue clients.

Example:

```
Device(config)# wireless wps rogue client contain mac-addr containment-level
```

Example:

```
Device(config)# wireless wps rogue client contain 74a0.2f45.c520 2
```

Enter the following option after you enter the **client** keyword:

contain—Contains the rogue client. After you choose this option, enter the MAC address for the *mac-addr* parameter and the containment level for *containment-level* parameter. The valid range for *containment-level* is from 1 to 4.

Step 5 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configure rogue classification rules (GUI)

Procedure

Step 1 Choose **Configuration** > **Security** > **Wireless Protection Policies**.

Step 2 In the **Wireless Protection Policies** page, choose **Rogue AP Rules** tab.

Step 3 On the **Rogue AP Rules** page, click the name of the **Rule** or click **Add** to create a new one.

Step 4 In the **Add/Edit Rogue AP Rule** window that is displayed, enter the name of the rule in the **Rule Name** field.

Step 5 Choose the rule type from the following **Rule Type** drop-down list options:

- Friendly
- Malicious
- Unclassified
- Custom

Configure rogue classification rules (CLI)

Establish rules for classifying rogue access points to enhance network security.

This configuration is used in environments where rogue access points need to be identified and classified to prevent unauthorized access.

Before you begin

Ensure you have the necessary permissions to configure rogue classification rules on the device.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create or enable a rule and set its priority.

Example:

```
Device(config)# wireless wps rogue rule rule-name priority priority
```

When creating a rule, you must enter the priority for the rule.

Note
After creating a rule, you can edit the rule and change the priority only for the rogue rules that are disabled. You cannot change the priority for the rogue rules that are enabled. While editing, changing the priority for a rogue rule is optional.

Step 3 Classify a rule.

Example:

```
Device(config)# wireless wps rogue rule rule_3 priority 3
Device(config-rule)# classify friendly state {alert | external | internal}
```

- **friendly**—Configures the friendly rogue access points. After that enter the **state** keyword followed by either of these options: **alert**, **internal**, or **external**. If you select an **internal** option, it indicates that you trust a foreign access point. If you select an **external** option, it indicates that you acknowledge the presence of a rogue access point.
- **malicious**—Configures the malicious rogue access points. After that enter the state keyword followed by either of these options: alert or contained.

- **alert**—Sets the malicious rogue access point to alert mode.
- **contained**—Sets the malicious rogue access point to contained mode.

Step 4 Add conditions to a rule.

Example:

```
Device(config)# wireless wps rogue rule rule_3 priority 3
```

```
Device(config-rule)# condition {client-count condition_value | duration duration_value |
encryption | infrastructure | rssi | ssid ssid_name | wildcard-ssid}
```

Adds the following conditions to a rule, which the rogue access point must meet:

- **client-count**—Requires that a minimum number of clients be associated to the rogue access point. For example, if the number of clients associated to the rogue access point is greater than or equal to the configured value, the access point could be classified as Malicious. If you choose this option, enter the minimum number of clients to be associated to the rogue access point for the parameter. The valid range is from 1 to 10 (inclusive), and the default value is 0.
- **duration**—Requires that the rogue access point be detected for a minimum period of time. If you choose this option, enter a value for the minimum detection period for the parameter. The valid range is from 0 to 3600 seconds (inclusive), and the default value is 0 seconds.
- **encryption**—Requires that the advertised WLAN does not have encryption enabled. You can choose **any** for any type of encryption, **off** for no encryption, **wpa1** for WPA encryption, **wpa2** for WPA2 encryption, **wpa3-owe** for WPA3 OWE encryption, or **wpa3-sae** for WPA3 SAE encryption.
- **infrastructure**—Requires the SSID to be known to the controller.
- **rssi**—The valid range is from –95 to –50 dBm (inclusive).
- **ssid**—Requires the rogue access point to have a specific SSID. You could specify up to 25 different SSIDs. You should specify an SSID that is not managed by the controller. If you choose this option, enter the SSID for the parameter.
- **wildcard-ssid**—Allows you to specify an expression that could match an SSID string. You can specify up to 25 of these SSIDs.

Step 5 Specify matching conditions for the rule.

Example:

```
Device(config)# wireless wps rogue rule rule_3 priority 3
```

```
Device(config-rule)# match {all | any}
```

Specifies whether a detected rogue access point must meet all or any of the conditions specified by the rule for the rule to be matched and the rogue access point to adopt the classification type of the rule.

Step 6 Set a command to its default.

Example:

```
Device(config-rule)# default
```

Step 7 Exit the sub-mode.

Example:

```
Device(config)# wireless wps rogue rule rule_3 priority 3
```

```
Device(config-rule)# exit
Device(config)#
```

Step 8 Disable a particular rogue rule.

Example:

```
Device(config)# wireless wps rogue rule rule_3 priority 3
Device(config-rule)# shutdown
```

Disables a particular rogue rule. In this example, the rule *rule_3* is disabled.

Step 9 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Returns to privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Step 10 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 11 Disable all the rogue rules.

Example:

```
Device(config)# wireless wps rogue rule shutdown
```

Step 12 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Returns to privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

You have now configured the rogue classification rules, enabling effective management of rogue access points in the network..

Monitor rogue classification rules

You can monitor the rogue classification rules using these commands.

Table 39: Commands for monitoring rogue classification rules

Command	Purpose
show wireless wps rogue rule detailed	Displays detailed information of a classification rule.
show wireless wps rogue rule summary	Displays a summary of the classification rules.

Examples: classifying rogue AP

This example shows how to classify a rogue AP with MAC address 00:11:22:33:44:55 as malicious and mark it for being contained by 2 managed APs:

```
Device# configure terminal
Device(config)# wireless wps rogue ap malicious 0011.2233.4455 state contain 2
```

This example shows how to create a rule that can categorize a rogue AP that is using SSID **my-friendly-ssid**, and it is seen for at least for 1000 seconds as friendly internal:

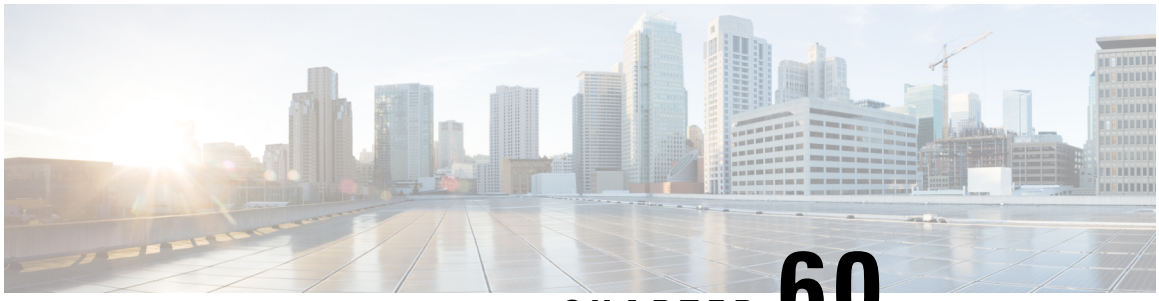
```
Device# configure terminal
Device(config)# wireless wps rogue rule ap1 priority 1
Device(config-rule)# condition ssid my-friendly-ssid
Device(config-rule)# condition duration 1000
Device(config-rule)# match all
Device(config-rule)# classify friendly state internal
Device(config-rule)# no shutdown
```

This example shows how to apply a condition that a rogue access point must meet:

```
Device# configure terminal
Device(config)# wireless wps rogue rule ap1 priority 1
Device(config-rule)# condition client-count 5
Device(config-rule)# condition duration 1000
Device(config-rule)# no shutdown
Device(config-rule)# end
```

This example shows a condition to classify rogue devices with the controller SSIDs as malicious:

```
Device# configure terminal
Device(config)# wireless wps rogue rule ap1 priority 1
Device(config-rule)#  classify malicious state alert
Device(config-rule)#  condition duration 30
Device(config-rule)#  condition infrastructure ssid
Device(config-rule)#  match all
Device(config-rule)#  no shutdown
Device(config-rule)# end
```



CHAPTER 60

Configuring Secure Shell

- SSH, on page 543

SSH

A secure shell (SSH) protocol is a network security mechanism that

- establishes encrypted and authenticated connections between remote devices. and
- protects data confidentiality and integrity during communication.
- supports multiple version standards, including SSHv1 and SSHv2.

How SSH sorks and security benefits

Secure Shell (SSH) protocols offer a secure alternative to older remote access methods, such as Telnet, by encrypting data exchanged between a client and a server. Authentication further ensures that only authorized users can access devices. SSH increases security for network administrators by preventing eavesdropping and protecting credentials.

- Connecting securely to a router or switch for remote configuration.
- Transferring files securely between devices using SCP, which operates over SSH.

SSH and device access

A Secure Shell (SSH) protocol is a network access method that

- uses strong encryption and authentication to secure remote connections
- offers enhanced security over Telnet by encrypting session and authentication data, and
- supports both IPv4 and IPv6 environments for flexible device access.

Additional information

SSH is a secure protocol for remote device access, supporting both IPv4 and IPv6, and provides strong encryption for authenticated sessions.

SSH servers and integrated clients

A SSH integrated client is a feature that - runs over the SSH protocol to provide device authentication - enables secure, encrypted connections to other devices, and - supports various user authentication methods.

Supported versions and functionalities

The SSH client enables a Cisco device to make a secure, encrypted connection to another Cisco device or to any other device running the SSH server.

This connection provides functionality similar to that of an outbound Telnet connection except that the connection is encrypted.

With authentication and encryption, the SSH client allows for secure communication over an unsecured network.

The SSH server and SSH integrated client are applications that run on the switch.

The switch supports an SSHv1 or an SSHv2 server.

The switch supports an SSHv1 client.



Note The SSH client functionality is available only when the SSH server is enabled.

User authentication is performed like that in the Telnet session to the device. SSH also supports the following user authentication methods:

- TACACS+
- RADIUS
- Local authentication and authorization

SSH configuration guidelines

General SSH configuration guidelines

Follow these guidelines when configuring the switch as an SSH server or SSH client:

- An RSA key pair generated by a SSHv1 server can be used by an SSHv2 server, and the reverse.
- If the SSH server is running on an active switch and the active switch fails, the new active switch uses the RSA key pair generated by the previous active switch.
- If you get CLI error messages after entering the **crypto key generate rsa** global configuration command, an RSA key pair has not been generated. Reconfigure the hostname and domain, and then enter the **crypto key generate rsa** command.
- When generating the RSA key pair, the message No host name specified might appear. If it does, you must configure a hostname by using the **hostname** global configuration command.
- When generating the RSA key pair, the message No domain specified might appear. If it does, you must configure an IP domain name by using the **ip domain-name** global configuration command.

- When configuring the local authentication and authorization authentication method, make sure that AAA is disabled on the console.

SCP

A Secure Copy Protocol is a method for securely transferring files that

- provides a secure and authenticated method for copying switch configurations or switch image files
- relies on Secure Shell (SSH) for secure transport, and
- requires correct configuration of SSH, authentication, and authorization on the switch.

Supporting reference information

For SSH to work, the switch needs an RSA public or private key pair. This is the same with SCP, which relies on SSH for its secure transport.

Because SSH also relies on AAA authentication, and SCP relies further on AAA authorization, correct configuration is necessary.

- Before enabling SCP, you must correctly configure SSH, authentication, and authorization on the switch.
- Because SCP relies on SSH for its secure transport, the router must have a Rivest, Shamir, and Adelman (RSA) key pair.



Note When using SCP, you cannot enter the password into the copy command. You must enter the password when prompted.

Secure copy protocol

A Secure Copy Protocol is a network protocol that

- provides a secure and authenticated method for copying files
- relies on SSH for security, and
- requires authentication, authorization, and accounting (AAA) authorization.

Additional information on SCP

The behavior of SCP is similar to that of remote copy (rcp), which comes from the Berkeley r-tools suite.

To configure the SCP, you should understand the SCP concepts.

SFTP support

SFTP client support is introduced from Cisco IOS XE Gibraltar 16.10.1 release onwards. SFTP client is enabled by default and no separate configuration required. The SFTP procedures can be invoked using the

copy command, which is similar to that of **scp** and **tftp** commands. A typical file download procedure using **sftp** command can be carried out as shown below:

copy sftp://*user* :*password @server-ip/file-name* **flash0://** *file-name*

For more details on the **copy** command, see the following URL:
https://www.cisco.com/c/m/en_us/techdoc/dc/reference/cli/nxos/commands/fund/copy.html

Prerequisites for configuring SSH

- For SSH to work, the switch needs an Rivest, Shamir, and Adleman (RSA) public/private key pair. This is the same with Secure Copy Protocol (SCP), which relies on SSH for its secure transport.
- Before enabling SCP, you must correctly configure SSH, authentication, and authorization on the switch.
- Because SCP relies on SSH for its secure transport, the router must have an Rivest, Shamir, and Adelman (RSA) key pair.
- SCP relies on SSH for security.
- SCP requires that authentication, authorization, and accounting (AAA) authorization be configured so the router can determine whether the user has the correct privilege level.
- A user must have appropriate authorization to use SCP.
- A user who has appropriate authorization can use SCP to copy any file in the Cisco IOS File System (IFS) to and from a switch by using the **copy** command. An authorized administrator can also do this from a workstation.
- The Secure Shell (SSH) server requires an IPsec (Data Encryption Standard [DES] or 3DES) encryption software image; the SSH client requires an IPsec (DES or 3DES) encryption software image.
- Configure a hostname and host domain for your device by using the **hostname** and **ip domain-name** commands in global configuration mode.

Restrictions for configuring SSH

These are restrictions for configuring the device for secure shell.

- From Cisco IOS XE Dublin 17.10.x, Key Exchange and MAC algorithms like diffie-hellman-group14-sha1, hmac-sha1, hmac-sha2-256, and hmac-sha2-512 are not supported by default and it may impact some SSH clients that only support these algorithms. However, you can add them manually if required. For information on manually adding these algorithms, see the https://www.cisco.com/c/en/us/td/docs/routers/ios/config/17-x/sec-vpn/b-security-vpn/m_sec-secure-shell-algorithm-ccc.html.
- The switch supports Rivest, Shamir, and Adelman (RSA) authentication.
- SSH supports only the execution-shell application.
- The SSH server and the SSH client are supported only on Data Encryption Standard (DES) (56-bit) and 3DES (168-bit) data encryption software. In DES software images, DES is the only encryption algorithm available. In 3DES software images, both DES and 3DES encryption algorithms are available.
- The device supports the Advanced Encryption Standard (AES) encryption algorithm with a 128-bit key, 192-bit key, or 256-bit key. However, symmetric cipher AES to encrypt the keys is not supported.

- When using SCP, you cannot enter the password into the **copy** command. You must enter the password when prompted.
- The login banner is not supported in Secure Shell Version 1. It is supported in Secure Shell Version 2.
- The -l keyword and userid :{number} {ip-address} delimiter and arguments are mandatory when configuring the alternative method of Reverse SSH for console access.
- To authenticate clients with FreeRADIUS over RADSEC, you should generate an RSA key longer than 1024 bit. Use the **crypto key generate rsa general-keys exportable label** *label-name* command to achieve this.

How to configure SSH

Set up the device to run SSH

Enable SSH on the device for secure remote access.

Follow the procedure given below to set up your device to run SSH:

Before you begin

Configure user authentication for local or remote access.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the hostname and IP domain name for your device.

Example:

```
Device(config)# hostname your_hostname
```

Note
Follow this procedure only if you are configuring the device as an SSH server.

Step 3 Configure a host domain for your device.

Example:

```
Device(config)# ip domain name your_domain
```

Step 4 Enable the SSH server and generate an RSA key pair.

Example:

```
Device(config)# crypto key generate rsa
```

Generating an RSA key pair for the device automatically enables SSH.

We recommend that a minimum modulus size of 1024 bits.

When you generate RSA keys, you are prompted to enter a modulus length. A longer modulus length might be more secure, but it takes longer to generate and to use.

Note
Follow this procedure only if you are configuring the device as an SSH server.

Step 5 Exit configuration mode.

Example:

```
Device(config)# end
```

The device is now set up to run SSH, allowing secure remote access.

Configure the SSH server

Set up the SSH server to allow secure remote access to the device.

Follow the procedure given below to configure the SSH server:



Note This procedure is only required if you are configuring the device as an SSH server.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 (Optional) Configure the device to run SSH Version 2.

Example:

```
Device(config)# ip ssh version 2
```

If you do not enter this command or do not specify a keyword, the SSH server selects the latest SSH version supported by the SSH client.

Step 3 Configure the SSH control parameters.

Example:

```
Device(config)# ip ssh timeout
seconds
authentication-retries
number
```

Specify the time-out value in seconds; the default is 120 seconds. The range is 0 to 120 seconds. This parameter applies to the SSH negotiation phase.

By default, up to five simultaneous, encrypted SSH connections for multiple CLI-based sessions over the network are available (session 0 to session 4).

Step 4 (Optional) Use one or both of the following:

- `line vty` *line_number* [*ending_line_number*]
- **transport input ssh**

Example:

```
Device(config)# line vty
line-number
ending-line-number
```

or

```
Device(config-line)# transport input ssh
```

Enters line configuration mode to configure the virtual terminal line settings. For *line-number* and *ending-line-number* , specify a pair of lines. The range is 0 to 15.

Specifies that the device prevent non-SSH Telnet connections. This limits the router to only SSH connections.

Note
If the Virtual Terminal (VTY) lines are exhausted, Telnet or SSH will fail. You can either disconnect the Telnet or SSH sessions to free up the VTY lines, or follow the recovery steps given below to clear VTY lines and reload Telnet or SSH:

```
Device# configure terminal
Device(config)# clear line
line number
```

Step 5 Return to privileged EXEC mode.

Example:

```
Device(config-line)# end
```

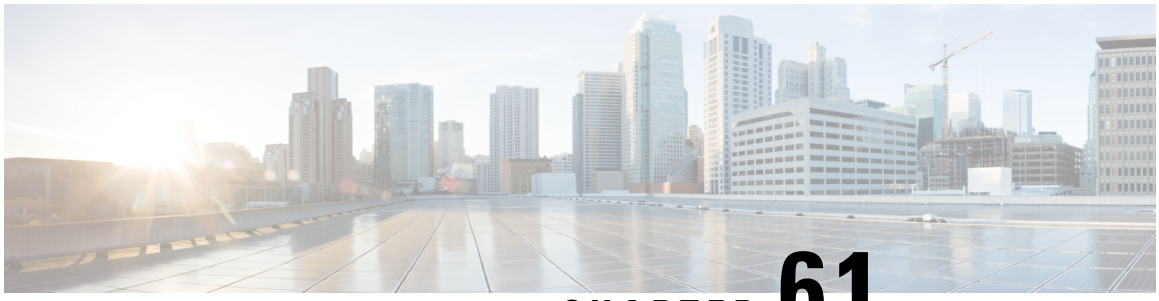
Returns to privileged EXEC mode.

The SSH server is now configured and ready for secure remote access.

Monitor the SSH configuration and status

This table displays the SSH server configuration and status.

Command	Purpose
show ip ssh	Shows the version and configuration information for the SSH server.
show ssh	Shows the status of the SSH server.



CHAPTER 61

Private Shared Key

- Private preshared keys, on page 551
- Limitations, on page 551
- How identity PSK authentication works, on page 552
- Configure a PSK in a WLAN, on page 553
- Configure a PSK in a WLAN using GUI, on page 554
- Apply a policy profile to a WLAN (GUI), on page 554
- Apply a policy profile to a WLAN using CLI, on page 555
- Verify a private PSK, on page 556

Private preshared keys

A private preshared key (PSK) is a security protocol for network authentication that

- enables devices to securely connect to wireless local area networks (WLANs),
- assigns unique keys to individual devices or user groups, reducing the risk of unauthorized access, and
- ensures compatibility with systems where advanced authentication methods like 802.1X are unsupported.

Understanding identity PSKs

Identity PSKs are unique PSKs created for individuals or groups of users on the same SSID. They provide the same simplicity of PSK while enabling features such as:

- Stronger security for IoT by supporting devices that do not use 802.1X.
- Easy revocation of access for a specific device or individual without affecting others.
- Scalable management of thousands of keys distributed through the AAA server.

These features make Identiy PSKs ideal for IoT, BYOD, and guest deployments.

Limitations

SSID Preshared Key Special Characters

- Special characters, such as '<' and '>' are not supported in SSID Preshared key.

SSID Preshared Key Whitespace Support

PSK supports whitespace in passwords (before or after or in-between) within double quotes only; single quotes for whitespaces are not supported.

How identity PSK authentication works

Summary

The key components involved in the process are:

- Client device: Sends an association request to connect to the access point.
- AP: Broadcasts the SSID and forwards association requests to the controller.
- Embedded Wireless Controller: Constructs RADIUS requests and relays them to the authentication server; manages computation of PSKs and applies received configuration parameters.
- RADIUS (AAA) server: Authenticates client MAC addresses, authorizes access, and returns passphrases or additional parameters as needed.

Workflow

Here are the stages you will follow for Identity PSK authentication:

1. The client device attempts to connect to the wireless network by sending an association request to the SSID broadcast by the access point.
2. The access point forwards the association request to the Embedded Wireless Controller.
3. The controller creates a RADIUS authentication request packet containing the client's MAC address and relays it to the RADIUS (AAA) server.
4. The RADIUS server performs authentication and determines whether the client is authorized.
    - If authorized, the server sends an ACCESS-ACCEPT response; otherwise, it sends an ACCESS-REJECT.
5. If the client is authorized, the RADIUS server includes the AV-pair passphrase (the identity PSK) in the response, as well as optional parameters such as username, VLAN, and Quality of Service (QoS).
6. Upon receiving the response, the controller uses the passphrase to compute the Pairwise Master Key (PMK) and apply any additional attributes for the client's session.
7. If you have multiple devices, the same passphrase can apply to all of them.
8. If a configured PSK is shorter than 15 characters (when Federal Information Processing Standard, FIPS, is enabled), the controller allows the WLAN configuration but displays the following console warning:

Note AP is allowed to join but corresponding WLAN will not be pushed to the access point.

Result

Your device will either be granted access to the network with its assigned unique PSK and relevant settings, or access will be denied based on the authentication outcome. This information could be better presented in a separate paragraph or subsection to distinctively address the outcome of the process.

Configure a PSK in a WLAN

Set up security for a pre-shared key (PSK) in a WLAN environment using command-line instructions.

Before you begin

- Configure security for a pre-shared key (PSK) in a WLAN.
- If there is no override from the AAA server, the system uses the WLAN value for authentication.
- In Federal Information Processing Standard (FIPS) and common criteria mode, ensure that the PSK WLAN uses at least 15 ASCII characters.

Procedure

Step 1 Configure terminal

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 2 Configure the WLAN and the SSID

Example:

```
Device(config)# wlan test-profile 4 abc
```

Configures the WLAN and SSID.

Step 3 Disable security AKM for 802.11

Example:

```
Device(config-wlan)# no security wpa akm dot1x
```

Disables security AKM for 802.11x.

Step 4 Configure the security type PSK

Example:

```
Device(config-wlan)# security wpa akm psk
```

Configures the security type PSK.

Step 5 Configure PSK authenticated key management (AKM) shared key

Example:

```
Device(config-wlan)# security wpa akm psk set-key asci 0
```

Configures the PSK authenticated key management (AKM) shared key.

Step 6 Configure PSK support

Example:

```
Device(config-wlan)# security wpa akm psk
```

Configures PSK support.

Step 7 Specify MAC filtering in WLAN

Example:

```
Device(config-wlan)# mac-filtering test1
```

Specifies MAC filtering in a WLAN.

The WLAN is configured to use a pre-shared key for client authentication.

Configure a PSK in a WLAN using GUI

Configure a pre-shared key (PSK) for a WLAN.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 On the **Wireless Networks** page, click **Security** tab.

Step 3 In the **Layer 2** window that is displayed, go to the **WPA Parameters** section.

Step 4 From the **Auth Key Mgmt** drop-down, select the PSK format and type.

Step 5 Enter the Pre-Shared Key in hexadecimal characters.

- If you selected the PSK format as HEX, the key length must be exactly 64 characters.
- If you selected the PSK format as ASCII, ensure the key length ranges from 8 to 63 characters.

After configuring the key, these details are not visible due to security reasons. Even if you click on the eye icon next to the Pre-Shared Key box, the details remain hidden.

Step 6 Click **Save & Apply to Device**.

The PSK is configured and applied to the selected WLAN.

What to do next

Check the WLAN connectivity to ensure successful configuration.

Apply a policy profile to a WLAN (GUI)

This task helps you configure WLAN by applying policy profiles for better network management.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags**.

Step 2 On the **Manage Tags** page, click **Policy** tab.

Step 3 Click **Add** to view the **Add Policy Tag** window.

Step 4 Enter the policy tag name and its description.

Step 5 Click **Add** to map WLAN and policy.

Step 6 Choose the WLAN profile to map with the appropriate policy profile, then click the tick icon.

Step 7 Click **Save & Apply to Device**.

Once the task is completed, you successfully map the WLAN to the chosen policy profile

What to do next

Verify the changes by checking the applied profiles under Wireless Local Area Network (WLAN) settings.

Monitor network performance to confirm the policy effectiveness.

Apply a policy profile to a WLAN using CLI

The goal of this task is to effectively apply a policy profile to a WLAN using CLI commands, which helps manage network configurations efficiently.

Procedure

Step 1 Enter global configuration mode

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 2 Configure the default policy profile

Example:

```
Device(config)# wireless profile policy policy-iot
```

Configures the default policy profile.

Step 3 Configure AAA override to apply policies coming from the AAA server

Example:

```
Device(config-wireless-policy)# aaa-override
```

Configures AAA override to apply policies coming from the AAA server or ISE, the Cisco Identity Services Engine server.

Once you apply the policy profile, configure the WLAN with the specified policy settings to enable the expected network management and security features.

What to do next

You should verify the applied configuration by checking the WLAN settings to ensure all policies are correctly enforced.

- Confirm connectivity and performance with the new settings.

Verify a private PSK

To verify the configuration of a WLAN and a client, use the following **show** commands

Verify wireless client configuration

```
Device# show wlan id 2


WLAN Profile Name     : test_ppsk
==================================================
Identifier                                       : 2
Network Name (SSID)                              : test_ppsk
Status                                           : Enabled
Broadcast SSID                                   : Enabled
Universal AP Admin                               : Disabled
Max Associated Clients per WLAN                  : 0
Max Associated Clients per AP per WLAN           : 0
Max Associated Clients per AP Radio per WLAN     : 0
Number of Active Clients                         : 0
Exclusionlist Timeout                            : 60
CHD per WLAN                                     : Enabled
Interface                                        : default
Multicast Interface                              : Unconfigured
WMM                                              : Allowed
WifiDirect                                       : Invalid
Channel Scan Defer Priority:
  Priority (default)                             : 4
  Priority (default)                             : 5
  Priority (default)                             : 6
Scan Defer Time (msecs)                          : 100
Media Stream Multicast-direct                    : Disabled
CCX - AironetIe Support                          : Enabled
CCX - Diagnostics Channel Capability             : Disabled
Peer-to-Peer Blocking Action                     : Disabled
Radio Policy                                     : All
DTIM period for 802.11a radio                    : 1
DTIM period for 802.11b radio                    : 1
Local EAP Authentication                         : Disabled
Mac Filter Authorization list name               : test1
Accounting list name                             : Disabled
802.1x authentication list name                  : Disabled
Security
```

```
    802.11 Authentication                        : Open System
    Static WEP Keys                              : Disabled
    802.1X                                       : Disabled
    Wi-Fi Protected Access (WPA/WPA2)            : Enabled
        WPA (SSN IE)                             : Disabled
        WPA2 (RSN IE)                            : Enabled
            TKIP Cipher                          : Disabled
            AES Cipher                           : Enabled
        Auth Key Management
            802.1x                               : Disabled
            PSK                                  : Enabled
            CCKM                                 : Disabled
            FT dot1x                             : Disabled
            FT PSK                               : Disabled
            PMF dot1x                            : Disabled
            PMF PSK                              : Disabled
    CCKM TSF Tolerance                           : 1000
    FT Support                                   : Disabled
        FT Reassociation Timeout                 : 20
        FT Over-The-DS mode                      : Enabled
    PMF Support                                  : Disabled
        PMF Association Comeback Timeout         : 1
        PMF SA Query Time                        : 200
    Web Based Authentication                     : Disabled
    Conditional Web Redirect                     : Disabled
    Splash-Page Web Redirect                     : Disabled
    Webauth On-mac-filter Failure                : Disabled
    Webauth Authentication List Name             : Disabled
    Webauth Parameter Map                        : Disabled
    Tkip MIC Countermeasure Hold-down Timer      : 60
Call Snooping                                    : Disabled
Passive Client                                   : Disabled
Non Cisco WGB                                    : Disabled
Band Select                                      : Disabled
Load Balancing                                   : Disabled
Multicast Buffer                                 : Disabled
Multicast Buffer Size                            : 0
IP Source Guard                                  : Disabled
Assisted-Roaming
    Neighbor List                                : Disabled
    Prediction List                              : Disabled
    Dual Band Support                            : Disabled
IEEE 802.11v parameters
    Directed Multicast Service                   : Disabled
    BSS Max Idle                                 : Disabled
        Protected Mode                           : Disabled
    Traffic Filtering Service                    : Disabled
    BSS Transition                               : Enabled
        Disassociation Imminent                  : Disabled
            Optimised Roaming Timer              : 40
            Timer                                : 200
    WNM Sleep Mode                               : Disabled
802.11ac MU-MIMO                                 : Disabled
```

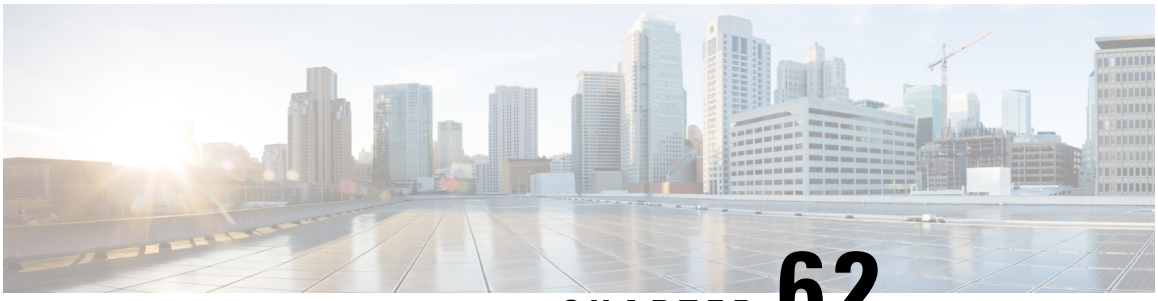
Commands for PSK verification

```
Device# show wireless client mac-address a886.adb2.05f9 detail


Client MAC Address : a886.adb2.05f9
Client IPv4 Address : 9.9.58.246
Client Username : A8-86-AD-B2-05-F9
AP MAC Address : c025.5c55.e400
```

```
AP Name: saurabh-3600
AP slot : 1
Client State : Associated
Policy Profile : default-policy-profile
Flex Profile : default-flex-profile
Wireless LAN Id : 6
Wireless LAN Name: SSS_PPSK
BSSID : c025.5c55.e40f
Connected For : 280 seconds
Protocol : 802.11n - 5 GHz
Channel : 60
Client IIF-ID : 0xa0000001
Association Id : 1
Authentication Algorithm : Open System
Client CCX version : No CCX support
Session Timeout : 320 sec (Remaining time: 40 sec)
Input Policy Name  :
Input Policy State : None
Input Policy Source : None
Output Policy Name  :
Output Policy State : None
Output Policy Source : None
WMM Support : Enabled
U-APSD Support : Enabled
  U-APSD value : 0
  APSD ACs    : BK, BE, VI, VO
Fastlane Support : Disabled
Power Save : OFF
Current Rate : m22
Supported Rates : 9.0,18.0,36.0,48.0,54.0
Mobility:
  Move Count                  : 0
  Mobility Role               : Local
  Mobility Roam Type          : None
  Mobility Complete Timestamp : 09/27/2017 16:32:25 IST
Policy Manager State: Run
NPU Fast Fast Notified : No
Last Policy Manager State : IP Learn Complete
Client Entry Create Time : 280 seconds
Policy Type : WPA2
Encryption Cipher : CCMP (AES)
Authentication Key Management : PSK
AAA override passphrase: Yes
Management Frame Protection : No
Protected Management Frame - 802.11w : No
EAP Type : Not Applicable
VLAN : 58
Access VLAN : 58
Anchor VLAN : 0
WFD capable : No
Manged WFD capable : No
Cross Connection capable : No
Support Concurrent Operation : No
Session Manager:
  Interface        : capwap_90000005
  IIF ID           : 0x90000005
  Device Type      : Apple-Device
  Protocol Map     : 0x000001
  Authorized       : TRUE
  Session timeout  : 320
  Common Session ID: 1F3809090000005DC30088EA
  Acct Session ID  : 0x00000000
  Auth Method Status List
        Method : MAB
```

```
                SM State        : TERMINATE
                Authen Status   : Success
  Local Policies:
        Service Template : wlan_svc_default-policy-profile (priority 254)
                Absolute-Timer   : 320
                VLAN             : 58
  Server Policies:
  Resultant Policies:
                VLAN             : 58
                Absolute-Timer   : 320
Client Capabilities
  CF Pollable : Not implemented
  CF Poll Request : Not implemented
  Short Preamble : Not implemented
  PBCC : Not implemented
  Channel Agility : Not implemented
  Listen Interval : 0
Fast BSS Transition Details :
  Reassociation Timeout : 0
11v BSS Transition : Not implemented
FlexConnect Data Switching : Local
FlexConnect Dhcp Status : Local
FlexConnect Authentication : Central
FlexConnect Central Association : No
Client Statistics:
  Number of Bytes Received : 59795
  Number of Bytes Sent : 21404
  Number of Packets Received : 518
  Number of Packets Sent : 274
  Number of EAP Id Request Msg Timeouts :
  Number of EAP Request Msg Timeouts :
  Number of EAP Key Msg Timeouts :
  Number of Policy Errors : 0
  Radio Signal Strength Indicator : -32 dBm
  Signal to Noise Ratio : 58 dB
Fabric status : Disabled
```



CHAPTER 62

Multi-Preshared Key

- Multi-preshared key, on page 561
- Restrictions, on page 563
- Configure a multi-preshared key (GUI), on page 563
- Configure a multi-preshared key (CLI), on page 566
- Verify multi-PSK configurations, on page 567

Multi-preshared key

A multi-preshared key (multi-PSK) is a wireless security feature that

- Allows multiple pre-shared keys (PSKs) to be configured for a single SSID
- Enables any configured PSK to grant access to the same wireless network
- Improves network flexibility by supporting concurrent user groups or devices with different credentials.

PSK: A pre-shared key is a password or passphrase used to authenticate clients on a wireless network.

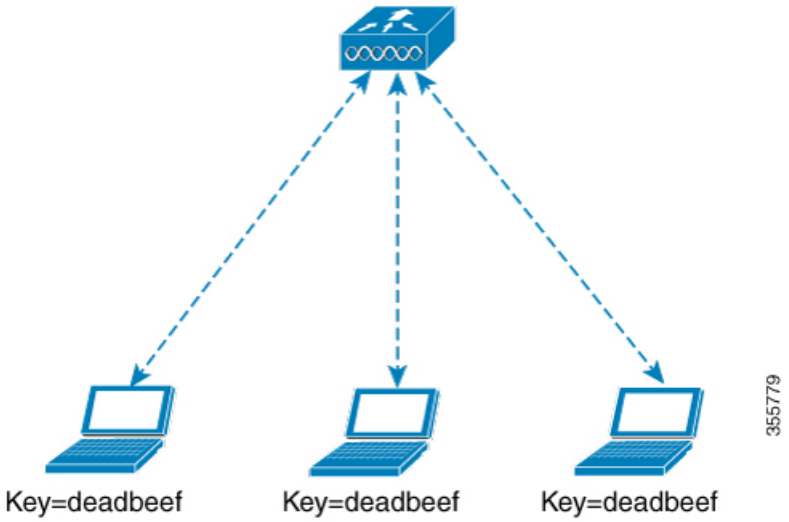
Supporting analogy: keycards to the same door

Having multi-PSk keys for a single SSID is like giving different colored keycards to various teams. Each keycard opens the same door, but you can manage which card goes to which team. This approach increases flexibility and security compared to using one generic key.

Comparing traditional PSK with

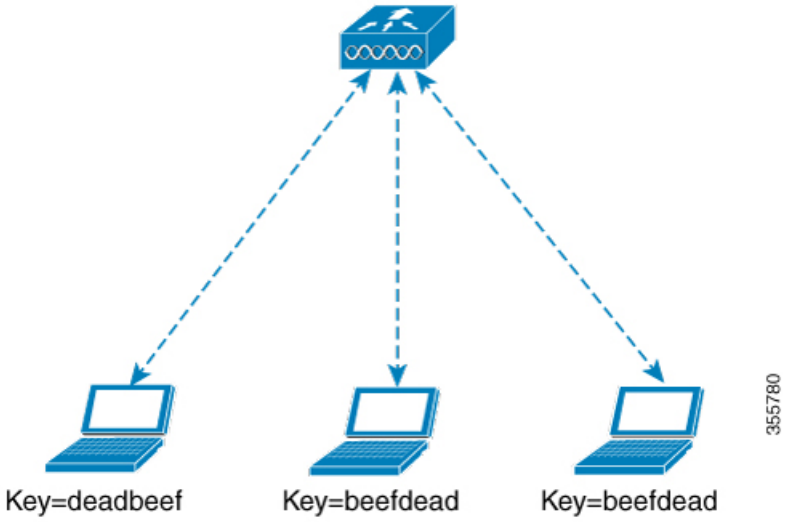
In a traditional PSK, all the clients joining the network use the same password as shown in the figure.

Figure 7: Traditional PSK



But with multi-PSK, client can use any of the configured pre-shared keys to connect to the network as shown in the figure.

Figure 8: Multi-PSK



In the Multi-PSK example, two passwords—deadbeef and beefdead—are configured for the same SSIDIn this scenario, clients can connect to the network using either of the passwords.

Note

-
- Multi-PSK is different from iPSK. In iPSK, the PSK password comes from ISE authorization policy, so MAB is required. Multi-PSK uses a pool of passwords locally configured in WLAN, so Identity Service Engine is not used.

Feature	Traditional PSK	Multi-PSK	Identity PSK (iPSK)
Number of PSKs per SSID	One shared key	Multiple keys (up to five)	Unique key per user or per group
Use case flexibility	All users share one credential	Separate keys for groups or devices	Per-user or per-group credentials for high granularity
Example	All staff share same key	Staff, guests, IoT devices have different keys	Each staff member, contractor, or device gets its own key
Key management	Single change affects all users	Changes can target specific groups or devices	Changes can target specific users or devices; policy-driven from ISE
Security granularity	Lowest — one compromise affects all	Better — compromise isolated to that PSK group	Highest — compromise isolated to individual user or device and fully policy-based

Restrictions

- In central authentication flex mode, the standalone AP allows client join with the highest priority PSK (priority 0 key). New clients that do not use the highest priority PSK are rejected during the standalone mode.
- Multi-PSK does not support local authentication.

Configure a multi-preshared key (GUI)

Configure a WLAN to use a multi-PSK through the controller's GUI.

Before you begin

Know the required security settings such as Wired Equivalent Privacy (WEP), Wi-Fi Protected Access (WPA), PSK, and so on for your WLAN.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 On the **Wireless Networks** page, click the name of the WLAN.

Step 3 In the **Edit WLAN** window, click the **Security** tab.

Step 4 In the **Layer2** tab, choose the **Layer2 Security Mode** from the options:

- None: No Layer 2 security

- 802.1X: WEP 802.1X data encryption type
- WPA + WPA2: Wi-Fi Protected Access
- Static WEP: Static WEP encryption parameters
- Static WEP+802.1X: Both Static WEP and 802.1X parameters

Parameters	Description
802.1X	
WEP Key Size	Choose the key size. The available values are: • None • 40 bits • 104 bits
WPA + WPA2	
Protected Management Frame	Possible values are: • Disabled • Optional • Required
WPA Policy	Check the check box to enable WPA policy.
WPA Encryption	Choose the WPA encryption standard. A WPA encryption standard must be specified if you have enabled WPA policy.
WPA2 Policy	Check the check box to enable WPA2 policy.
WPA2 Encryption	Choose the WPA2 encryption standard. A WPA encryption standard must be specified if you have enabled WPA policy.

Parameters	Description
Auth Key Mgmt	Possible rekeying mechanism options: • 802.1X • FT + 802.1X • PSK: You must specify the PSK format and a preshared key • Cisco Centralized Key Management: You must specify a Cisco Centralized Key Management Timestamp Tolerance value • 802.1X + Cisco Centralized Key Management: You must specify a Cisco Centralized Key Management Timestamp Tolerance value • FT + 802.1X + Cisco Centralized Key Management: You must specify a Cisco Centralized Key Management Timestamp Tolerance value
Static WEP	
Key Size	Possible key size options: • 40 bits • 104 bits
Key Index	Choose a key index from 1 to 4. One unique WEP key index can be applied to each WLAN. As there are only four WEP key indexes, only four WLANs can be configured for static WEP Layer2 encryption.
Key Format	Choose the encryption key format as either ASCII or HEX.
Encryption Key	Enter an encryption key that is 13 characters long.
Static WEP + 802.1X	
Key Size	Possible key size options: • 40 bits • 104 bits
Key Index	Choose a key index from 1 to 4. One unique WEP key index can be applied to each WLAN. As there are only four WEP key indexes, only four WLANs can be configured for static WEP Layer2 encryption.

Parameters	Description
Key Format	Choose the encryption key format as either ASCII or HEX.
Encryption Key	Enter an encryption key that is 13 characters long.
WEP Key Size	Choose from the WEP key sizes: • None • 40 bits • 104 bits

Step 5 Click **Save & Apply to Device**.

The WLAN is updated with the selected multi-PSK security settings.

Configure a multi-preshared key (CLI)

Configure a WLAN to use a multi-PSK through the controller's CLI.

Before you begin

Know the required security settings (WEP, WPA, PSK, and so on.) for your WLAN.

Procedure

	Command or Action	Purpose
Step 1	Enter global configuration mode. **Example:** `Device# configure terminal`	
Step 2	Configure WLAN and SSID. **Example:** `Device(config)# wlan mywlan 1 SSID_name`	
Step 3	Disable security AKM for dot1x. **Example:** `Device(config-wlan)# no security wpa akm dot1x`	
Step 4	Configure PSK. **Example:**	

	Command or Action	Purpose
	`Device(config-wlan)# security wpa akm psk`	
Step 5	Configure multi-PSK. **Example:** `Device(config-wlan)# security wpa wpa2 mpsk`	
Step 6	Configure PSK priority and all its related passwords using the **priority** *priority_value* **set-key** {**ascii** [**0** | **8**] *pre-shared-key* | **hex** [**0** | **8**] *pre-shared-key*} command. **Example:** `Device(config-mpsk)# priority 0 set-key ascii 0 deadbeef`	The *priority_value* ranges from 0 to 4. **Note** You need to configure **priority 0** key for multi-PSK.
Step 7	Enable WLAN. **Example:** `Device(config-mpsk)# no shutdown`	
Step 8	Exit WLAN configuration mode and returns to configuration mode. **Example:** `Device(config-wlan)# exit`	
Step 9	Return to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode. **Example:** `Device(config)# end`	

The WLAN is updated with the selected multi-PSK security settings.

Verify multi-PSK configurations

To verify the configuration of a WLAN and a client, use the following command:

```
Device# show wlan id 8
WLAN Profile Name     : wlan_8
================================================
Identifier                                       : 8
Network Name (SSID)                              : ssid_8
Status                                           : Enabled
```

```
Broadcast SSID                                  : Enabled
Universal AP Admin                              : Disabled
Max Associated Clients per WLAN                 : 0
Max Associated Clients per AP per WLAN          : 0
Max Associated Clients per AP Radio per WLAN    : 200
Number of Active Clients                        : 0
CHD per WLAN                                    : Enabled
Multicast Interface                             : Unconfigured
WMM                                             : Allowed
WifiDirect                                      : Invalid
Channel Scan Defer Priority:
  Priority (default)                            : 5
  Priority (default)                            : 6
Scan Defer Time (msecs)                         : 100
Media Stream Multicast-direct                   : Disabled
CCX - AironetIe Support                         : Enabled
CCX - Diagnostics Channel Capability            : Disabled
Peer-to-Peer Blocking Action                    : Disabled
Radio Policy                                    : All
DTIM period for 802.11a radio                   : 1
DTIM period for 802.11b radio                   : 1
Local EAP Authentication                        : Disabled
Mac Filter Authorization list name              : Disabled
Mac Filter Override Authorization list name     : Disabled
Accounting list name                            :
802.1x authentication list name                 : Disabled
802.1x authorization list name                  : Disabled
Security
    802.11 Authentication                       : Open System
    Static WEP Keys                             : Disabled
    802.1X                                      : Disabled
    Wi-Fi Protected Access (WPA/WPA2/WPA3)      : Enabled
        WPA (SSN IE)                            : Disabled
        WPA2 (RSN IE)                           : Enabled
            MPSK                                : Enabled
            AES Cipher                          : Enabled
            CCMP256 Cipher                      : Disabled
            GCMP128 Cipher                      : Disabled
            GCMP256 Cipher                      : Disabled
        WPA3 (WPA3 IE)                          : Disabled
        Auth Key Management
            802.1x                              : Disabled
            PSK                                 : Enabled
            CCKM                                : Disabled
            FT dot1x                            : Disabled
            FT PSK                              : Disabled
            FT SAE                              : Disabled
            PMF dot1x                           : Disabled
            PMF PSK                             : Disabled
            SAE                                 : Disabled
            OWE                                 : Disabled
            SUITEB-1X                           : Disabled
            SUITEB192-1X                        : Disabled
    CCKM TSF Tolerance                          : 1000
    FT Support                                  : Adaptive
        FT Reassociation Timeout                : 20
        FT Over-The-DS mode                     : Enabled
    PMF Support                                 : Disabled
        PMF Association Comeback Timeout        : 1
        PMF SA Query Time                       : 200
    Web Based Authentication                    : Disabled
    Conditional Web Redirect                    : Disabled
    Splash-Page Web Redirect                    : Disabled
    Webauth On-mac-filter Failure               : Disabled
```

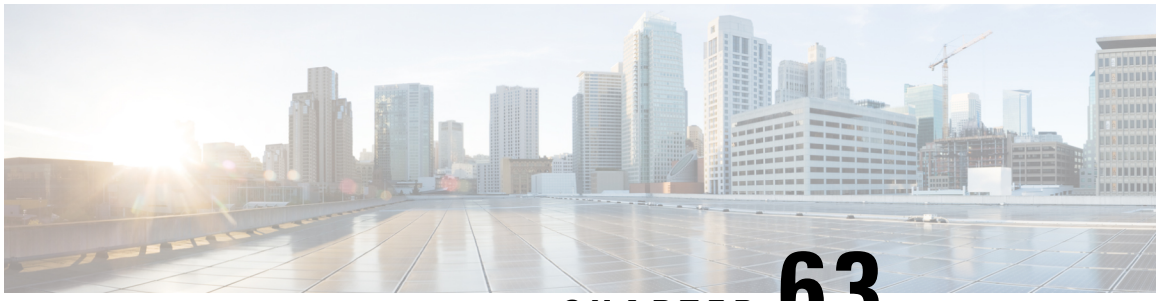
```
    Webauth Authentication List Name           : Disabled
    Webauth Authorization List Name            : Disabled
    Webauth Parameter Map                      : Disabled
    Tkip MIC Countermeasure Hold-down Timer    : 60
Non Cisco WGB                                  : Disabled
Band Select                                    : Enabled
Load Balancing                                 : Disabled
Multicast Buffer                               : Disabled
Multicast Buffer Size                          : 0
IP Source Guard                                : Disabled
Assisted-Roaming
    Neighbor List                              : Disabled
    Prediction List                            : Disabled
    Dual Band Support                          : Disabled
IEEE 802.11v parameters
    Directed Multicast Service                 : Disabled
    BSS Max Idle                               : Disabled
        Protected Mode                         : Disabled
    Traffic Filtering Service                  : Disabled
    BSS Transition                             : Enabled
        Disassociation Imminent                : Disabled
            Optimised Roaming Timer            : 40
            Timer                              : 200
    WNM Sleep Mode                             : Disabled
802.11ac MU-MIMO                               : Disabled
802.11ax paramters
    OFDMA Downlink                             : unknown
    OFDMA Uplink                               : unknown
    MU-MIMO Downlink                           : unknown
    MU-MIMO Uplink                             : unknown
    BSS Color                                  : unknown
    Partial BSS Color                          : unknown
    BSS Color Code                             :
```

To view the WLAN details, use the following command:

```
Device# show run wlan
wlan wlan_8 8 ssid_8
 security wpa psk set-key ascii 0 deadbeef
 no security wpa akm dot1x
 security wpa akm psk
 security wpa wpa2 mpsk
  priority 0 set-key ascii 0 deadbeef
  priority 1 set-key ascii 0 deaddead
  priority 2 set-key ascii 0 d123d123
  priority 3 set-key hex 0 0234567890123456789012345678901234567890123456789012345678901234

  priority 4 set-key hex 0 1234567890123456789012345678901234567890123456789012345678901234

 no shutdown
```



CHAPTER 63

Multiple Authentications for a Client

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- Configure multiple authentications for a client, on page 572
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- Configuring ISE for Central Web Authentication with Dot1x (GUI), on page 586
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Multiple authentications for a client

Multiple authentications for a client is a network security feature that

- enables both Layer 2 (L2) and Layer 3 (L3) authentication for wireless client devices
- enhances security by requiring clients to complete multiple types of authentication before connecting, and
- applies only to regular client devices joining a wireless network.

Additional information

- You can enable both L2 and L3 authentication for a given SSID.
- Multiple authentications feature is not supported for guest or specialized client types.

Supported combination of authentications for a client

The Multiple Authentications for a Client feature supports multiple combination of authentications for a given client configured in the WLAN profile.

The Multiple Authentications for a Client feature supports multiple combinations of authentications for clients configured in the WLAN profile.

The table outlines the supported combinations of authentications for clients.

Layer 2	Layer 3	Supported
MAB	CWA	Yes
MAB Failure	LWA	Yes

802.1X	CWA	Yes
PSK	CWA	Yes
iPSK + MAB	CWA	Yes
iPSK	LWA	No
MAB Failure + PSK	LWA	No Yes
MAB Failure + PSK	CWA	No

Unsupported combinations

The table outlines the combination of authentications on MAC failure that are not supported on a given client:

Authentication Types	Foreign	Anchor	Supported
WPA3-OWE+LWA	Cisco AireOS	Cisco Catalyst 9800 Controller	No
WPA3-SAE+LWA	Cisco AireOS	Cisco Catalyst 9800 Controller	No

Jumbo frame support for RADIUS packets

RADIUS packets are fragmented according to the MTU of the egress interface when you meet all of these conditions.

- The command **ip radius source-interface** is configured under the relevant AAA group server radius group to point to the egress interface.
- The **ip mtu NNN** command is configured on the egress interface.

Note If you set the MTU of the source interface to less than 1500 bytes, additional fragmentation can occur. This may cause packet drops by upstream devices, such as firewalls and load balancers. Authentication failures may result. Verify these configurations during upgrades to prevent these issues.

\

Configure multiple authentications for a client

Configure a WLAN for 802.1X and LWA

Set up a WLAN to enforce strong user authentication with 802.1X and provide local web authentication using the controller interface.

Perform this task when you want to secure WLAN user access with 802.1X credentials and enable local web authentication for guest or additional user workflows.

Before you begin

Confirm that WLAN profiles and the necessary authentication lists are already created or available.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Select the required WLAN from the list of WLANs displayed.

Step 3 Choose **Security** > **Layer2** tab.

Step 4 Select the security method from the **Layer 2 Security Mode** drop-down list.

Step 5 In the **Auth Key Mgmt**, check the **802.1x** check box.

Step 6 Check the **MAC Filtering** check box to enable the feature.

Step 7 After MAC Filtering is enabled, from the **Authorization List** drop-down list, choose an option.

Step 8 Choose **Security** > **Layer3** tab.

Step 9 Check the **Web Policy** check box to enable the web authentication policy.

Step 10 From the **Web Auth Parameter Map** and the **Authentication List** drop-down lists, choose an option.

Step 11 Click **Update & Apply to Device**.

The WLAN is now configured to use both 802.1X authentication and local web authentication policies.

Configure a WLAN for 802.1X and LWA (CLI)

Set up a WLAN to enforce strong user authentication with 802.1X and provide local web authentication using the controller interface.

Perform this task when you want to secure WLAN user access with 802.1X credentials and enable local web authentication for guest or additional user workflows.

Before you begin

Confirm that WLAN profiles and the necessary authentication lists are already created or available.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN.

Example:

```
Device(config)# wlan wlan-name wland-id SSID-name
```

- **wlan-name** is the name of the configured WLAN.
- **wlan-id** is the WLAN identifier. The range is one to 512.
- **SSID-name** is the SSID name which can have up to 32 alphanumeric characters.

If you have already created and configured the WLAN, use the **wlan** *wlan-name* command.

Step 3 Enable security authentication list for dot1x security.

Example:

```
Device(config-wlan)# security dot1x authentication-list auth-list-name
```

The configuration is similar for all dot1x security WLANs.

Step 4 Enable web authentication.

Example:

```
Device(config-wlan)# security web-auth
```

Step 5 Enable authentication list for dot1x security.

Example:

```
Device(config-wlan)# security web-auth authentication-list default authenticate-list-name
```

Step 6 Map the parameter map name.

Example:

```
Device(config-wlan)# security web-auth parameter-map parameter-map-name
```

If a parameter map is not associated with a WLAN, the configuration is considered from the global parameter map.

Step 7 Enable the WLAN.

Example:

```
Device(config-wlan)# no shutdown
```

The WLAN is now configured to use both 802.1X authentication and local web authentication policies.

Configure WLAN for Preshared Key (PSK) and LWA (GUI)

Set up a WLAN to use both Preshared Key (PSK) and local web authentication via the graphical user interface.

Use this procedure when you want to enforce both PSK and local web authentication for user access to your wireless network.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Select the required WLAN.

Step 3 Choose **Security** > **Layer2** tab.

Step 4 Select the security method from the **Layer 2 Security Mode** drop-down list.

Step 5 In the Auth Key Mgmt, uncheck the **802.1x** check box.

Step 6 Check the **PSK** check box.

Step 7 Enter the **Pre-Shared Key**. Next, choose the PSK Format from the **PSK Format** drop-down list. Then, choose the PSK Type from the **PSK Type** drop-down list.

Step 8 Choose **Security** > **Layer3** tab.

Step 9 Check the **Web Policy** checkbox to enable web authentication policy.

Step 10 Choose the Web Auth Parameter Map from the **Web Auth Parameter Map** drop-down list. Then, choose the authentication list from the **Authentication List** drop-down list.

Step 11 Click **Update & Apply to Device**.

The selected WLAN now enforces both PSK and local web authentication settings

Configure WLAN for Preshared Key (PSK) and LWA (CLI)

Set up a WLAN to use both Preshared Key (PSK) and local web authentication.

Use this procedure when you want to enforce both PSK and local web authentication for user access to your wireless network.

Procedure

	Command or Action	Purpose
Step 1	Enter global configuration mode. **Example:** `Device# configure terminal`	
Step 2	Configure the WLAN. **Example:** `Device(config)# wlan wlan-name wland-id SSID-name`	• **wlan-name** is the name of the configured WLAN. • **wlan-id** is the WLAN identifier. The range is one to 512. • **SSID-name** is the SSID name which can have up to 32 alphanumeric characters. If you have already created and configured the WLAN, use the **wlan** *wlan-name* command.
Step 3	Configure the PSK shared key using the **security wpa psk set-key** *ascii/hex key password* command. **Example:**	

	Command or Action	Purpose
	`Device(config-wlan)# security wpa psk set-key ascii 0 PASSWORD`	
Step 4	Disable security AKM for dot1x. **Example:** `Device(config-wlan)# no security wpa akm dot1x`	
Step 5	Configure the PSK support. **Example:** `Device(config-wlan)# security wpa akm psk`	
Step 6	Enable web authentication for WLAN. **Example:** `Device(config-wlan)# security web-auth`	
Step 7	Enable authentication list for dot1x security. **Example:** `Device(config-wlan)# security web-auth authentication-list authenticate-list-name`	
Step 8	Configure the parameter map. **Example:** `(config-wlan)# security web-auth parameter-map parameter-map-name`	If parameter map is not associated with a WLAN, the configuration is considered from the global parameter map.

The selected WLAN now enforces both PSK and local web authentication settings.

Configure WLAN for PSK or iPSK and CWA

Configure WLAN for PSK or iPSK and CWA (GUI)

Configure a WLAN to use either a Pre-Shared Key (PSK) or Identity Pre-Shared Key (iPSK) for authentication, and enable central web authentication for enhanced wireless security.

Use this task to set up secure WLAN access for users and devices, combining key-based authentication with web-based login, using your wireless controller's GUI.

Before you begin

Gather required PSK or iPSK values and authentication lists, as needed.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Select the required WLAN.

Step 3 Choose **Security** > **Layer2** tab.

Step 4 Select the security method from the **Layer 2 Security Mode** drop-down list.

Step 5 In the **Auth Key Mgmt**, uncheck the **802.1x** check box.

Step 6 Check the **PSK** check box.

Step 7 Enter the **Pre-Shared Key**. Then, choose the PSK Format from the **PSK Format** drop-down list and the PSK Type from the **PSK Type** drop-down list.

Step 8 Check the **MAC Filtering** check box to enable the feature.

Step 9 With MAC Filtering enabled, choose the Authorization List from the **Authorization List** drop-down list.

Step 10 Choose **Security** > **Layer3** tab.

Step 11 Check the **Web Policy** checkbox to enable web authentication policy.

Step 12 Choose the Web Auth Parameter Map from the **Web Auth Parameter Map** drop-down list and the authentication list from the **Authentication List** drop-down list.

Step 13 Click **Update &Apply to Device**.

The WLAN is now updated to use PSK or iPSK authentication and central web authentication, combining key-based access with web-based login for network users.

Configure WLAN for PSK or iPSK and CWA (CLI)

Configure a WLAN to use either a Pre-Shared Key (PSK) or Identity Pre-Shared Key (iPSK) for authentication, and enable central web authentication for enhanced wireless security.

Use this task to set up secure WLAN access for users and devices, combining key-based authentication with web-based login, using your wireless controller's CLI.

Before you begin

Gather required PSK or iPSK values and authentication lists, as needed.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN.

Example:

```
Device(config)# wlan wlan-name wland-id SSID-name
```

- **wlan-name** is the name of the configured WLAN.
- **wlan-id** is the WLAN identifier. The range is one to 512.
- **SSID-name** is the SSID name which can have up to 32 alphanumeric characters.

If you have already created and configured the WLAN, use the **wlan** *wlan-name* command.

Step 3 Disable security AKM for dot1x.

Example:

```
Device(config-wlan)# no security wpa akm dot1x
```

Step 4 Configure the PSK AKM shared key using the **security wpa psk set-key** *ascii/hex key password* command.

Example:

```
Device(config-wlan)# security wpa psk set-key ascii 0 PASSWORD
```

Step 5 Set the MAC filtering parameters.

Example:

```
Device(config-wlan)# mac-filtering auth-list-name
```

The WLAN is now updated to use PSK or iPSK authentication and central web authentication, combining key-based access with web-based login for network users.

Apply a policy profile to a WLAN

Configure and activate a policy profile for a WLAN using CLI.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the default policy profile.

Example:

```
Device(config)# wireless profile policy policy-iot policy-profile-name
```

Step 3 Configure AAA override to apply policies coming from the AAA or ISE servers.

Example:

```
Device(config-wireless-policy)# aaa-override
```

Step 4 Configure NAC in the policy profile.

Example:

```
Device(config-wireless-policy)# nac
```

Step 5 Shutdown the WLAN.

Example:

```
Device(config-wireless-policy)# no shutdown
```

Step 6 Return to privileged EXEC mode.

Example:

```
Device(config-wireless-policy)# end
```

The policy profile is applied to the WLAN and operational.

Configuring 802.1x and CWA on controller (CLIs)

Configure AAA authentication

Set up authentication, authorization, and accounting (AAA) on your device.

Decide which authentication methods and servers you want to use if you plan to configure additional settings.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create an AAA authentication model.

Example:

```
Device(config)# aaa new-model
```

AAA authentication is now enabled on the controller. Configure specific authentication methods as needed.

Configure AAA server for external authentication

Configure an AAA server to enable external authentication using a RADIUS server.

Use this process to allow external authentication for network devices through a specified RADIUS server.

Before you begin

- Obtain the RADIUS server IP address, key, and server name.
- Confirm network connectivity between the device and the RADIUS server.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a call station identifier sent in the RADIUS authentication messages.

Example:

```
Device(config)# radius-server attribute wireless authentication call-station-id ap-name-ssid
```

Step 3 Set the RADIUS server.

Example:

```
Device(config)# radius server server-name
```

Step 4 Specify the RADIUS server address.

Example:

```
Device(config-radius-server)# address ipv4 radius-server-ip-address
```

Step 5 Specify the time-out value in seconds.

Example:

```
Device(config-radius-server)# timeout time-in-seconds
```

The range is between 10 and 1000 seconds.

Step 6 Specify the number of retries to the server.

Example:

```
Device(config-radius-server)# retransmit number-of-retries
```

The range is between zero and 100.

Step 7 Specify the authentication and encryption key used between the device and the key string RADIUS daemon running on the RADIUS server.

Example:

```
Device(config-radius-server)# key key-
```

key-name can assume these values:

- 0—Specifies unencrypted key.
- 6—Specifies encrypted key.
- 7—Specifies HIDDEN key.
- Word—Unencrypted (cleartext) server key.

Step 8 Return to the configuration mode.

Example:

```
Device(config-radius-server)# exit
```

Step 9 Create a RADIUS server group identification.

Example:

```
Device(config)# aaa group server radius server-group
```

Step 10 Configure the server name.

Example:

```
Device(config)# server name server-name
```

Step 11 Define the time in minutes when a server marked as DEAD is held in that state

Example:

```
Device(config)# radius-server deadtime time-in-mins
```

Once the deadtime expires, the controller marks the server as UP (ALIVE) and notifies the registered clients about the state change. If the server is still unreachable after the state is marked as UP and if the DEAD criteria is met, then server is marked as DEAD again for the deadtime interval.

time-in-mins—Valid values range from one to 1440 minutes. Default value is zero. To return to the default value, use the **no radius-server deadtime** command.

The **radius-server deadtime** command can be configured globally or per aaa group server level.

You can use the **show aaa dead-criteria** or **show aaa servers** command to check for dead-server detection. If the default value is zero, deadtime is not configured.

The AAA server is configured for external authentication using the specified RADIUS server settings.

Configure AAA for authentication

Specify authentication methods for user logins and network access.

Use this task to define how the device authenticates users when accessing the CLI or network services. This process ensures that only authorized individuals can log in.

Before you begin

Ensure you have defined the necessary AAA server groups (for example, ISE2).

Procedure

	Command or Action	Purpose
Step 1	Define the authentication method at login. **Example:** `Device# aaa authentication login ISE_GROUP group ISE2 local`	Defines the authentication method at login.
Step 2	Define the authentication method at 802.1X. **Example:** `Device(config)# aaa authentication network ISE_GROUP group ISE2 local`	

The device now uses the authentication methods you specified for login and network access. This enforces AAA policies and improves security

Configure an accounting identity list

Enable accounting for user sessions on your device. This allows you to track when users are authorized and when their sessions end.

Use this configuration to send accounting records to a RADIUS server for identity management. This process also supports auditing and compliance.

Before you begin

Ensure the RADIUS server and AAA group server are configured.

Procedure

Enable accounting so that a start record accounting notice is sent when a client is authorized, and a stop record notice is sent when the session ends.

Example:

```
Device# aaa accounting identity ISE-named-list start-stop group ISE-server-group-name
```

Note
You can use the default list instead of specifying a named list.

The device sends accounting records to the specified RADIUS server when a user's session is authorized and when the session ends.

Configure AAA for CWA

Enable Change of Authorization (CoA) for RADIUS authentication on the controller for Central Web Authentication (CWA).

Before you begin

Ensure the RADIUS server and AAA group server are configured.

Procedure

Step 1 Configures the CoA on the controller.

Example:

```
Device# aaa server radius dynamic-author
```

Step 2 Configure a server key for a RADIUS client.

Example:

```
Device(config-locsvr-da-radius)# client client-ip-addr server-key key
```

After completing these steps, the controller uses dynamic CoA for Central Web Authentication. RADIUS clients can trigger authorization changes.

Define an ACL for RADIUS server

Create an access control list (ACL) to restrict and control traffic flow to and from the RADIUS server. Only authorized access is allowed, and authentication redirection is enforced.

Configure an extended access control list to work with Cisco Identity Services Engine (ISE) to redirect unauthenticated web traffic. Explicitly deny or permit specific protocols and sources.

Before you begin

Identify the IP addresses of your Cisco ISE, DHCP, and DNS servers.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the redirect ACL.

Example:

```
Device(config)# ip access-list extended redirect
```

HTTP and HTTPS browsing does not work without authentication per the other ACL. ISE is configured to use a redirect ACL named **redirect**.

Step 3 Specify packets to reject according to the sequence number

Example:

```
Device(config-ext-nacl)# sequence-number deny icmp any
```

.

Note
You must have the DHCP, DNS, and ISE servers in the reject sequences. See Configuration Example to Define an Access Control List for Radius Server, wherein the *111.111.111.111* refers to the IP address of the ISE server.

Step 4 Redirect all HTTP or HTTPS access to the Cisco ISE login page.

Example:

```
Device(config-ext-nacl)# permit TCP any any eq web-address
```

The ACL restricts access as specified by your deny rules and directs unauthenticated HTTP or HTTPS traffic to the Cisco ISE login page.

Example: Define an ACL for RADIUS server

This example shows how to define an access control list for RADIUS server:

```
Device# configure terminal
Device(config-ext-nacl) # 10 deny icmp any
Device(config-ext-nacl) # 20 deny udp any any eq bootps
Device(config-ext-nacl) # 30 deny udp any any eq bootpc
Device(config-ext-nacl) # 40 deny udp any any eq domain
Device(config-ext-nacl) # 50 deny tcp any host 111.111.111.111 eq 8443
Device(config-ext-nacl) # 55 deny tcp host 111.111.111.111 eq 8443 any
Device(config-ext-nacl) # 40 deny udp any any eq domain
Device(config-ext-nacl) # end
```

Configure WLAN with 802.1X authentication

Set up a WLAN with 802.1X authentication using CLI commands.

Perform this task to enable secure wireless access via a controller supporting 802.1X authentication.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enter WLAN configuration mode.

Example:

```
Device(config)# wlan wlan-name
```

Step 3 Configure 802.1X for a WLAN.

Example:

```
Device(config-wlan)# security dot1x authentication-list ISE_GROUP
```

Step 4 Enable the WLAN.

Example:

```
Device(config-wlan)# no shutdown
```

You have configured and enabled your WLAN with 802.1X authentication.

Configure policy profile

Configure a wireless policy profile supporting AAA, DHCP, NAC, and VLAN, then enable it for use on your network.

Use this task to define policy settings applied to wireless clients, including authentication, DHCP handling, network access control, and VLAN assignment. These settings help enforce security and operational requirements for WLAN deployments.

Before you begin

Know the desired profile name, accounting list name, and VLAN ID.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the policy profile.

Example:

```
Device(config)# wireless profile policy profile-name
```

Step 3 Configure AAA override to apply policies coming from the AAA or Cisco Identify Services Engine (ISE) server.

Example:

```
Device(config-wireless-policy)# aaa-override
```

Step 4 Set the accounting list for IEEE 802.1x.

Example:

```
Device(config-wireless-policy)# accounting-list list-name
```

Step 5 Configure DHCP parameters for WLAN.

Example:

```
Device(config-wireless-policy)# ipv4 dhcp required
```

Step 6 Configure Network Access Control (NAC) in the policy profile. NAC is used to trigger the Central Web Authentication (CWA).

Example:

```
Device(config-wireless-policy)# nac
```

Step 7 Configure guest VLAN profile.

Example:

```
Device(config-wireless-policy)# vlan 25
```

Step 8 Enable policy profile.

Example:

```
Device(config-wireless-policy)# no shutdown
```

The wireless policy profile is configured with specified authentication, access control, DHCP, and VLAN parameters, and is enabled for use

Map a WLAN and policy profile to a policy tag

Assign a policy profile to a WLAN and link both to a policy tag, enabling dynamic assignment of policies to wireless networks.

Use this task when you need to organize WLAN and policy profiles under a single policy tag on your wireless controller using CLI commands.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure policy tag and enters policy tag configuration mode.

Example:

```
Device(config-policy-tag)# wireless tag policy policy-tag-name
```

Step 3 Map a policy profile to a WLAN profile.

Example:

```
Device(config-policy-tag)# wlan wlan-name policy profile-policy-name
```

Step 4 Save the configuration and exits the configuration mode and returns to privileged EXEC mode.

Example:

```
Device(config-policy-tag)# end
```

The WLAN and policy profile are now associated with the selected policy tag, and the configuration is applied to the device.

Configuring ISE for Central Web Authentication with Dot1x (GUI)

Define guest portal

Configure or select a guest portal for visitor access in Cisco Identity Services Engine (ISE).

Before you begin

Decide whether to create a new guest portal or use the default guest portal.

Procedure

Step 1 Login to the Cisco Identity Services Engine (ISE).

Step 2 Choose **Work Centers** > **Guest Access** > **Portals & Components**.

Step 3 Click **Guest Portal**.

The Guest Portal page opens, allowing you to configure the portal settings or use the default configuration for guest access.

Define authorization profile for a client

Configure an authorization profile in Cisco Identity Services Engine (ISE) to manage client redirection, guest portal access, and network authorization parameters.

Authorization profiles in Cisco ISE control how clients are redirected, such as directing guests to authentication portals. They also set parameters that manage client access to the network. You can create a custom profile or modify the default Cisco_Webauth result to suit your configuration needs.

Before you begin

Identify the requirements for client access, including portal settings and access control lists (ACLs).

Procedure

Step 1 Log in to the Cisco Identity Services Engine (ISE).

Step 2 Choose **Policy** > **Policy Elements** > **Authorization** > **Authorization Profiles**.

Step 3 Click **Add** to create your own custom or edit the Cisco_Webauth default result.

The authorization profile is configured in Cisco ISE, allowing targeted redirection and access control for clients according to your specified parameters.

Define an authentication rule

Create an authentication rule in Cisco Identity Services Engine (ISE) to specify user identification conditions within a policy set.

Use this task when you need to manage network access authentication criteria in your ISE deployment.

Procedure

Step 1 Login to the Cisco Identity Services Engine (ISE).

Step 2 Choose **Policy** > **Policy Sets** and click on the appropriate policy set.

Step 3 Expand **Authentication** policy.

Step 4 Expand **Options** and choose an appropriate **User ID**.

The authentication rule is configured for the selected policy set, allowing for defined user identification during authentication.

Define an authorization rule

Create an authorization rule to control access for users authenticating via 802.1x with a specific SSID in Cisco ISE.

Use this procedure to specify matching conditions and assign an authorization profile in Identity Services Engine (ISE).

Procedure

Step 1 Log in to the Cisco Identity Services Engine (ISE).

Step 2 Choose **Policy** > **Policy Sets** > **Authorization Policy**.

Step 3 Create a rule that matches the condition for 802.1x with a specific SSID (using Radius-Called-Station-ID).

Note
You get to view the CWA redirect attribute.

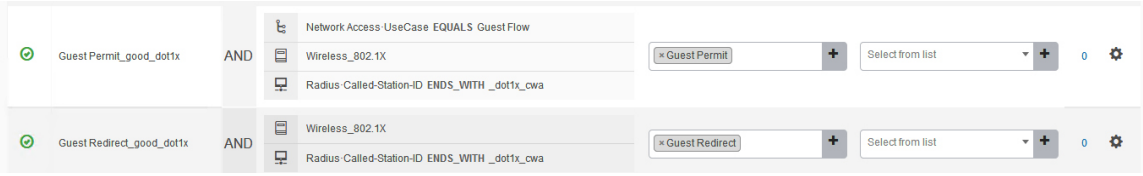
Step 4 Choose the already created authorization profile.

Step 5 From the **Result/Profile** column, choose the already created authorization profile.

Step 6 Click **Save**.

The image shows a sample working configuration.

Figure 9: Working Configuration Sample



The new authorization rule is now active and governs access based on the specified condition.

Create rules to match guest flow conditions

Before you begin

You must create a second rule that matches the guest flow condition and returns to network access details once the user completes authentication in the portal.

Configure Cisco ISE to grant network access to guest users after successful portal authentication.

Use this procedure to automatically apply the correct network access policies for guest users who connect to a specific SSID via 802.1X authentication.

Procedure

Step 1 Log in to the Cisco Identity Services Engine (ISE).

Step 2 Choose **Policy** > **Policy Sets** > **Authorization Policy**.

Step 3 Create a rule for 802.1X so Network Access-UseCase is Guest and a specific SSID is matched using RADIUS Called-Station-ID.

Note
You get to view the Permit Access.

Step 4 From the **Result/Profile** column, choose an existing authorization profile.

Step 5 Choose either the default or custom Permit Access profile.

Step 6 Click **Save**.

After successful authentication in the portal, guest users receive network access. The configured authorization profile is applied automatically.

Verify multiple authentication configurations

Layer 2 authentication

After L2 authentication (Dot1x) is complete, the client is moved to state.

To verify the client state after L2 authentication, use these commands:

```
Device# show wireless client summary
Number of Local Clients: 1
MAC Address  AP Name  WLAN  State  Protocol  Method  Role
-------------------------------------------------------------------------------------------------------------

58ef.68b6.aa60 ewlc1_ap_1   3  Webauth Pending    11n(5)        Dot1x  Local
Number of Excluded Clients: 0

Device# show wireless client mac-address <mac_address> detail

Auth Method Status List

Method: Dot1x
Webauth State: Init
Webauth Method: Webauth
Local Policies:
Service Template: IP-Adm-V6-Int-ACL-global (priority 100)
URL Redirect ACL: IP-Adm-V6-Int-ACL-global
Service Template: IP-Adm-V4-Int-ACL-global (priority 100)
URL Redirect ACL: IP-Adm-V4-Int-ACL-global
Service Template: wlan_svc_default-policy-profile_local (priority 254)
Absolute-Timer: 1800
VLAN: 50

Device# show platform software wireless-client chassis active R0

        ID  MAC Address      WLAN  Client     State
-----------------------------------------------------------------------------------------
  0xa0000003      58ef.68b6.aa60    3             L3          Authentication

Device# show platform software wireless-client chassis active F0

    ID     MAC Address   WLAN  Client     State  AOM ID    Status
-----------------------------------------------------------------------------------------------------
```

```
0xa0000003    58ef.68b6.aa60    3           L3          Authentication.         730.
Done
```

```
Device# show platform hardware chassis active qfp feature wireless wlclient cpp-client
summary

Client Type Abbreviations:
RG - REGULAR   BLE - BLE
HL - HALO    LI - LWFL INT

Auth State Abbrevations:
UK - UNKNOWN    IP - LEARN    IP IV - INVALID
L3 - L3 AUTH RN - RUN

Mobility State Abbreviations:
UK - UNKNOWN       IN - INIT
LC - LOCAL               AN - ANCHOR
FR - FOREIGN          MT - MTE
IV - INVALID


EoGRE Abbreviations:
N - NON EOGRE Y - EOGRE

CPP IF_H   DP IDX       MAC Address      VLAN   CT   MCVL AS MS E   WLAN      POA
------------------------------------------------------------------------------------
0X49     0XA0000003    58ef.68b6.aa60     50    RG     0  L3 LC N wlan-test 0x90000003
```

```
Device# show platform hardware chassis active qfp feature wireless wlclient datapath summary
Vlan   DP IDX         MAC Address      VLAN   CT   MCVL AS MS E   WLAN      POA
------------------------------------------------------------------------------------
0X49   0xa0000003    58ef.68b6.aa60     50    RG     0  L3 LC N wlan-test 0x90000003
```

Layer 3 Authentication

Once L3 authentication is successful, the client is moved to *Run* state.

To verify the client state after L3 authentication, use these commands:

```
Device# show wireless client summary

Number of Local Clients: 1
MAC Address  AP Name  WLAN  State  Protocol  Method  Role
---------------------------------------------------------------------------------------------------------

58ef.68b6.aa60   ewlc1_ap_1  3     Run    11n(5)   Web Auth      Local
Number of Excluded Clients: 0
```

```
Device# show wireless client mac-address 58ef.68b6.aa60 detail

Auth Method Status List

Method: Web Auth
Webauth State: Authz
Webauth Method: Webauth
Local Policies:
Service Template: wlan_svc_default-policy-profile_local (priority 254)
Absolute-Timer: 1800
VLAN: 50

Server Policies:

Resultant Policies:
VLAN: 50
Absolute-Timer: 1800
```

```
Device# show platform software wireless-client chassis active R0

ID          MAC Address     WLAN    Client State
-----------------------------------------------
0xa0000001 58ef.68b6.aa60    3          Run

Device# show platform software wireless-client chassis active f0

ID         MAC Address       WLAN    Client State   AOM ID.  Status
-------------------------------------------------------------------
0xa0000001 58ef.68b6.aa60.   3          Run         11633    Done

Device# show platform hardware chassis active qfp feature wireless wlclient cpp-client
summary

Client Type Abbreviations:
RG - REGULAR   BLE - BLE
HL - HALO      LI - LWFL INT

Auth State Abbrevations:
UK - UNKNOWN    IP - LEARN    IP IV - INVALID
L3 - L3 AUTH RN - RUN
Mobility State Abbreviations:
UK - UNKNOWN       IN - INIT
LC - LOCAL         AN - ANCHOR
FR - FOREIGN       MT - MTE
IV - INVALID
EoGRE Abbreviations:
N - NON EOGRE Y - EOGRE

CPP IF_H   DP IDX       MAC Address   VLAN  CT  MCVL AS MS E   WLAN     POA
-------------------------------------------------------------------------------
0X49     0XA0000003    58ef.68b6.aa60  50   RG   0   RN LC N wlan-test 0x90000003

Device# show platform hardware chassis active qfp feature wireless wlclient datapath summary

Vlan   pal_if_hd1        mac           Input Uidb     Output Uidb
-----------------------------------------------------------------
50     0xa0000003    58ef.68b6.aa60     95929            95927
```

Verifying PSK+Webauth Configuration

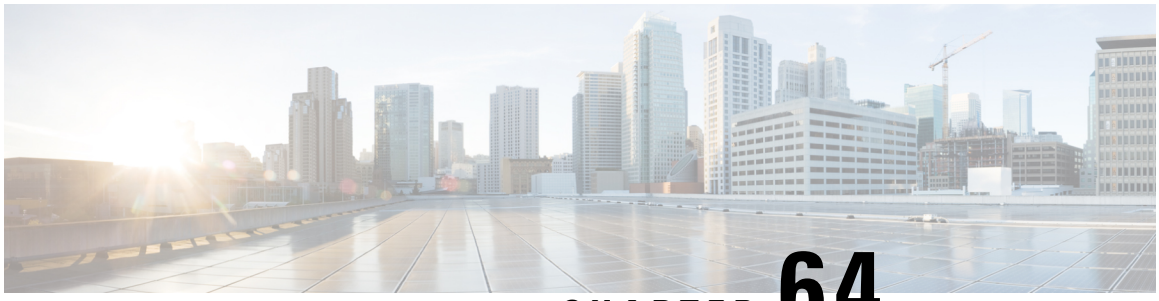
```
Device# show wlan summary

Load for five secs: 0%/0%; one minute: 0%; five minutes: 0%
Time source is NTP, 12:08:32.941 CEST Tue Oct 6 2020


Number of WLANs: 1

ID Profile Name SSID Status Security
-----------------------------------------------------------------------------------------------------------------

23 Gladius1-PSKWEBAUTH Gladius1-PSKWEBAUTH UP [WPA2][PSK][AES],[Web Auth]
```



CHAPTER 64

Support for Hash-to-Element for Password Element in SAE Authentication

- Hash-to-Element (H2E), on page 593
- YANG (RPC model), on page 594
- Configure WPA3 SAE H2E (CLI), on page 594
- Verify WPA3 SAE H2E support in WLAN, on page 596

Hash-to-Element (H2E)

An SAE password element method is a cryptographic procedure that

- Derives the secret password element (PWE) in the Simultaneous Authentication of Equals (SAE) protocol
- Transforms a password into a secure intermediary element for authentication, and
- Provides protection against security threats such as group downgrade attacks.

Hash-to-Element is a new SAE Password Element (PWE) calculation method for wireless security protocols.

- **Hash-to-Element (H2E)**: Hash-to-Element is a SAE password element method that derives the PWE directly from a password using a hashing process. When a station (STA) supporting H2E initiates SAE with an AP, it checks if the AP supports H2E. If supported, the AP uses the H2E method to generate the PWE, as indicated by a new Status Code in the SAE Commit message.

PWE derivation steps in H2E

When using the H2E method, PWE derivation consists of two steps:

1. Creation of secret intermediary element (PT): The secret intermediary element (PT) is derived offline from the password when it is initially configured for each supported group.
2. Derivation of the PWE: The PWE is generated in real-time from the stored PT during the SAE exchange, using the negotiated group and the Media Access Control (MAC) addresses of both peers.

Additional reference information

- If a device uses the older Hunting-and-Pecking method, the overall SAE exchange remains unchanged.

- The H2E method protects against man-in-the-middle attacks, including Group Downgrade attacks. During authentication, peers exchange lists of rejected groups as part of PMK derivation. If there is a mismatch, the system terminates authentication to prevent a downgrade attack.

- In a typical SAE exchange on a 6 GHz network, only the H2E method is used for password element generation.
- A station using H2E checks AP support, and if supported, uses H2E for secure and efficient authentication.

YANG (RPC model)

To create an RPC for SAE Password Element (PWE) mode, use this RPC model:

```
<nc:rpc xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
message-id="urn:uuid:0a77124f-c563-469d-bd21-cc625a9691cc">
<nc:edit-config>
<nc:target>
<nc:running/>
</nc:target>
<nc:config>
<wlan-cfg-data xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-wireless-wlan-cfg">
<wlan-cfg-entries>
<wlan-cfg-entry>
<profile-name>test</profile-name>
<wlan-id>2</wlan-id>
<sae-pwe-mode>both-h2e-hnp</sae-pwe-mode>
</wlan-cfg-entry>
</wlan-cfg-entries>
</wlan-cfg-data>
</nc:config>
</nc:edit-config>
</nc:rpc>
```

Note The **delete** operation performs one action at a time due to the current infra limitation. That is, in YANG module, the **delete** operation on multiple nodes are not supported.

Configure WPA3 SAE H2E (CLI)

Enable WPA3 SAE Hash-to-Element (H2E) for secure WLAN connectivity.

Use this task to configure WPA3 SAE H2E for a WLAN on a device running Cisco IOS-XE.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enter the WLAN configuration sub-mode.

Example:

```
Device(config)# wlan wlan-name wlan-id SSID-name
```

Example:

```
Device(config)# wlan WPA3 1 WPA3
```

Step 3 Disable security AKM for 802/1X.

Example:

```
Device(config-wlan)# no security wpa akm dot1x
```

Step 4 Disable fast transition over the data source on the WLAN.

Example:

```
Device(config-wlan)# no security ft over-the-ds
```

Step 5 Disable 802.11r fast transition on the WLAN.

Example:

```
Device(config-wlan)# no security ft
```

Step 6 Disable WPA2 security. PMF is disabled now.

Example:

```
Device(config-wlan)# no security wpa wpa2
```

Step 7 Configure WPA2 cipher.

Example:

```
Device(config-wlan)# security wpa wpa2 ciphers aes
```

Note
You can check whether cipher is configured using **no security wpa wpa2 ciphers aes** command. If cipher is not reset, configure the cipher.

Step 8 Specify a preshared key

Example:

```
Device(config-wlan)# security wpa psk set-key ascii value preshared-key
```

Example:

```
Device(config-wlan)# security wpa psk set-key ascii 0 Cisco123
```

Step 9 Enable WPA3 support.

Example:

```
Device(config-wlan)# security wpa wpa3
```

Step 10 Enable AKM SAE support.

Example:

```
Device(config-wlan)# security wpa akm sae
```

Step 11 Enable AKM SAE PWE support using the **security wpa akm sae pwe** {**h2e** | **hnp** | **both-h2e-hnp**} command.

Example:

```
Device(config-wlan)# security wpa akm sae pwe
```

PWE supports these options:

- h2e: Hash-to-Element only; disables HnP.
- hnp: Hunting and Pecking only; disables H2E.
- Both-h2e-hnp: Both Hash-to-Element and Hunting and Pecking support (Is the default option).

Step 12 Enable the WLAN.

Example:

```
Device(config-wlan)# no shutdown
```

Step 13 Return to the privileged EXEC mode.

Example:

```
Device(config-wlan)# end
```

WPA3 SAE H2E is enabled for the specified WLAN. Wireless clients can now connect securely using WPA3 SAE H2E.

Verify WPA3 SAE H2E support in WLAN

To view the WLAN properties (PWE method) based on the WLAN ID, use this command:

```
Device# show wlan id 1
WLAN Profile Name     : wpa3
================================================
Identifier                                : 1
Description                               :
Network Name (SSID)                       : wpa3
Status                                    : Enabled
Broadcast SSID                            : Enabled
Advertise-Apname                          : Disabled
Universal AP Admin                        : Disabled
Max Associated Clients per WLAN           : 0
Max Associated Clients per AP per WLAN    : 0
Max Associated Clients per AP Radio per WLAN   : 200
OKC                                       : Enabled
Number of Active Clients                  : 0
CHD per WLAN                              : Enabled
WMM                                       : Allowed
WiFi Direct Policy                        : Disabled
Channel Scan Defer Priority:
  Priority (default)                      : 5
  Priority (default)                      : 6
Scan Defer Time (msecs)                   : 100
Media Stream Multicast-direct             : Disabled
CCX - AironetIe Support                   : Disabled
Peer-to-Peer Blocking Action              : Disabled
DTIM period for 802.11a radio             : 1
DTIM period for 802.11b radio             : 1
```

```
Local EAP Authentication                        : Disabled
Mac Filter Authorization list name              : Disabled
Mac Filter Override Authorization list name     : Disabled
Accounting list name                            :
802.1x authentication list name                 : Disabled
802.1x authorization list name                  : Disabled
Security
    802.11 Authentication                       : Open System
    Static WEP Keys                             : Disabled
    Wi-Fi Protected Access (WPA/WPA2/WPA3)      : Enabled
        WPA (SSN IE)                            : Disabled
        WPA2 (RSN IE)                           : Disabled
        WPA3 (WPA3 IE)                          : Enabled
            AES Cipher                          : Enabled
            CCMP256 Cipher                      : Disabled
            GCMP128 Cipher                      : Disabled
            GCMP256 Cipher                      : Disabled
        Auth Key Management
            802.1x                              : Disabled
            PSK                                 : Disabled
            CCKM                                : Disabled
            FT dot1x                            : Disabled
            FT PSK                              : Disabled
            Dot1x-SHA256                        : Disabled
            PSK-SHA256                          : Disabled
            SAE                                 : Enabled
            OWE                                 : Disabled
            SUITEB-1X                           : Disabled
            SUITEB192-1X                        : Disabled
    SAE PWE Method                              : Hash to Element(H2E)
    Transition Disable                          : Disabled
    CCKM TSF Tolerance (msecs)                  : 1000
    OWE Transition Mode                         : Disabled
    OSEN                                        : Disabled
    FT Support                                  : Disabled
        FT Reassociation Timeout (secs)         : 20
        FT Over-The-DS mode                     : Disabled
    PMF Support                                 : Required
        PMF Association Comeback Timeout (secs): 1
        PMF SA Query Time (msecs)               : 200
    Web Based Authentication                    : Disabled
    Conditional Web Redirect                    : Disabled
    Splash-Page Web Redirect                    : Disabled
    Webauth On-mac-filter Failure               : Disabled
    Webauth Authentication List Name            : Disabled
    Webauth Authorization List Name             : Disabled
    Webauth Parameter Map                       : Disabled
Band Select                                     : Disabled
Load Balancing                                  : Disabled
Multicast Buffer                                : Disabled
Multicast Buffers (frames)                      : 0
IP Source Guard                                 : Disabled
Assisted-Roaming
    Neighbor List                               : Enabled
    Prediction List                             : Disabled
    Dual Band Support                           : Disabled
IEEE 802.11v parameters
    Directed Multicast Service                  : Enabled
    BSS Max Idle                                : Enabled
        Protected Mode                          : Disabled
    Traffic Filtering Service                   : Disabled
    BSS Transition                              : Enabled
        Disassociation Imminent                 : Disabled
            Optimised Roaming Timer (TBTTS)     : 40
```

```
           Timer (TBTTS)                        : 200
        Dual Neighbor List                      : Disabled
    WNM Sleep Mode                              : Disabled
802.11ac MU-MIMO                                : Enabled
802.11ax parameters
    802.11ax Operation Status                   : Enabled
    OFDMA Downlink                              : Enabled
    OFDMA Uplink                                : Enabled
    MU-MIMO Downlink                            : Enabled
    MU-MIMO Uplink                              : Enabled
    BSS Target Wake Up Time                     : Enabled
    BSS Target Wake Up Time Broadcast Support   : Enabled
802.11 protocols in 2.4ghz band
    Protocol                                    : dot11bg
Advanced Scheduling Requests Handling           : Enabled
mDNS Gateway Status                             : Bridge
WIFI Alliance Agile Multiband                   : Disabled
Device Analytics
    Advertise Support                           : Enabled
    Advertise Support for PC analytics          : Enabled
    Share Data with Client                      : Disabled
Client Scan Report (11k Beacon Radio Measurement)
    Request on Association                      : Disabled
    Request on Roam                             : Disabled
WiFi to Cellular Steering                       : Disabled
Advanced Scheduling Requests Handling           : Enabled
Locally Administered Address Configuration
    Deny LAA clients                            : Disabled
```

To verify the client association who have used the PWE method as H2E or HnP, use this command:

```
Device# show wireless client mac-address e884.a52c.47a5 detail
Client MAC Address : e884.a52c.47a5
Client MAC Type : Universally Administered Address
Client DUID: NA
Client IPv4 Address : 11.11.0.65
Client IPv6 Addresses : fe80::c80f:bb8c:86f6:f71f
Client Username: N/A
AP MAC Address : d4ad.bda2.e9e0
AP Name: APA453.0E7B.E73C
AP slot : 1
Client State : Associated
Policy Profile : default-policy-profile
Flex Profile : N/A
Wireless LAN Id: 1
WLAN Profile Name: wpa3
Wireless LAN Network Name (SSID): wpa3
BSSID : d4ad.bda2.e9ef
Connected For : 72 seconds
Protocol : 802.11ax - 5 GHz
Channel : 36
Client IIF-ID : 0xa0000001
Association Id : 2
Authentication Algorithm : Simultaneous Authentication of Equals (SAE)
Idle state timeout : N/A
Session Timeout : 1800 sec (Remaining time: 1728 sec)
Session Warning Time : Timer not running
Input Policy Name  : None
Input Policy State : None
Input Policy Source : None
Output Policy Name  : None
Output Policy State : None
Output Policy Source : None
WMM Support : Enabled
U-APSD Support : Disabled
```

```
Fastlane Support : Disabled
Client Active State : Active
Power Save : OFF
Current Rate : m6 ss2
Supported Rates : 6.0,9.0,12.0,18.0,24.0,36.0,48.0,54.0
AAA QoS Rate Limit Parameters:
  QoS Average Data Rate Upstream             : 0 (kbps)
  QoS Realtime Average Data Rate Upstream    : 0 (kbps)
  QoS Burst Data Rate Upstream               : 0 (kbps)
  QoS Realtime Burst Data Rate Upstream      : 0 (kbps)
  QoS Average Data Rate Downstream           : 0 (kbps)
  QoS Realtime Average Data Rate Downstream  : 0 (kbps)
  QoS Burst Data Rate Downstream             : 0 (kbps)
  QoS Realtime Burst Data Rate Downstream    : 0 (kbps)
Mobility:
  Move Count                  : 0
  Mobility Role               : Local
  Mobility Roam Type          : None
  Mobility Complete Timestamp : 08/24/2021 04:39:47 Pacific
Client Join Time:
  Join Time Of Client : 08/24/2021 04:39:47 Pacific
Client State Servers : None
Client ACLs : None
Policy Manager State: Run
Last Policy Manager State : IP Learn Complete
Client Entry Create Time : 72 seconds
Policy Type : WPA3
Encryption Cipher : CCMP (AES)
Authentication Key Management : SAE
AAA override passphrase : No
SAE PWE Method : Hash to Element(H2E)
Transition Disable Bitmap : None
User Defined (Private) Network : Disabled
User Defined (Private) Network Drop Unicast : Disabled
Encrypted Traffic Analytics : No
Protected Management Frame - 802.11w : Yes
EAP Type : Not Applicable
VLAN Override after Webauth : No
VLAN : VLAN0011
Multicast VLAN : 0
WiFi Direct Capabilities:
  WiFi Direct Capable           : No
Central NAT : DISABLED
Session Manager:
  Point of Attachment : capwap_90000006
  IIF ID              : 0x90000006
  Authorized          : TRUE
  Session timeout     : 1800
  Common Session ID: 000000000000000C76750C17
  Acct Session ID  : 0x00000000
  Auth Method Status List
   Method : SAE
  Local Policies:
   Service Template : wlan_svc_default-policy-profile_local (priority 254)
    VLAN             : VLAN0011
    Absolute-Timer   : 1800
  Server Policies:
  Resultant Policies:
                VLAN Name        : VLAN0011
    VLAN             : 11
    Absolute-Timer   : 1800
DNS Snooped IPv4 Addresses : None
DNS Snooped IPv6 Addresses : None
Client Capabilities
```

```
  CF Pollable : Not implemented
  CF Poll Request : Not implemented
  Short Preamble : Not implemented
  PBCC : Not implemented
  Channel Agility : Not implemented
  Listen Interval : 0
Fast BSS Transition Details :
  Reassociation Timeout : 0
11v BSS Transition : Implemented
11v DMS Capable : No
QoS Map Capable : Yes
FlexConnect Data Switching : N/A
FlexConnect Dhcp Status : N/A
FlexConnect Authentication : N/A
Client Statistics:
  Number of Bytes Received from Client : 21757
  Number of Bytes Sent to Client : 4963
  Number of Packets Received from Client : 196
  Number of Packets Sent to Client : 37
  Number of Policy Errors : 0
  Radio Signal Strength Indicator : -72 dBm
  Signal to Noise Ratio : 20 dB
Fabric status : Disabled
Radio Measurement Enabled Capabilities
  Capabilities: Neighbor Report, Passive Beacon Measurement, Active Beacon Measurement,
Table Beacon Measurement
Client Scan Report Time : Timer not running
Client Scan Reports
Assisted Roaming Neighbor List
```

To view the number of SAE authentications using the H2E and HnP, use this command:

```
Device# show wireless stats client detail
Total Number of Clients : 0

Protocol Statistics

--------------------------------------------------------------------------------
Protcol            Client Count
 802.11b              : 0
 802.11g              : 0
 802.11a              : 0
 802.11n-2.4GHz       : 0
 802.11n-5 GHz        : 0
 802.11ac             : 0
 802.11ax-5 GHz       : 0
 802.11ax-2.4 GHz     : 0
  802.11ax-6 GHz      : 0



Current client state statistics:
--------------------------------------------------------------------------------
  Authenticating         : 0
  Mobility               : 0
  IP Learn               : 0
  Webauth Pending        : 0
  Run                    : 0
  Delete-in-Progress     : 0


Client Summary
-----------------------------
Current Clients : 0
```

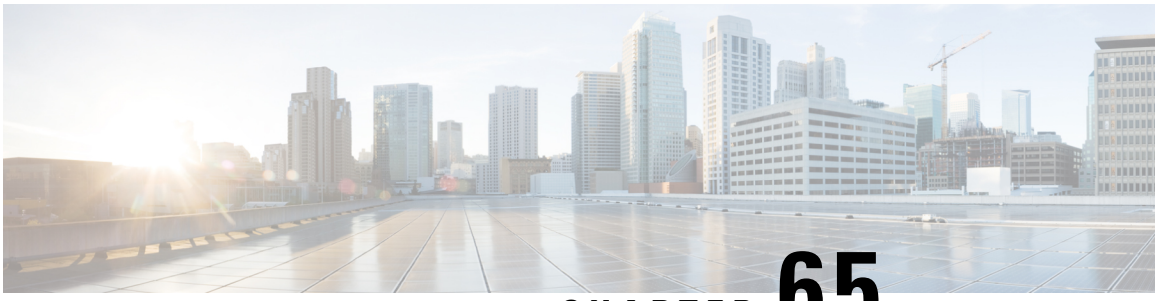
```
Excluded Clients: 0
Disabled Clients: 0
Foreign Clients : 0
Anchor Clients  : 0
Local Clients   : 0
Idle Clients    : 0
Locally Administered MAC Clients: 0

client global statistics:
---------------------------------------------------------------------------
Total association requests received              : 0
Total association attempts                       : 0
Total FT/LocalAuth requests                      : 0
Total association failures                       : 0
Total association response accepts               : 0
Total association response rejects               : 0
Total association response errors                : 0
Total association failures due to exclusion list      : 0
Total association drops due to multicast mac     : 0
Total association drops due to random mac        : 0
Total association drops due to throttling        : 0
Total association drops due to unknown bssid     : 0
Total association drops due to parse failure     : 0
Total association drops due to other reasons     : 0
Total association requests wired clients         : 0
Total association drops wired clients            : 0
Total association success wired clients          : 0
Total peer association requests wired clients    : 0
Total peer association drops wired clients       : 0
Total peer association success wired clients     : 0
Total association success wifi direct clients    : 0
Total association rejects wifi direct clients    : 0
Total association response errors                : 0
Total 11r ft authentication requests received    : 0
Total 11r ft authentication response success     : 0
Total 11r ft authentication response failure     : 0
Total 11r ft action requests received            : 0
Total 11r ft action response success             : 0
Total 11r ft action response failure             : 0
Total 11r PMKR0-Name mismatch                    : 0
Total 11r PMKR1-Name mismatch                    : 0
Total 11r MDID mismatch                          : 0
Total AID allocation failures                    : 0
Total AID free failures                          : 0
Total Roam Across Policy Profiles                : 0
Total roam attempts                              : 0
  Total CCKM roam attempts                       : 0
  Total 11r roam attempts                        : 0
  Total 11r slow roam attempts                   : 0
  Total 11i fast roam attempts                   : 0
  Total 11i slow roam attempts                   : 0
  Total other roam type attempts                 : 0
Total roam failures in dot11                     : 0

Total WPA3 SAE attempts                          : 0
Total WPA3 SAE successful authentications        : 0
Total WPA3 SAE authentication failures           : 0
  Total incomplete protocol failures             : 0
Total WPA3 SAE commit messages received          : 0
Total WPA3 SAE commit messages rejected                                  : 0
  Total unsupported group rejections                                     : 0
  Total PWE method mismatch for SAE Hash to Element commit received      : 0
  Total PWE method mismatch for SAE Hunting And Pecking commit received : 0
Total WPA3 SAE commit messages sent              : 0
```

```
Total WPA3 SAE confirm messages received         : 0
Total WPA3 SAE confirm messages rejected         : 0
  Total WPA3 SAE message confirm field mismatch  : 0
  Total WPA3 SAE confirm message invalid length  : 0
Total WPA3 SAE confirm messages sent             : 0
Total WPA3 SAE Open Sessions                     : 0
Total SAE Message drops due to throttling        : 0
Total WPA3 SAE Hash to Element commit received   : 0
Total WPA3 SAE Hunting and Pecking commit received : 0

Total Flexconnect local-auth roam attempts       : 0
  Total AP 11i fast roam attempts                : 0
  Total AP 11i slow roam attempts                : 0
  Total 11r flex roam attempts                   : 0
```



CHAPTER 65

Cisco Umbrella WLAN

- Cisco Umbrella WLAN, on page 603
- Register Embedded Wireless Controller to Cisco Umbrella account , on page 604
- Restrictions for Umbrella WLAN, on page 605
- Configure Cisco Umbrella WLAN, on page 606
- Verify the Cisco Umbrella configuration, on page 613

Cisco Umbrella WLAN

A Cisco Umbrella WLAN is a cloud-based security solution for wireless networks that

- provides DNS-level protection by detecting and blocking both known and emergent threats
- enables granular policy configuration per user group, network, device, and IP address, and
- offers real-time security dashboards and scheduled reporting.

Additional features and policy configuration

- Allows policy configuration at a single point for each user group and supports local policy, AP group, and WLAN priority order.
- Publishes visual, real-time activity dashboards with aggregated reports.
- Supports up to 60 content categories and lets administrators add custom allowed and blocked list entries.
- Enables scheduled email reporting.

Policy priority order

When you configure multiple policies in Cisco Umbrella WLAN, you enforce them in order of priority:

1. **Local policy** – This is the most specific policy and is applied first. Local policies override any broader group or network rules for individual devices or users.
2. **AP group policy** – If no local policy exists, the rules defined for the AP group are applied next.
3. **WLAN policy** – If there are no local or AP group policies, the general policy for the entire wireless network (WLAN) is applied.

To summarize, the most specific rules take priority over broader ones. If a local rule exists, it is enforced first. If not, the system checks for an AP group rule. If neither exists, the general WLAN policy is used.

Register Embedded Wireless Controller to Cisco Umbrella account

This section describes the process followed to register the Embedded Wireless Controller to the Cisco Umbrella account. Here are the prerequisites:

- Have an account with Cisco Umbrella.
- Have an API token from Cisco Umbrella.

Summary

Registering Embedded Wireless Controller to Cisco Umbrella accounts enables centralized DNS security management and policy enforcement for wireless devices. This integration requires account access, API tokens, and specific parameter mappings.

The key components involved in the process are:

- embedded wireless controllercontroller: Wireless network devices that will be registered with Cisco Umbrella for DNS query management.
- **Cisco Umbrella account**: The cloud-based platform providing DNS security services and device identity management.
- **API token**: A credential generated from Cisco Umbrella and used for authenticating and mapping devices during registration.
- **Umbrella parameter map**: Controller-side configuration map that links API tokens to device profiles.
- **DHCP servers and DNS servers**: Network services facilitating IP assignment and DNS query redirection for WLAN clients.

This process involves obtaining an API token, applying it to the controller, and verifying device registration in Cisco Umbrella.

Workflow

These stages describe the registration of the Embedded Wireless Controller to Cisco Umbrella Account.

1. **Obtain prerequisites:** Ensure you have a Cisco Umbrella account and generate an API token from the Umbrella dashboard.
2. **Configure umbrella parameter map on the controller:** Create an Umbrella parameter map on the controller embedded wireless controller, assigning the API token.
3. **Register the device:** Register the controller to the Cisco Umbrella server using the configured parameter map. Cisco Umbrella responds with a device ID, mapped in a one-to-one relationship with the parameter map name.
4. **Verify device registration:** In the Cisco Umbrella dashboard, confirm that the controller embedded wireless controller appears under Device Name with its identity information.

5. **Apply the API token configuration:** Register the Cisco Umbrella API token on the network through controller configuration.
6. **Redirect DNS queries:** Once registration and parameter mapping are complete, DNS queries from WLAN clients not matching local RegEx domain settings are redirected to the Umbrella DNS resolver, with encryption applied based on DNScrypt options in the parameter map.
7. **Apply profiles and handle mobility:** Apply wireless Cisco Umbrella profiles to WLAN or AP groups if device registration is successful. For Layer 3 mobility, always apply Cisco Umbrella on the anchor controller.
8. **Distribute Umbrella server IPs through DHCP:** When two DNS servers are configured under DHCP, two Cisco Umbrella server IPs are sent to clients using DHCP option 6; only one IP is sent if a single DNS server is configured.

Result

Embedded Wireless Controller are successfully registered with Cisco Umbrella accounts. Wireless entities can be managed with Umbrella profiles, and DNS queries are securely redirected according to policy. Device identity, profile application, and DNS traffic handling are centrally managed.

For more information on the Cisco Umbrella configurations, see the Integration for ISR 4K and ISR 1100 – Security Configuration Guide.

Restrictions for Umbrella WLAN

- Wireless Cisco Umbrella profiles can be applied only to WLAN or AP groups after successful device registration.
- In Layer 3 mobility environments, Cisco Umbrella must be enabled on the anchor .
- DHCP configuration determines how many Cisco Umbrella DNS server IPs are distributed to clients.

DNS dependency restrictions

Cisco Umbrella WLAN protections are only effective when client devices perform DNS queries through the network. If DNS is bypassed, Umbrella protection does not apply.

- If an application or host connects directly using an IP address, bypassing DNS resolution, Umbrella WLAN protections are not enforced.

These restrictions apply to all deployments of Cisco Umbrella WLAN where DNS traffic is required for policy enforcement.

Umbrella WLAN leverages DNS queries to monitor and enforce security policies. Direct IP or proxy-based connections circumvent DNS-based protections.

Clients that bypass DNS, or use web proxies that resolve server addresses without DNS queries, may not be protected by Umbrella WLAN security policies.

Ensure all client devices perform DNS queries through the WLAN and avoid proxy configurations that bypass DNS to maintain optimal Umbrella protection.

Configure Cisco Umbrella WLAN

To configure Cisco Umbrella on the Embedded Wireless Controller, you need to meet these prerequisites:

- Obtain the API token from the Cisco Umbrella dashboard.
- You must have the root certificate to establish an HTTPS connection with the Cisco Umbrella registration server: api.opendns.com. Import the root certificate from digicert.com to the Embedded Wireless Controller using the command **crypto pki trustpool import terminal** .

Import CA certificate to the trust pool

Before you begin

Ensure you have the root certificate and an established HTTPS connection with the Cisco Umbrella registration server.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Perform either of these steps:

- Import the root certificate directly from the Cisco website. The Trustpool bundle contains the root certificate of *digicert.com* together with other CA certificates.

```
Device(config)# crypto pki trustpool import url
http://www.cisco.com/security/pki/trs/ios.p7b
```

- Import the root certificate by executing the **import terminal** command.

```
Device(config)# crypto pki trustpool import terminal
```

- Import the root certificate by pasting the CA certificate from the digicert.com. Enter the PEM-formatted CA certificate from these location. See the Related Information section to download the CA certificate.

```
-----BEGIN CERTIFICATE-----
MIIE6jCCA9KgAwIBAgIQCjUI1VwpKwF9+K1lwA/35DANBgkqhkiG9w0BAQsFADBhMQswCQYDVQQG
EwJVUzEVMBMGA1UEChMMRGlnaUNlcnQgSW5jMRkwFwYDVQQLExB3d3cuZGlnaWNlcnQuY29tMSAw
HgYDVQQDExdEaWdpQ2VydCBHbG9iYWwgUm9vdCBDQTAeFw0yMDA5MjQwMDAwMDBaFw0zMDA5MjMy
MzU5NTlaME8xCzAJBgNVBAYTAlVTMRUwEwYDVQQKEwxEaWdpQ2VydCBJbmMxKTAnBgNVBAMTIERp
Z2lDZXJ0IFRMUyBSU0EgU0hBMjU2IDIwMjAgQ0ExMIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIB
CgKCAQEAwUuzZUdwvN1PWNvsnO3DZuUfMRNUrUpmRh8sCuxkB+Uu3Ny5CiDt3+PE0J6aqXodgojl
EVbbHp9YwlHnLDQNLtKS4VbL8Xlfs7uHyiUDe5pSQWYQYE9XE0nw6Ddng9/n00tnTCJRpt8OmRDt
V1F0JuJ9x8piLhMbfyOIJVNvwTRYAIuE//i+p1hJInuWraKImxW8oHzf6VGo1bDtN+I2tIJLYrVJ
muzHZ9bjPvXj1hJeRPG/cUJ9WIQDgLGBAfr5yjK7tI4nhyfFK3TUqNaX3sNk+crOU6JWvHgXjkkD
Ka77SU+kFbnO8lwZV21reacroicgE7XQPUDTITAHk+qZ9QIDAQABo4IBrjCCAaowHQYDVR0OBBYE
FLdrouqoqoSMeeq02g+YssWVdrn0MB8GA1UdIwQYMBaAFAPeUDVW0Uy7ZvCj4hsbw5eyPdFVMA4G
A1UdDwEB/wQEAwIBhjAdBgNVHSUEFjAUBggrBgEFBQcDAQYIKwYBBQUHAwIwEgYDVR0TAQH/BAgw
BgEB/wIBADB2BggrBgEFBQcBAQRqMGgwJAYIKwYBBQUHMAGGGGh0dHA6Ly9vY3NwLmRpZ2ljZXJ0
LmNvbTBABggrBgEFBQcwAoY0aHR0cDovL2NhY2VydHMuZGlnaWNlcnQuY29tL0RpZ2lDZXJ0R2xv
YmFsUm9vdENBLmNydDB7BgNVHR8EdDByMDegNaAzhjFodHRwOi8vY3JsMy5kaWdpY2VydC5jb20v
RGlnaUNlcnRHbG9iYWxSb290Q0EuY3JsMDegNaAzhjFodHRwOi8vY3JsNC5kaWdpY2VydC5jb20v
```

```
RGlnaUNlcnRHbG9iYWxSb290Q0EuY3JsMDAGA1UdIAQpMCcwBwYFZ4EMAQEwCAYGZ4EMAQIBMAgG
BmeBDAECAjAIBgZngQwBAgMwDQYJKoZIhvcNAQELBQADggEBAHert3onPa679n/gWlbJhKrKW3EX
3SJH/E6f7tDBpATho+vFScH90cnfjK+URSxGKqNjOSD5nkoklEHIqdninFQFBstcHL4AGw+oWv8Z
u2XHFq8hVt1hBcnpj5h232sb0HIMULkwKXq/YFkQZhM6LawVEWwtIwwCPgU7/uWhnOKK24fXSuhe
50gG66sSmvKvhMNbg0qZgYOrAKHKCjxMoiWJKiKnpPMzTFuMLhoClw+dj20tlQj7T9rxkTgl4Zxu
YRiHas6xuwAwapu3r9rxxZf+ingkquqTgLozZXq8oXfpf2kUCwA/d5KxTVtzhwoT0JzI8ks5T1KE
SaZMkE4f97Q=
-----END CERTIFICATE-----
```

Step 3 (Optional) Import the root certificate by entering the quit command.

Example:

```
Device(config)# quit
```

Note
You will receive a message after the certificate has been imported.

Create a local domain RegEx parameter map

To create a regex parameter map for matching specific domain patterns.

This procedure is used in network configurations where domain name filtering is required based on regex patterns.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a regex parameter map.

Example:

```
Device(config)# parameter-map type regex parameter-map-name
```

Step 3 Configure the regex pattern to match.

Example:

```
Device(config-profile)# pattern regex-pattern
```

Example:

```
Device(config-profile)# pattern www.google.com
```

Note
These patterns are supported:

- Begins with `.*`. For example: **`.*facebook.com`**
- Begins with `.*` and ends with `*`. For example: **`.*google*`**
- Ends with `*`. For example: **`www.facebook*`**
- No special character. For example: **`www.facebook.com`**

Step 4 Return to privileged EXEC mode.

Example:

```
Device(config-profile)# end
```

The local domain RegEx parameter map is created and configured successfully.

Configure parameter map name in WLAN (GUI)

Assign a parameter map to a WLAN, enabling custom policy enforcement for DNS traffic and access restrictions.

This procedure ensures that your WLAN profile enforces the intended policies for DNS and wireless client access using Cisco Umbrella integration.

Before you begin

Confirm that required parameter maps are defined

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy** .

Step 2 Click on the Policy Profile Name. The **Edit Policy Profile** window is displayed.

Step 3 Choose the **Advanced** tab.

Step 4 In the **Umbrella** settings, from the **Umbrella Parameter Map** drop-down list, choose the parameter map.

Step 5 Enable or disable **Flex DHCP Option for DNS** and **DNS Traffic Redirect** toggle buttons.

Step 6 Click Update & Apply to Device.

The WLAN profile is updated with the selected parameter map, and the associated DNS and access policies are enforced for connected wireless clients.

Configure the Umbrella parameter map

To configure the Umbrella Parameter Map for network security and management.

This configuration is used to manage and secure network traffic through the Umbrella service, which provides DNS-layer security.

Before you begin

Ensure you have the necessary permissions and access to the device for configuration.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create an Umbrella global or customized parameter map.

Example:

```
Device(config)# parameter-map type umbrella global parameter-map-name
```

Example:

```
Device(config)# parameter-map type umbrella global
```

Creates an umbrella global parameter map.

Step 3 Configure an Umbrella token.

Example:

```
Device(config-profile)# token token-value
```

Example:

```
Device(config-profile)# token 5XXXXXXXXCXXXXXXXAXXXXXXXFXXXXCXXXXXXXX
```

Step 4 Configure local domain RegEx parameter maps.

Example:

```
Device(config-profile)# local-domain regex-parameter-map-name
```

Example:

```
Device(config-profile)# local-domain dns_wl
```

Configures local domain RegEx parameter map.

Step 5 Configure the Anycast address.

Example:

```
Device(config-profile)# resolver IPv6 10:1:1:1::10
```

The default address is applied when there is no specific address configured.

Step 6 Return to privileged EXEC mode.

Example:

```
Device(config-profile)# end
```

The Umbrella parameter map is now configured and ready for use in managing network security.

Enable or disable DNScrypt using GUI

Use this task when you need to control whether DNS queries are encrypted, or to specify exceptions and update your Umbrella settings.

Configure DNScrypt to enhance or relax DNS traffic encryption as needed to adapt your organization's security requirements.

Before you begin

- Obtain the registration token from Cisco Umbrella.
- Determine domains to whitelist if needed.

Procedure

Step 1 Choose **Configuration** > **Security** > **Threat Defence** > **Umbrella** .

Step 2 Enter the **Registration Token** received from Umbrella. Alternatively, you can click on **Click here to get your Token** to get the token from Umbrella.

Step 3 Enter the **Whitelist Domains** that you want to exclude from filtering.

Step 4 Check or uncheck the **Enable DNS Packets Encryption** check box to encrypt or decrypt the DNS packets.

Step 5 Click **Apply** .

The DNScrypt setting is updated. DNS packets is now be encrypted or unencrypted based on your selection, and any specified domains will be excluded from filtering.

Enable or disable DNScrypt

To configure DNScrypt settings for enhanced DNS security.

This procedure is used to enable or disable DNScrypt, which provides encryption for DNS queries, enhancing privacy and security.

Before you begin

Ensure you have access to the device's global configuration mode.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create an umbrella global parameter map.

Example:

```
Device(config)# parameter-map type umbrella global
```

Step 3 Enable DNScrypt

Example:

```
Device(config-profile)# no dnscrypt
```

By default, the DNScrypt option is enabled.

Note
Cisco Umbrella DNScrypt is not supported when DNS-encrypted responses are sent in the data-DTLS encrypted tunnel (either mobility tunnel or AP CAPWAP tunnel).

Step 4 (Optional) Return to privileged EXEC mode.

Example:

```
Device(config-profile)# end
```

The DNScrypt settings have been successfully configured.

Configure timeout for UDP sessions.

To set a timeout value for UDP sessions to manage session persistence and resource allocation.

This configuration is useful in environments where UDP sessions need to be managed effectively to prevent resource exhaustion.

Before you begin

Ensure you have access to the device and the necessary privileges to enter global configuration mode.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create an umbrella global parameter map.

Example:

```
Device(config)# parameter-map type umbrella global
```

Step 3 Configure timeout value for UDP sessions.

Example:

```
Device(config-profile)# udp-timeout timeout_value
```

The *timeout_value* ranges from 1 to 30 seconds.

Note
The **public-key** and **resolver** parameter-map options are automatically populated with the default values. So, you need not change them.

Step 4 (Optional) Return to privileged EXEC mode.

Example:

```
Device(config-profile)# end
```

The UDP session timeout is configured successfully, allowing for better management of UDP resources.

Configuring Parameter Map Name in WLAN (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 Click on the Policy Profile Name. The **Edit Policy Profile** window is displayed.

Step 3 Choose the **Advanced** tab.

Step 4 In the **Umbrella** settings, from the **Umbrella Parameter Map** drop-down list, choose the parameter map.

Step 5 Enable or disable **Flex DHCP Option for DNS** and **DNS Traffic Redirect** toggle buttons.

Step 6 Click **Update & Apply to Device**.

Configure parameter map name in WLAN

Configure a parameter map name to enable Cisco Umbrella OpenDNS integration on a WLAN.

This procedure is used when secure DNS filtering and policy enforcement are required on WLANs. The parameter map defines the Umbrella integration settings for the profile.

Before you begin

Ensure that the WLAN profile has been created and the network device is running the appropriate software version for Umbrella OpenDNS support.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Enters global configuration mode.

Step 2 Create a policy profile for the WLAN.

Example:

```
Device(config)# wireless profile policy policy-profile-name
```

The *default-policy-profile* is the profile name of the policy profile.

Step 3 Configure the Umbrella parameter map in the policy profile.

Example:

```
Device(config-wireless-policy)# umbrella-param-map umbrella-name
```

Configures the Cisco Umbrella OpenDNS feature for the WLAN using the specified parameter map.

The *global* parameter map contains policy and key settings for Umbrella integration.

Step 4 Exit wireless policy configuration and return to privileged EXEC mode.

Example:

```
Device(config-wireless-policy)# end
```

Alternatively, you can press Ctrl-Z.

The Umbrella parameter map name is now configured for the WLAN. DNS protection policies will be applied to wireless clients associating with this profile.

Verify the Cisco Umbrella configuration

To view the Umbrella configuration details, use the command:

```
Device# show umbrella config
Umbrella Configuration
=======================
Token: 5XXXXXXABXXXXXFXXXXXXXXXXDXXXXXXXXXXXXABXX
API-KEY: NONE
OrganizationID: xxxxxxx
Local Domain Regex parameter-map name: dns_bypass
DNSCrypt: Not enabled
Public-key: NONE
UDP Timeout: 5 seconds
Resolver address:
1. 10.1.1.1
2. 5.5.5.5
3. XXXX:120:50::50
4. XXXX:120:30::30
```

To view the Umbrella DNSCrypt details, use the command:

```
Device# show umbrella dnscrypt
DNSCrypt: Enabled
   Public-key: B111:XXXX:XXXX:XXXX:3E2B:XXXX:XXXX:XXXE:XXX3:3XXX:DXXX:XXXX:BXXX:XXXB:XXXX:FXXX

   Certificate Update Status: In Progress
```

To view the Umbrella global parameter map details, use the command:

```
Device# show parameter-map type umbrella global
```

To view the regex parameter map details, use the command:

```
Device# show parameter-map type regex <parameter-map-name>
```

To view the Umbrella details on the AP, use the following command:

```
AP#show client opendns summary
Server-IP role
208.67.220.220 Primary
208.67.222.222 Secondary

Server-IP role
2620:119:53::53 Primary
2620:119:35::35 Secondary

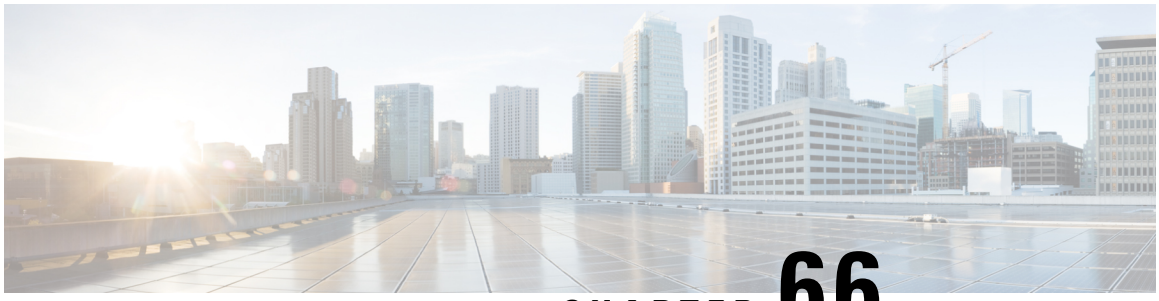
Wlan Id DHCP OpenDNS Override Force Mode
0 true false
1 false false
...

15 false false
Profile-name Profile-id
```

```
vj-1 010a29b176b34108
global 010a57bf502c85d4
vj-2 010ae385ce6c1256
AP0010.10A7.1000#

Client to profile command

AP#show client opendns address 50:3e:aa:ce:50:17
Client-mac Profile-name
50:3E:AA:CE:50:17 vj-1
AP0010.10A7.1000#
```



CHAPTER 66

Locally significant certificates

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- Provisioning locally significant certificates, on page 618
- AP certificate renewal (LSC), on page 638
- MIC and LSC APs joining the controller, on page 644
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Locally significant certificates

A locally significant certificate (LSC) is a PKI certificate that

- provides mutual authentication between Cisco Embedded Wireless Controller on Catalyst Access Points and Lightweight Access Points (LAPs)
- generates certificates directly on APs and embedded wireless controllers, and
- enables organizations to use their own PKI for better security control and Certificate Authority (CA) management.

LSC provisioning and communication process

You need to provision the new LSC certificate on the embedded wireless controller and then the Lightweight Access Point (LAP) from the CA Server.

The LAP communicates with the embedded wireless controller using the CAPWAP protocol. Any request to sign the certificate and issue the CA certificates for LAP and embedded wireless controller itself must be initiated from the embedded wireless controller. The LAP does not communicate directly with the CA server. The CA server details must be configured on the embedded wireless controller and must be accessible.

The embedded wireless controller makes use of the Simple Certificate Enrollment Protocol (SCEP) to forward certReqs generated on the devices to the CA and makes use of SCEP again to get the signed certificates from the CA.

The SCEP is a certificate management protocol that the PKI clients and CA servers use to support certificate enrollment and revocation. It is widely used in Cisco and supported by many CA servers. In SCEP, HTTP is used as the transport protocol for the PKI messages. The primary goal of SCEP is the secure issuance of certificates to network devices. SCEP is capable of many operations, but for our release, SCEP is utilized for the following operations:

- CA and Router Advertisement (RA) Public Key Distribution
- Certificate Enrollment

Certificate provisioning in controllers

Certificate provisioning in controllers is a security process that you use to:

- Install new Locally Significant Certificate (LSC) certificates (both Certificate Authority (CA) certificates and device certificates) on the controller
- Use Simple Certificate Enrollment Protocol (SCEP) to receive Certificate Authority (CA) certificates from the CA server during initial setup when the controller has no certificates, and
- Push the same Certificate Authority (CA) certificates to Access Points (APs) when you provision the Access Points (APs) with Locally Significant Certificates (LSCs).

RSA keypair recommendations

These recommendations apply when configuring PKI certificates with RSA keypairs:

Note We recommend that you use a new RSA keypair name for the newly configured PKI certificate. If you want to reuse an existing RSA keypair name (that is associated with an old certificate) for a new PKI certificate, do either of the following:

- Do not regenerate a new RSA keypair with an existing RSA keypair name. Instead, reuse the existing RSA keypair name. All certificates associated with the existing RSA keypair become invalid when you regenerate a new RSA keypair with an existing name.
- Remove the old PKI certificate configurations before reusing the existing RSA keypair name for the new PKI certificate.

How device certificate enrollment works

When your Lightweight Access Point (LAP) and controller request Certificate Authority (CA)-signed certificates, they send the certRequest as a PKCS#10 message. The Certificate Authority (CA) receives a PKCS#10 certRequest. The Certificate Authority (CA) requires additional information to authenticate the identity of the requester and verify that the request is unaltered.

Summary

The key components involved in the device certificate enrollment process are:

- Lightweight Access Point (LAP) and controller: request Certificate Authority (CA)-signed certificates by sending PKCS#10 messages. These messages contain Subject Name, Public Key, and other attributes.
- Certificate Authority (CA): transforms the certRequest into an X.509 certificate after authentication and verification

- PKCS#10 certRequest: contains digitally signed certificate request information including Subject Name and Public Key
- Simple Certificate Enrollment Protocol (SCEP) client: provides functionality to wrap PKCS#10 in PKCS#7 Signed Data message type

Workflow

Your device certificate enrollment process works through these stages:

1. The Lightweight Access Point (LAP) and controller create a PKCS#10 certificate request containing the Subject Name, Public Key, and other attributes to be included in the X.509 certificate, and digitally sign it with the Private Key of the requester.
2. The PKCS#10 is wrapped in a PKCS#7 Signed Data message type as part of the Simple Certificate Enrollment Protocol (SCEP) client functionality, and the PKCSReq message is sent to the controller.
3. The Certificate Authority (CA) receives the PKCS#10 certRequest and authenticates the identity of the requester and verifies that the request is unaltered.
4. The Certificate Authority (CA) transforms the certRequest into an X.509 certificate.

Result

Upon successful enrollment operation, both the Certificate Authority (CA) and device certificates are available on the controller.

How certificate provisioning works on lightweight APs

Certificate provisioning enables lightweight APs (LAPs) to obtain new signed X.509 certificates while operating in CAPWAP mode. This process ensures secure communications between APs and controllers using updated security credentials.

Summary

The key components involved in certificate provisioning on lightweight APs are:

- Lightweight Access Point (LAP): Initiates certificate requests and receives new certificates while in CAPWAP mode
- Controller: Acts as a CA proxy to help obtain signed certificates from the Certificate Authority for the LAP
- Certificate Authority (CA): Signs and validates certificate requests to issue new X.509 certificates
- LWAPP payloads: Transport mechanism for certificate requests and responses between LAP and controller

Workflow

These stages describe how certificate provisioning works on lightweight APs:

1. The LAP sends a certificate request to the controller to obtain a new signed X.509 certificate.

   The controller acts as a CA proxy and helps obtain the certificate request signed by the CA for the LAP.

2. The certificate requests and certificate responses are transmitted between the LAP and controller using LWAPP payloads.
3. Both the LSC CA and LAP device certificates are installed in the LAP, and the system reboots automatically.
4. When the system comes up after reboot, the AP sends the LSC device certificate to the controller as part of the JOIN Request because it is configured to use LSCs.

   As part of the JOIN Response, the controller sends the new device certificate and validates the inbound LAP certificate with the new CA root certificate.

What's next

To configure, authorize, and manage certificate enrollment with the existing PKI infrastructure for controller and AP, you need to use the LSC provisioning functionality.

Restrictions for locally significant certificates

- The locally significant certificate (LSC) workflow differs in FIPS and WLANCC mode. Your Certificate Authority (CA) server must support Enrollment over Secure Transport (EST) protocol. Your CA server must also issue EC certificates in FIPS and WLANCC mode.
- The Elliptic Curve Digital Signature Algorithm (ECDSA) cipher works only if both your AP and controller have EC certificates provisioned with LSC.
- EC certificates (LSC-EC) can be provisioned only if CA server supports EST (and not SCEP).
- You must configure FIPS and CC security modes to provision EC certificates.

Provisioning locally significant certificates

Configure RSA key for PKI trustpoint

Generate RSA cryptographic keys for PKI trustpoint authentication and secure communications.

RSA keys are essential components of PKI infrastructure, providing the cryptographic foundation for certificate-based authentication and encryption on wireless controllers.

Before you begin

Ensure the device is in a stable operational state and has sufficient processing resources for key generation.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Generate RSA key for PKI trustpoint.

Example:

```
Device(config)# crypto key generate rsa exportable general-keys modulus key-size label
RSA-key-label
```

Example:

```
Device(config)# crypto key generate rsa exportable
general-keys modulus 2048 label lsc-tp
```

exportable is an optional keyword. You may or may not want to configure an exportable-key. If selected, you can export the key out of the box, if required.

- *key-size*: Size of the key modulus. The valid range is from 2048 to 4096.
- *RSA-key-label*: RSA key pair label.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The RSA key is successfully generated and labeled for use with PKI trustpoint configurations.

Configure PKI trustpoint parameters

Configure a PKI trustpoint with RSA key parameters for certificate enrollment and authentication.

PKI trustpoints define the relationship between the device and a Certificate Authority (CA), enabling secure certificate-based authentication and encryption.

Before you begin

Ensure the CA server is accessible and configured to accept certificate requests.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a new trustpoint for an external CA server.

Example:

```
Device(config)# crypto pki trustpoint trustpoint-name
```

Example:

```
Device(config)# crypto pki trustpoint microsoft-ca
```

The *trustpoint-name* refers to the trustpoint name.

Step 3 Specify the URL of the CA on which your router should send certificate requests.

Example:

```
Device(ca-trustpoint)# enrollment url HTTP-URL
```

Example:

```
Device(ca-trustpoint)# enrollment url http://CA_server/certsrv/mscep/mscep.dll
```

HTTP-URL: URL of the file system where your router 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. For more enrollment method options, see the enrollment url (ca-trustpoint) command page.

Step 4 Create subject name parameters for the trustpoint.

Example:

```
Device(ca-trustpoint)# subject-name subject-name
```

Example:

```
Device(ca-trustpoint)# subject-name C=IN, ST=KA, L=Bengaluru, O=Cisco,
CN=eagle-eye/emailAddress=support@abc.com
```

Step 5 Map RSA key with that of the trustpoint.

Example:

```
Device(ca-trustpoint)# rsakeypair RSA-key key-size
```

Example:

```
Device(ca-trustpoint)# rsakeypair ewlc-tp1
```

- *RSA-key*: RSA key pair label.
- *key-size*: Signature key length. Range is from 360 to 4096.

Step 6 Configure revocation checking method.

Example:

```
Device(ca-trustpoint)# revocation {crl | none | ocsp}
```

Example:

```
Device(ca-trustpoint)# revocation none
```

Step 7 Return to privileged EXEC mode.

Example:

```
Device(ca-trustpoint)# end
```

The PKI trustpoint is now configured with the specified parameters and ready for certificate enrollment operations.

Authenticate and enroll a Public Key Infrastructure (PKI) trustpoint (GUI)

Use this procedure to add and authenticate a Public Key Infrastructure (PKI) trustpoint to enable certificate-based security for your device.

Before you begin

Obtain the enrollment URL and certificate authority information from your network administrator.

Procedure

Step 1 Choose **Configuration** > **Security** > **Public Key Infrastructure (PKI) Management**.

Step 2 In the **Public Key Infrastructure (PKI) Management** window, click the **Trustpoints** tab.

Step 3 In the **Add Trustpoint** dialog box, provide this information:

a) In the **Label** field, enter the RSA key label.
b) In the **Enrollment URL** field, enter the enrollment URL.
c) Check the **Authenticate** check box to authenticate the Public Certificate from the enrollment URL.
d) In the **Subject Name** section, enter the **Country Code**, **State**, **Location**, **Organization**, **Domain Name**, and **Email Address**.
e) Check the **Key Generated** check box to view the available RSA keypairs. Choose an option from the **Available RSA Keypairs** drop-down list.
f) Check the **Enroll Trustpoint** check box.
g) In the **Password** field, enter the password.
h) In the **Re-Enter Password** field, confirm the password.
i) Click **Apply to Device**.

The new trustpoint is added to the trustpoint name list.

The new trustpoint is now listed in the trustpoint name list and is ready for use.

What to do next

After enrolling the trustpoint, configure it for use with your security policies or certificate-based authentication features.

Authenticate and enroll the PKI trustpoint with CA server (CLI)

Establish secure communication between the device and Certificate Authority by authenticating and enrolling a PKI trustpoint.

PKI trustpoints enable secure certificate-based authentication. The authentication process fetches the CA certificate, while enrollment generates and submits a certificate request to obtain a client certificate.

Before you begin

Ensure the PKI trustpoint is configured and the CA server is accessible.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Fetch the CA certificate.

Example:

```
Device(config)# crypto pki authenticate trustpoint-name
```

Example:

```
Device(config)# crypto pki authenticate microsoft-ca
```

Step 3 Accept the CA certificate.

Example:

```
Device(config)# % Do you accept this certificate? [yes/no]:
yes Trustpoint CA certificate accepted.
```

Step 4 Enroll the client certificate.

Example:

```
Device(config)# crypto pki enroll trustpoint-name
```

Example:

```
Device(config)# crypto pki enroll microsoft-ca
%
% Start certificate enrollment ..
% Create a challenge password. You will need to verbally
provide this password to the CA Administrator in order to
revoke your certificate. For security reasons your password
will not be saved in the configuration.
Please make a note of it.
```

Step 5 Enter a challenge password to the CA server.

Example:

```
Device(config)# password
```

Example:

```
Device(config)# abcd123
```

Step 6 Re-enter the challenge password to the CA server.

Example:

```
Device(config)# password
```

Example:

```
Device(config)# abcd123
```

Step 7 Include the router serial number in the subject name.

Example:

```
Device(config)# % Include the router serial number
in the subject name? [yes/no]: yes
```

Step 8 Exclude IP address from the subject name.

Example:

```
Device(config)# % Include an IP address
in the subject name? [no]: no
```

Step 9 Request certificate from CA.

Example:

```
Device(config)#
Request certificate from CA? [yes/no]: yes
% Certificate request sent to Certificate Authority
```

```
% The 'show crypto pki certificate verbose
client' command will show the fingerprint.
```

Step 10 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The PKI trustpoint is authenticated and enrolled with the CA server, enabling secure certificate-based communication.

Configure AP join attempts with LSC certificate

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 In the **All Access Points** window, click the LSC Provision name.

Step 3 From the **Status** drop-down list, choose a status to enable LSC.

Step 4 From the **Trustpoint Name** drop-down list, choose the trustpoint.

Step 5 In the **Number of Join Attempts** field, enter the number of retry attempts that will be permitted.

Step 6 Click **Apply**.

Configure AP join attempts with LSC certificate (CLI)

Configure the maximum number of AP join failure attempts with a newly provisioned LSC certificate to ensure proper fallback to MIC when needed.

When APs attempt to join with LSC certificates and exceed the configured failure limit, they automatically fall back to using their Manufacturer Installed Certificate (MIC) for authentication.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify the maximum number of AP join failure attempts with the newly provisioned LSC certificate.

Example:

```
Device(config)# ap lsc-provision join-attempt number-of-attempts
```

Example:

```
Device(config)# ap lsc-provision join-attempt 10
```

When the number of AP joins exceed the specified limit, AP joins back with the Manufacturer Installed Certificate (MIC).

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

The AP join attempt limit with LSC certificate is now configured. APs will fall back to MIC authentication after exceeding the specified number of failed join attempts.

Configure subject-name parameters in LSC certificate

Configure the subject-name parameters that will be included in LSC certificates generated by access points.

Subject-name parameters define the identity information included in Local Significant Certificate (LSC) requests generated by access points. These parameters include geographical and organizational details that identify the certificate holder.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify the attributes to be included in the subject-name parameter of the certificate request generated by an AP.

Example:

```
Device(config)# ap lsc-provision subject-name-parameter
country country-str state state-str city city-str domain domain-str org
org-str email-address email-addr-str
```

Example:

```
Device(config)# ap lsc-provision subject-name-parameter
country India state Karnataka city Bangalore domain domain1 org
Right email-address adc@gfe.com
```

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The subject-name parameters are now configured for LSC certificate generation on access points.

Configure key size for LSC certificate

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify the size of keys to be generated for the LSC on AP.

Example:

```
Device(config)# ap lsc-provision key-size key-size
```

Example:

```
Device(config)# ap lsc-provision key-size 2048
```

Valid key size options are 2048, 3072, or 4096 bits.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Configure trustpoint for LSC provisioning on an AP

Establish a trustpoint for Local Significant Certificate (LSC) provisioning to enable secure communication between access points and the controller.

LSC provisioning allows access points to obtain certificates from a designated trustpoint, enhancing network security through certificate-based authentication.

Before you begin

Ensure the trustpoint is properly configured and accessible on the network.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify the trustpoint with which the LSC is provisioned to an AP.

Example:

```
Device(config)# ap lsc-provision trustpoint tp-name
```

Example:

```
Device(config)# ap lsc-provision trustpoint microsoft-ca
```

The *tp-name* is the trustpoint name.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The trustpoint for LSC provisioning is now configured and ready to provision certificates to access points.

Configure an AP LSC provision list (GUI)

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 In the **All Access Points** window, click the corresponding LSC Provision name.

Step 3 From the **Status** drop-down list, choose a status to enable LSC.

Step 4 From the **Trustpoint Name** drop-down list, choose a trustpoint.

Step 5 In the **Number of Join Attempts** field, enter the number of retry attempts that are allowed.

Step 6 From the **Key Size** drop-down list, choose a key.

Step 7 In the **Edit AP Join Profile** window, click the **CAPWAP** tab.

Step 8 In the **Add APs to LSC Provision List** section, click **Select File** to upload the CSV file that contains AP details.

Step 9 Click **Upload File**.

Step 10 In the **AP MAC Address** field, enter the AP MAC address. and add them. (The APs added to the provision list are displayed in the **APs in provision List** .)

Step 11 In the **Subject Name Parameters** section, enter the following details:

- **Country**
- **State**
- **City**
- **Organization**
- **Department**
- **Email Address**

Step 12 Click **Apply**.

Configure an AP LSC provision list (CLI)

Add access points to the LSC provision list for certificate-based authentication.

The LSC provision list allows you to specify which access points can use locally significant certificates for authentication with the wireless controller.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Add the AP to the LSC provision list.

Example:

```
Device(config)# ap lsc-provision mac-address mac-address
```

Example:

```
Device(config)# ap lsc-provision
mac-address 001b.3400.02f0
```

Note
You can provision a list of APs using the **ap lsc-provision provision-list** command.

(Or)

You can provision all the APs using the **ap lsc-provision** command.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The AP is now added to the LSC provision list and can use locally significant certificates for authentication.

Configure LSC provisioning for all the APs (GUI)

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 In the **Access Points** window, expand the **LSC Provision** section.

Step 3 Set **Status** to **Enabled** state.

Note
If you set **Status** to **Provision List**, LSC provisioning will be configured only for APs that are a part of the provision list.

Step 4 From the **Trustpoint Name** drop-down list, choose the appropriate trustpoint for all APs.

Step 5 In the **Number of Join Attempts** field, enter the number of retry attempts that the APs can make to join the embedded wireless controller.

Step 6 From the **Key Size** drop-down list, choose the appropriate key size of the certificate:

- **2048**
- **3072**
- **4096**

Step 7 In the **Add APs to LSC Provision List** section, click **Select File** to upload the CSV file that contains the AP details.

Step 8 Click **Upload File**.

Step 9 In the **AP MAC Address** field, enter the AP MAC address. (The APs that are added to the provision list are displayed in the **APs in Provision List** section.)

Step 10 In the **Subject Name Parameters** section, enter the following details:

a. **Country**

b. **State**

c. **City**

d. **Organization**

e. **Department**

f. **Email Address**

Step 11 Click **Apply**.

Configure LSC provisioning for all APs (CLI)

Enable LSC (Local Significant Certificate) provisioning across all access points to enhance security through automatic certificate management.

LSC provisioning allows access points to automatically obtain and manage security certificates, reducing manual certificate deployment overhead while maintaining secure wireless communications.

Before you begin

Ensure you have administrative access to the wireless controller and that all APs are properly registered with the controller.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable LSC provisioning for all APs.

Example:

```
Device(config)# ap lsc-provision
```

By default, LSC provisioning is disabled for all APs.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

LSC provisioning is now enabled for all access points, allowing them to automatically obtain and manage security certificates.

Configure LSC provisioning for the APs in the provision list

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable LSC provisioning for a set of APs configured in the provision list.

Example:

```
Device(config)# ap lsc-provision provision-list
```

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Unprovisioning Local Significant Certificates

To unprovision the Local Significant Certificates (LSC), complete the following steps:

1. Move the chassis to WLAN Common Criteria (WLANCC) mode.
2. Reload the APs by provisioning LSC and the wireless management trustpoint. For more information, refer to Configure LSC provisioning and management trustpoint, on page 629 .
3. Remove Federal Information Processing Standard (FIPS) and WLANCC. For more information, refer to Remove FIPS and WLAN common criteria, on page 630 .
4. Remove LSC provisioning. For more information, refer to Remove LSC provisioning, on page 631 .

Configure LSC provisioning and management trustpoint

Before you begin

Identify the name of the standby access point using the **show chassis** command when an EWC (Embedded Wireless Controller) HA pair is configured.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the AP LSC Provisioning parameters.

Example:

```
Device(config)# ap lsc-provision
```

Step 3 Configure the management trustpoint for LSC authentication.

Example:

```
Device(config)# wireless management trustpoint trustpoint-name
```

Step 4 Save the configuration.

Example:

```
Device# copy running-config startup-config
```

The standby AP joins the controller. The HA pair is not yet formed at this point.

Step 5 Reload the internal AP.

Example:

```
Device# wireless ewc-ap ap reload
```

This will also reload the controller on the AP.

The standby AP starts the controller and becomes the new active AP for the HA pair.

Remove FIPS and WLAN common criteria

Disable FIPS and WLAN common criteria to allow for standard operation of the device.

This procedure is applicable in scenarios where FIPS compliance is no longer required, and the device needs to operate in a non-FIPS mode.

Before you begin

Ensure that the device is currently configured for FIPS and WLAN common criteria.

Procedure

	Command or Action	Purpose
Step 1	Enter global configuration mode. **Example:** `Device# configure terminal`	
Step 2	Configure the AP DTLS version. **Example:**	

	Command or Action	Purpose
	`Device(config)# ap dtls-version dtls_1_2`	
Step 3	Configure the AP DTLS ciphersuite. **Example:** `Device(config)# ap dtls-cipher ECDHE-ECDSA-AES256-GCM-SHA384`	
Step 4	Disable WLAN CC on the controller. **Example:** `Device(config)# no wireless wlancc`	
Step 5	Disable the authorization key for FIPS. **Example:** `Device(config)# no fips authorization-key`	
Step 6	Return to privileged EXEC mode. **Example:** `Device(config)# end`	
Step 7	Save the configuration. **Example:** `Device# write memory`	
Step 8	Reload the device. **Example:** `Device# reload`	

The device is now configured to operate without FIPS and WLAN common criteria.

Remove LSC provisioning

Before you begin

Wait for the standby AP to come up.

Procedure

	Command or Action	Purpose
Step 1	Enter global configuration mode. **Example:** `Device# configure terminal`	
Step 2	Disable AP LSC provisioning parameters. **Example:** `Device(config)# no ap lsc-provision`	
Step 3	Disable AP DTLS cipher suite.	

	Command or Action	Purpose
	Example: `Device(config)# no ap dtls-cipher ECDHE-ECDSA-AES256-GCM-SHA384`	
Step 4	Disable the DTLS version. **Example:** `Device(config)# no ap dtls-version dtls_1_2`	
Step 5	Disable the wireless management trustpoint. **Example:** `Device(config)# no wireless management trustpoint`	
Step 6	Save the configuration changes. **Example:** `Device# copy running-config startup-config`	
Step 7	Reload the internal AP. **Example:** `Device# wireless ewc-ap ap reload`	

The LSC provisioning has been successfully removed from the wireless controller.

Import a CA certificate to the trustpool (GUI)

PKI Trustpool Management is used to store a list of trusted certificates (either downloaded or built in) used by the different services on the controller. This is also used to authenticate a multilevel CA certificate. The built in CA certificate bundle in the PKI trustpool receives automatic updates from Cisco if they are not current, are corrupt, or if certain certificates need to be updated.

Perform this task to manually update the CA certificates in the PKI trustpool.

Note If your LSC has been issued by an intermediate CA, you must import the complete chain of CA certificates into the trustpool. Otherwise, you will not be able to provision the APs without the complete chain being present on the controller. The import step is not required if the certificate has been issued by a root CA.

Follow these steps to import a CA certificate to the trustpool using GUI:

Procedure

Step 1 Choose **Configuration** > **Security** > **PKI Management**.

Step 2 In the **PKI Management** window, click the **Trustpool** tab.

Step 3 Click **Import**.

Step 4 In the **CA Certificate** field, copy and paste the CA certificate. Link together the multiple CA certificates in **.pem** format.

Step 5 Click **Apply to Device**.

Import a CA certificate to the trustpool

Import a CA certificate to establish trust relationships for secure communications.

The trustpool stores CA certificates that the device uses to validate certificates presented by other entities during secure communications.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Import the root certificate to the trustpool.

Example:

```
Device(config)# crypto pki trust pool import terminal
% Enter PEM-formatted CA certificate.
% End with a blank line or "quit" on a line by itself.
-----BEGIN CERTIFICATE-----
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
-----END CERTIFICATE-----
Aug 23 02:47:33.450: %PKI-6-TRUSTPOOL_DOWNLOAD_SUCCESS:
Trustpool Download is successful
```

You need to paste the CA certificate from the **digicert.com**.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

The CA certificate is successfully imported to the trustpool and can be used for certificate validation.

Clean the CA certificates imported in trustpool (GUI)

Procedure

Step 1 Choose **Configuration** > **Security** > **PKI Management**.

Step 2 In the **PKI Management** window, click the **Trustpool** tab.

Step 3 Click **Clean**.

Note
This erases the downloaded CA certificate bundles. However, it does not erase the built-in CA certificate bundles.

Step 4 Click **Yes**.

Clean CA certificates imported in trustpool (CLI)

You cannot delete a specific CA certificate from the trustpool. However, you can clear all the CA certificates that are imported to the Trustpool.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Erase the downloaded CA certificate bundles.

Example:

```
Device(config)# crypto pki trustpool clean
```

This command does not erase the built-in CA certificate bundles.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press Ctrl-Z to exit global configuration mode.

Create a new trustpoint dedicated to a single CA certificate

Establish a trustpoint that is specifically configured for a single Certificate Authority (CA) certificate to enable secure PKI operations.

A trustpoint represents a Certificate Authority (CA) or identity certificate that is used for PKI operations. Creating a dedicated trustpoint for a single CA certificate helps organize and manage different certificate authorities in the network.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a trustpoint.

Example:

```
Device(config)# crypto pki trustpoint tp-name
```

Example:

```
Device(config)# crypto pki trustpoint tp_name
```

Step 3 Create an enrollment terminal for the trustpoint.

Example:

```
Device(ca-trustpoint)# enrollment terminal
```

Step 4 Exit from the trustpoint configuration.

Example:

```
Device(ca-trustpoint)# exit
```

Step 5 Authenticate the trustpoint.

Example:

```
Device(config)# crypto pki authenticate tp-name
```

Example:

```
Device(config)# crypto pki authenticate tp_name
<<< PASTE CA-CERT in PEM format followed by quit >>>
```

The trustpoint is now created and authenticated with the CA certificate, ready for PKI operations.

Verify LSC configuration

Use show commands to verify Local Security Certificate (LSC) configuration. View wireless management trustpoint details and Local Security Certificate (LSC) provision-related configuration for your access points.

To view the wireless management trustpoint details, use this command:

```
Device# show wireless management trustpoint

Trustpoint  Name : microsoft-ca
Certificate Info : Available
Certificate Type : LSC
Certificate Hash : 9e5623adba5307facf778e6ea2f5082877ea4beb
 Private key Info : Available
```

To view the Local Security Certificate (LSC) provision-related configuration details for an AP, use this command:

```
Device# show ap lsc-provision summary

AP LSC-provisioning : Disabled
Trustpoint used for LSC-provisioning : microsoft-ca
LSC Revert Count in AP reboots : 10

AP LSC Parameters :
```

```
Country : IN
State : KA
City : BLR
Orgn : ABC
Dept : ABC
Email : support@abc.com
Key Size : 2048

AP LSC-provision List : Enabled
Total number of APs in provision list: 3

Mac Address
-----------
0038.df24.5fd0
2c5a.0f22.d4ca
e4c7.22cd.b74f
```

```
Device# show ap lsc-provision summary

AP LSC-provisioning : Disabled
Trustpoint used for LSC-provisioning : lsc-root-tp
Certificate chain status : Available
Number of certs on chain : 2
Certificate hash : 7f9d05183deecac4e5a79db65d538245685e8e30
LSC Revert Count in AP reboots : 1

AP LSC Parameters :
Country : IN
State : KA
City : BLR
Orgn : ABC
Dept : ABC
Email : support@abc.com
Key Size : 2048
EC Key Size : 384 bit

AP LSC-provision List :

Total number of APs in provision list: 2

Mac Addresses :
--------------
1880.90f5.1540
2c5a.0f70.84dc
```

Configure management trustpoint to LSC

Procedure

Step 1 Choose **Administration** > **Management** > **HTTP/HTTPS**.

Step 2 In the **HTTP Trust Point Configuration** section, set **Enable Trust Point** to the **Enabled** state.

Step 3 From the **Trust Points** drop-down list, choose the appropriate trustpoint.

Step 4 Save the configuration.

Configure management trustpoint to LSC (CLI)

Configure management trustpoint to enable Local Significant Certificate (LSC) authentication for access points.

After LSC provisioning, the APs will automatically reboot and join at the LSC mode after bootup. Similarly, if you remove the AP LSC provisioning, the APs reboot and join at non-LSC mode.

In EWC, the internal APs will not automatically reboot. You should manually reboot the internal AP to make it work in LSC and non-LSC mode.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the management trustpoint to LSC.

Example:

```
Device(config)# wireless management trustpoint trustpoint-name
```

Example:

```
Device(config)# wireless management trustpoint microsoft-ca
```

The internal AP will not able to join before a reload, so follow the steps given below to reload the internal AP.

Step 3 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Step 4 Save the configuration.

Example:

```
Device# copy running-config startup-config
```

Step 5 Reload the internal AP.

Example:

```
Device# wireless ewc-ap ap reload
```

This will also reload the controller on the AP.

The management trustpoint is now configured for LSC authentication, and access points will join using LSC mode after rebooting.

AP certificate renewal (LSC)

AP certificate renewal (LSC)

AP certificate renewal (LSC) is a feature that

- allows the renewal of Locally Significant Certificates (LSCs) for Access Points before their expiration
- ensures that the APs can continue to provide seamless services by renewing their certificates in a timely manner
- enables the controller to orchestrate this process to minimize service disruption. The process focuses on automatic renewal mechanisms that do not require manual intervention.

LSC provisioning and renewal methods

This feature supports LSC provisioning for Access Points from two sources. You can provision from the controller through proxy-enrollment or from the Cisco Catalyst Center through secure AP onboarding. These certificates are crucial for your Access Points because they authenticate network communications. This renewal process is essential. Without a valid certificate, Access Points may lose network connectivity and affect network services.

The controller uses these methods to renew certificates:

- **Gradual Succession**: A method where Access Points are renewed one at a time, which is suitable when the number of Access Points that are due for renewal is under a certain threshold.
- **Staggered Rollover**: Access Points are renewed in a staggered fashion, minimizing the impact on radio coverage when the number of Access Points is larger.
- **One-Shot Renewal**: All affected Access Points are renewed simultaneously, which can be disruptive and should be used as a last resort.

Benefits of AP certificate renewal (LSC)

- **Automated Renewal Process**: Reduces the need for manual certificate updates, ensuring continuous service.
- **Seamless Network Operations**: Minimizes network downtime by renewing certificates before they expire.
- **Enhanced Security**: Maintains a high level of security by ensuring that all Access Points have valid certificates.
- **Scalable Management**: Supports staggered AP renewal to reduce impact on network operations.

Requirements for AP certificate renewal (LSC)

Configure the controller and access points to use locally significant certificates before you proceed with certificate renewal.

- Provision the locally significant certificates through the controller (proxy-enrollment) or Cisco Catalyst Center-PNP workflows.
- Define the maintenance windows if scheduling is required for renewal.

Restrictions for AP certificate renewal (LSC)

These restrictions for access point certificate renewal (Local Significant Certificate) are:

- Only one Local Significant Certificate is supported per access point.
- Enable either staggered or one-shot renewal, not both.
- Local Significant Certificate renewal applies to Cisco Wave 2 access points and newer models; older access points do not support this feature.
- The staggered algorithm does not apply to access points in bridge mode. All Local Significant Certificate renewals for bridge mode access points occur at the same time.

Configure AP certificate auto-renewal (LSC) (GUI)

Follow these steps to configure AP certificate auto-renewal (LSC):

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points** > **LSC Provision**.

Step 2 In the **LSC Renewal** section, check the **LSC Auto-Renewal** check box and follow these steps:

a. Enter a value for due time. The valid range is 5 to 60.

b. From the **Renewal Schedule** drop-down list, select an existing calendar profile schedule or click the icon to create a new calendar profile. For more information about creating a calendar profile, see the **Configuring a Calendar Profile (GUI)** and **Configuring a Calendar Profile (CLI)**.

c. Use the slider to enable **Syslog** messages for the LSC renewal updates.

d. From the **Renewal Mode** drop-down list, choose either *One Shot* or *Staggered*.

- If you choose One Shot, all impacted AP LSCs renew in a single iteration.
- If you choose Staggered, the system staggers the LSC renewal configuration for the APs and follow these steps:
  - Enter a value for the iteration expiry to set the expiry time for each iteration.
  - From the **AP LSC Renewal per Iteration** drop-down list, choose one of the following options to configure the percentage of APs to be renewed per iteration: 5%, 15%, or 25%.
  - Enable the **Client Steering** slider to move clients attached to APs undergoing renewal to other APs.
  - Enable the **Client Deauthentication** slider to deauthenticate clients associated with the AP before it starts upgrading.

- From the **Accounting Percentage** drop-down list, select the percentage of APs that should join the controller after each iteration to consider the renewal successful.
- Use the slider to configure **Accounting Action**. If you select **Terminate**, the renewal stops if the configured percentage of APs does not join the controller. If you select **Ignore**, the renewal continues regardless.

Step 3 Click **Apply**.

Configure AP certificate renewal (LSC) (CLI)

Follow these steps to configure AP certificate renewal (LSC) in the controller:

Procedure

Step 1 Enter configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure LSC provisioning on an AP.

Example:

```
Device(config)# ap lsc-provision
```

Step 3 Configure AP certificate renewal.

Example:

```
Device(config)# ap lsc-provision renew
```

Step 4 Renew AP LSCs automatically within the specified number of days.

Example:

```
Device(config)# ap lsc-provision renew due-time number-of-days
```

The valid range is from 5 to 60 days, with a default value of 30 days.

Step 5 Renew all AP LSCs in a single iteration.

Example:

```
Device(config)# ap lsc-provision renew one-shot
```

Note
The one-shot AP LSC renewal feature is disabled by default.

Step 6 Renew AP LSCs automatically in a staggered manner.

Example:

```
Device(config)# ap lsc-provision renew staggered timeout iteration-timeout-in-mins
```

Staggered AP LSC renewal is enabled by default.

Note
You cannot use one-shot and staggered renewal methods at the same time.

iteration-timeout-in-mins: The valid range is from 5 to 60 minutes.

Step 7 Configure time schedule for auto-renewal within a maintenance window.

Example:

```
Device(config)# ap lsc-provision renew scheduler calendar-profile
```

No scheduler is enabled by default.

When no scheduler is applied, the device auto-renews AP LSCs at 24-hour intervals and is triggered daily at 12:00 AM local time.

Note
You must configure the calendar-profile definition beforehand. For more information, see **Configuring a Calendar Profile (CLI)**.

You have successfully configured AP certificate renewal (LSC).

Configure forced renewal of AP certificate (LSC) for individual or multiple APs (GUI)

Follow these steps to configure forced renewal of AP certificate (LSC) for individual or multiple APs via GUI:

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Bulk AP Provisioning**.
Step 2 On the **Select Parameters** page, check the **Renew LSC** check box to renew the LSC for all selected APs.
Step 3 Click **Next**.

Configure forced renewal of AP Certificate (LSC) based on site tag (GUI)

Before you begin

Follow these steps to configure force renewal of AP certificate (LSC) based on site tag:

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags**.
Step 2 In the **Site** tab, check the check box for the required site tag.
Step 3 Click **Renew LSC** and follow these steps:

a. Enter the due time in days. The value must be between 1 and 60.

b. Click **Apply to Device**.

Configure forced renewal of AP Certificate (LSC) based on site tag (CLI)

Follow these steps to configure the forced renewal of an AP certificate (LSC) based on a site tag using the CLI:

Procedure

Step 1 Enable privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Renew a specific site-tag AP that is set to expire within the specified time.

Example:

```
Device# ap lsc renew due-time number-of-days site-tag site-tag-name
```

number-of-days: The valid range is from 1 to 60 days.

The configuration of the forced renewal of an AP Certificate (LSC) based on a site tag is complete.

Configure forced renewal of all APs (GUI)

Follow these steps to configure forced renewal of all APs (GUI):

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 From the **Select an Action** drop-down list, choose **Renew LSC**.

The **Renew LSC** pop-up window is displayed.

Step 3 Enter a due time value in minutes between 5 and 60.

Step 4 Click **Apply to Device**.

Verify AP certificate renewal (LSC)

Lists the various show commands and their outputs during the verification of the AP Certificate Renewal (LSC).

Verify LSC configuration

To verify LSC provision-related configuration details for an AP, use this command:

```
Device# show ap lsc-provision info
AP name     Ethernet MAC     Radio MAC      LSC authentication  LSC workflow    Cert expiry
   Last renew attempt  Last renew failure
=============================================================================================
AP-abc      1111.2222.3333  aaaa.bbbb.ccc0  Port-802.1x         PNP Onboarding  <time-stamp>
  <time-stamp>/NA     reason-code
AP-123      1234.5678.9012  dddd.eeee.fff0  DTLS                SCEP proxy      <time-stamp>
  <time-stamp>/NA     reason-code
AP-xyz      1010.1010.1010  abcd.efab.cde0  DTLS, Port-802.1x   SCEP proxy      <time-stamp>
  <time-stamp>/NA     reason-code
                                      0.0.0.0                         372            64
              AGL          Enabled
```

Verify staggered LSC renewal upgrade configuration

To verify progress and status of staggered LSC renewal upgrade, use this command:

```
Device# show ap upgrade
Status: In progress
From version:
To version: Unknown

Started at: 10/23/2025 08:16:01 IST
Configured percentage: 15
Percentage complete: 0
Expected time of completion: 10/23/2025 08:24:01 IST

Client steering: Enabled
Client de-authentication: Enabled
Accounting percentage: 90%
Iteration expiry time: 15 minutes

Progress Report
---------------
Iterations
----------
Iteration              Start time                        End time                   AP
count
-------------------------------------------------------------------------------------------------
0                      10/23/2025 08:16:01 IST           10/23/2025 08:16:01 IST     0

1                      10/23/2025 08:16:01 IST           10/23/2025 08:18:05 IST     1

2                      10/23/2025 08:18:05 IST           ONGOING                     0


Upgraded
--------
Number of APs: 0
AP Name                          Radio MAC              Iteration       Status
    Site
-------------------------------------------------------------------------------------------------
```

```
In Progress
-----------
Number of APs: 1
AP Name                          Radio MAC
-------------------------------------------------
1815W                            00be.7517.d980

Remaining
---------
Number of APs: 6
AP Name                          Radio MAC
-------------------------------------------------
9166-1                           10f9.20fd.5400
non-9120-1                       488b.0a47.d8c0
9136_1                           687d.b45f.1610
9120-Dev                         a00f.3704.f3a0
9162-antenna                     ecf4.0c0e.9920
9176+alpine                      ecf4.0c92.bac0

APs not handled by Rolling AP Upgrade
-------------------------------------
AP Name                          Radio MAC               Status          Reason for not
handling by Rolling AP Upgrade
-------------------------------------------------------------------------------------------------------------
```

MIC and LSC APs joining the controller

Support for MIC and LSC APs joining the controller

Support for MIC and LSC access points joining the controller is an authorization policy feature that

- allows MIC APs to join LSC-deployed controllers without requiring LSC provisioning
- enables LSC and MIC APs to coexist on the same controller simultaneously, and
- eliminates the need to provision LSC on MIC APs before moving them to LSC-deployed controllers.

Authorization policy behavior changes

The authorization policy behavior differs between software releases:

- **Cisco IOS XE Bengaluru 17.4.1 and earlier**: If your APs have default certificates (Manufacturing Installed Certificates [MIC] or Secure Unique Device Identifier [SUDI]), they cannot join an LSC-deployed controller, where the management certificate of the controller is an LSC. To resolve this issue, provision LSC on your APs. Use the provisioning controller before you move them to the LSC-deployed controller.
- **Cisco IOS XE Bengaluru 17.5.1 onwards**: The new authorization policy configuration allows MIC APs to join the LSC-deployed controller, so that LSC APs and MIC APs can coexist on the controller.

Recommendations and limitations

When you configure the CA server with manual enrollment to accept certificate signing request (CSR), the controller monitors for the CA server response. If the CA server does not respond for 10 minutes, the fallback mode activates.

- Cisco Wave 2 APs regenerate CSR, and a fresh CSR is sent to the CA server.
- Cisco IOS APs restart, and then Cisco IOS APs send a fresh CSR, which is in turn sent to the CA server.

The locally significant certificate (LSC) feature on the controller does not work with password challenge authentication. Therefore, for LSC to work, you must disable password challenge on the CA server.

If you are using Microsoft CA, use Windows Server 2012 or later as the CA server.

MIC and LSC access point authentication

Summary

The Manufacturer Installed Certificate (MIC) and Local Significant Certificate (LSC) access point authentication configuration involves these stages:

- Controller: Manages authentication policies and trustpoint configuration for secure access point connections
- Access points: Require certificate-based authentication to join the controller
- LSC trustpoint: Provides local significant certificate authentication mechanism
- AP certificate policy: Defines authentication requirements and allowed access point lists

Workflow

The key components involved in the MIC and LSC access point authentication configuration are:

1. The network administrator configures the LSC trustpoint on the LSC deployed controller using CLI.

   Configure LSC on the controller (CLI), on page 646

2. The network administrator enables the AP certificate policy on access points using CLI.

   Enable the AP certificate policy on the APs (CLI), on page 646

3. The network administrator configures the AP policy certificate using the GUI interface.

   Configure the AP policy certificate (GUI), on page 648

4. The network administrator configures the allowed list of APs to join the controller using CLI.

   Configure the allowed list of APs to join the controller (CLI), on page 648

Result

Access points are properly authenticated and authorized to join the controller with secure certificate-based authentication enabled.

Configure LSC on the controller (CLI)

The server certificate used by the controller for CAPWAP-DTLS (Control and Provisioning of Wireless Access Points - Datagram Transport Layer Security) is based on the following configuration.

Before you begin

- Ensure that you enable LSC by setting the appropriate trustpoints for the following wireless management services:
  - AP join process: CAPWAP DTLS server certificate
  - Mobility connections: Mobility DTLS certificate
  - NMSP (Network Mobility Services Protocol) and CMX (Connected Mobile Experiences) connections: NMSP TLS certificate

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the LSC trustpoint in the LSC-deployed controller.

Example:

```
Device(config)# wireless management trustpoint trustpoint-name
```

Enable the AP certificate policy on the APs (CLI)

Enable AP certificate policy during CAPWAP-DTLS handshake to allow MIC APs to join the controller.

- If the management trustpoint is a locally significant certificate (LSC), by default, manufacturing installed certificate (MIC) APs fail to join the controller. This configuration acts as an enable or disable configuration knob that allows MIC APs to join the controller.
- This configuration is a controller authorization to allow APs to join MIC at the time of Datagram Transport Layer Security (DTLS) handshake.

To prevent manufacturing installed certificate (MIC) expiry failures, ensure that you configure a policy, as shown here:

- Create a certificate map and add the rules:

```
configure terminal
crypto pki certificate map map1 1
issuer-name co Cisco Manufacturing CA
```



Note You can add multiple rules and filters under the same map. The rule mentioned in the example above specifies that any certificate whose issuer-name contains *Cisco Manufacturing CA* (case insensitive) is selected under this map.

- Use the certificate map under the trustpool policy:

```
configure terminal
crypto pki trustpool policy
match certificate map1 allow expired-certificate
```

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the trustpoint name for the controller certificate chain.

Example:

```
Device(config)# ap auth-list ap-cert-policy allow-mic-ap trustpoint trustpoint-name
```

Note
The allow-mic-ap trustpoint command is required only for the virtual controller (Cisco Catalyst 9800-CL Wireless Controller for Cloud). In all the other appliance controller platforms, the default certificate is selected. This default certificate is manufacturer-installed SUDI.

Step 3 Enable the AP certificate policy during CAPWAP-DTLS handshake.

Example:

```
Device(config)# ap auth-list ap-cert-policy allow-mic-ap
```

Step 4 Enable the AP certificate policy as MIC.

Example:

```
Device(config)# ap auth-list ap-cert-policy mac-address H.H.H policy-type mic
```

Example:

```
Device(config)# ap auth-list ap-cert-policy mac-address 1111.1111.1111 policy-type mic
```

The AP certificate policy is now enabled and configured for MIC APs to join the controller during CAPWAP-DTLS handshake.

Configure the AP policy certificate (GUI)

Procedure

Step 1 Choose **Configuration > Wireless > Access Points**

Step 2 In the **All Access Points** window, click **AP Certificate Policy**.

Step 3 In the **AP Policy Certificate** window, complete the following actions:

a) Click the **Authorize APs joining with MIC** toggle button to enable AP authorization.

b) From the **Trustpoint Name** drop-down list, choose the required trustpoint.

c) Click **Add MAC or Serial Number** to add a MAC address or a serial number manually or through a .csv file.
The **Add MAC or Serial Number** window is displayed.

d) Click the **AP Authlist Type** and enter the MAC address or the serial number. Upload the .csv file or enter the MAC address in the list box.
The newly added MAC address and serial numbers are displayed under **List of MAC Address and Serial Numbers**.

e) Click **Apply**.

The AP certificate policy is added to the **AP Inventory** window.

Note
To add a new AP with MIC, perform Step 1 to Step 3 described in Configuring the AP Policy Certificate (GUI) section. To add a new AP with LSC, perform the procedure described in the Configuring AP LSC Provision List (GUI) and Step 1 to Step 3 in the Configuring the AP Policy Certificate (GUI) section.

Configure the allowed list of APs to join the controller (CLI)

Create an allowed list of access points that can join the controller based on MAC address or serial number authentication.

The allowed list of APs can either be populated based on the Ethernet MAC address or based on the serial number of the APs.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the AP certificate policy based on the Ethernet MAC address or based on the assembly serial number of the AP.

Example:

```
Device(config)# ap auth-list ap-cert-policy mac-address AP-Ethernet-MAC-address policy-type
 mic
```

Example:

```
Device(config)# ap auth-list ap-cert-policy serial-number AP-serial-number policy-type mic
```

Example:

```
Device(config)# ap auth-list ap-cert-policy mac-address 00b0.e192.0d98 policy-type mic
```

The AP certificate policy is configured and the specified access points are added to the allowed list for joining the controller.

Verifying the configuration status

To verify if the APs have been authorized by the AP certificate policy, use this command:

```
Device# show ap auth-list ap-cert-policy
Authorize APs joining with MIC : ENABLED
MIC AP policy trustpoint
Name : CISCO_IDEVID_SUDI
Certificate status : Available
Certificate Type : MIC
Certificate Hash : xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
```

To verify the AP certificate policy on the MAC address and the serial number of the AP, use these commands:

```
Device# show ap auth-list ap-cert-policy mac-address
MAC address      AP cert policy
---------------------------------
1111.2222.3333   MIC
```

```
Device# show ap auth-list ap-cert-policy serial-number
Serial number    AP cert policy
-------------------------------
F1234567890      MIC
```

Note If you set an invalid trustpoint (not SSC), the **allow-mic-ap policy** does not enable. If you set an invalid trustpoint, this error displays on the console:

```
Device(config)# ap auth-list ap-cert-policy allow-mic-ap trustpoint lsc-root-tp
Dec 18 07:38:29.944: %CERT_MGR_ERRMSG-3-CERT_MGR_GENERAL_ERR: Chassis 1 R0/0: wncd: General
 error: MIC AP Policy trustpoint: 'lsc-root-tp' cert-chain type is LSC, It must be either
MIC or vWLC-SSC
```

LSC fallback APs

LSC fallback APs

LSC fallback is a state that

- occurs when an AP configured with LSC for CAPWAP fails to establish DTLS connection after reaching the maximum number of retry attempts
- causes the AP to revert to its default certificate (MIC) for CAPWAP authentication, and

- provides a backup authentication method when LSC-based CAPWAP connection attempts fail.

LSC fallback process

When you configure an AP with LSC for CAPWAP but it fails to establish a DTLS connection, the AP reboots. The AP then retries for a certain number of times. For information on how to configure an AP with LSC, see Configure AP join attempts with LSC certificate (CLI), on page 623.

The AP falls back to its default certificate (MIC) for CAPWAP after maximum number of failures. The AP fallback state is referred to as the LSC fallback.

Note MIC is also known as SUDI certificate.

Troubleshoot LSC fallback state

This task enables you to identify access points in LSC fallback state and understand the recovery process when APs fail to establish proper LSC connections with the controller.

When an AP in LSC fallback state joins the controller, it generates specific syslog messages and is held in a misconfigured state. The AP does not broadcast WLAN or SSID configurations in this state, which permits the admin to examine the reason for previous failures and recover APs.

Procedure

Step 1 Identify the syslog message generated when an AP in LSC fallback state joins the controller.

Example:

```
Jun 15 23:24:14.836: %APMGR_TRACE_MESSAGE-3-WLC_GEN_ERR: Chassis 1 R0/0: wncd: Error
in AP: 'AP2c5a.0f70.84dc' with address 70db.9888.cc20 is joined with MIC, while configuration

requires LSC. No WLANs will be pushed.
```

The controller allows such an AP to be joined with MIC (when AP certificate policy allows it) and AP is held in misconfigured state.

Note
The AP does not broadcast WLAN or SSID configurations in such state. This permits the admin to examine the reason for previous failures and recover APs.

Step 2 Use **show wireless summary** to identify LSC fallback APs.

Example:

```
Device# show wireless summary
…
Access Point Summary
…
DTLS LSC fallback APs     20 (No WLANs will be pushed to these APs)
…
For more information on DTLS LSC fallback APs,
    execute 'wireless config validate' and look for reported errors in
```

```
    'show wireless config validation status' CLI output.

Use 'show ap config general | inc AP Name | LSC fallback' to list DTLS LSC fallback APs.
Examine LSC fallback reasons / DTLS handshake failures with LSC then
    issue 'ap lsc dtls-fallback clear-certificate / clear-flag' to recover APs
```

You have successfully identified LSC fallback APs and understand the commands available for further investigation and recovery.

Recover from LSC fallback

Recover APs from LSC fallback state and restore normal LSC functionality for CAPWAP DTLS connections.

When LSC fallback occurs, APs may require recovery actions to restore normal operation. Recovery options depend on whether you want to retain the LSC certificate or clear it completely.

Procedure

Choose one of the following recovery methods based on your requirements:

- To clear the LSC fallback flag and retain the LSC certificate, use the **ap lsc dtls-fallback clear-flag** command to instruct the AP to reload.

  Note
  The AP reuses the LSC for CAPWAP DTLS connection post the reload.

- To clear the LSC certificate completely, use the **ap lsc dtls-fallback clear-certificate** command to clear LSC and instruct the AP to reload.

  Note
  The AP uses MIC for CAPWAP-DTLS post the reload. If LSC is used for Dot1x port authentication then further recovery is needed on switch port for AP authentication.

Note

- The **ap lsc dtls-fallback clear-flag** command is sufficient to retain LSC on AP. Both **ap lsc dtls-fallback clear-flag** and **ap lsc dtls-fallback clear-certificate** commands are not required at the same time.
- APs must be in connected state when issuing the recovery command. You will need to reissue the command, if any **LSC fallback** AP joins afterwards.

The access point reloads and recovers from the LSC fallback state according to the selected recovery method.

Configuring controller self-signed certificate for wireless AP join

Use cases for controller self-signed certificate for wireless AP join

You need controller self-signed certificates in specific circumstances to enable wireless APs to join the controller successfully.

Controller self-signed certificate use cases

These situations require controller self-signed certificates:

- The Cisco Catalyst 9800-CL platform is not equipped with manufacturer-installed SUDI certificates. Configure self-signed certificates on these controllers.
- Some APs running earlier software and using a Manufacturer Installed Certificate (MIC) issued by a SHA1 Cisco Trusted CA cannot join controllers with SHA2 SUDI certificates. During the CAPWAP join process, these APs display a bad certificate error and fail the DTLS handshake.

Workaround: To support AP upgrades, configure a self-signed certificate for the controller as a workaround for the second use case. After updating all APs, delete the self-signed certificates. Then, revert to the SUDI certificate.

Note This workaround does not apply to Embedded Wireless Controllers running on Catalyst 9000 series switches. It is only valid for hardware appliance controllers such as Cisco Catalyst 9800-40, 9800-80, and 9800-L.

Prerequisites for controller self-signed certificate for wireless AP join

- Ensure that the VLAN interface is up and that the IP address is reachable.
- Ensure that the **ip http server** is enabled. For more information, see Enabling HTTP Server .
- Set the **clock calendar-valid** command appropriately. For more information, see *Configure clock calendar.*
- Check whether the PKI CA server is configured. If it is, delete the existing CA server configuration.

Note The **show crypto pki server** command output should not display anything.

Configure clock calendar (CLI)

Set the clock calendar to ensure accurate timekeeping on the device.

This configuration is necessary for time-sensitive operations and logging on the device.

Before you begin

Access to the device with appropriate privileges to enter global configuration mode.

Follow these steps to configure clock calendar:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable clock calendar.

Example:

```
Device(config)# clock calendar-valid
```

Step 3 Exit configuration mode.

Example:

```
Device(config)# exit
```

The clock calendar is now configured and operational on the device.

Enable HTTP server using CLI

Enable the HTTP server to allow web-based management of the device.

This configuration is applicable for devices that require HTTP access for management purposes.

Before you begin

Ensure you have administrative access to the device.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable the HTTP server on your IP or IPv6 system.

Example:

```
Device(config)# ip http server
```

Enables the HTTP server on your IP or IPv6 system, including a Cisco web browser user interface. By default, the HTTP server uses the standard port 80.

Step 3 Enable the secure HTTP server on your IP or IPv6 system.

Example:

```
Device(config)# ip http secure-server
```

Enables the secure HTTP server on your IP or IPv6 system, providing encrypted access to the web interface.

Step 4 Exit configuration mode.

Example:

```
Device(config)# exit
```

The HTTP server is now enabled, allowing web-based management of the device.

Configure CA server (CLI)

Deploy a CA server to manage certificates for devices in the network.

This configuration is essential for environments that require secure communication through certificates.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Generate RSA keys for the CA server.

Example:

```
Device(config)# crypto key generate rsa general-keys modulus size_of_key_module label
keypair_name
```

Configures a certificate for the controller.

When you generate RSA keys, you are prompted to enter a modulus length. A longer modulus length might be more secure, but it takes longer to generate and to use.

Note
The recommended key-pair name is *WLC_CA* and key modulus is *2048* bits.

Step 3 Enable the IOS certificate server.

Example:

```
Device(config)# crypto pki server certificate_server_name
```

Enables IOS certificate server.

Note
The *certificate_server_name* must be the same name as the *keypair_name*.

Step 4 Configure the issuer name for the CA certificate.

Example:

```
Device(cs-server)# issuer-name O=Cisco Virtual Wireless LAN Controller, CN=CA-vWLC
```

Configures X.509 distinguished name for the issuer CA certificate.

Note
You need to configure the same *issuer-name* as suggested for AP join.

Step 5 Grant certificate requests automatically.

Example:

```
Device(cs-server)# grant auto
```

Grants certificate requests automatically.

Step 6 (Optional) Specify the hash function for the signature used in the granted certificates.

Example:

```
Device(cs-server)# hash sha256
```

Specifies the hash function for the signature used in the granted certificates.

Step 7 (Optional) Specify the lifetime in days of a CA certificate.

Example:

```
Device(cs-server)# lifetime ca-certificate time-interval
```

Specifies the lifetime in days of a CA certificate.

Step 8 (Optional) Specify the lifetime in days of a granted certificate.

Example:

```
Device(cs-server)# lifetime certificate time-interval
```

Specifies the lifetime in days of a granted certificate.

Step 9 Set the CA key and CA certificate archive format and password.

Example:

```
Device(cs-server)# database archive pkcs12 password 0 cisco123
```

Sets the CA key and CA certificate archive format and password to encrypt the file.

Step 10 Enable the certificate server.

Example:

```
Device(cs-server)# no shutdown
```

Enables the certificate server.

Note
Issue this command only after you have completely configured your certificate server.

Step 11 Return to privileged EXEC mode.

Example:

```
Device(cs-server)# end
```

Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

The CA server is now configured and ready to manage certificates for devices in the network.

Configure trustpoint (CLI)

Configure a trustpoint to enable secure communication with a Certificate Authority (CA).

This configuration is necessary for devices that require secure communications and certificate management.

Before you begin

Ensure you have access to the device and the necessary permissions to configure trustpoints.

Follow these steps to configure trustpoint using CLI commands:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Generate RSA keys for the trustpoint.

Example:

```
Device(config)# crypto key generate rsa exportable general-keys modulus
size-of-the-key-modulus label label
```

When you generate RSA keys, you are prompted to enter a modulus length. A longer modulus length might be more secure, but it takes longer to generate and to use.

Step 3 Create a new trustpoint for an external CA server.

Example:

```
Device(config)# crypto pki trustpoint trustpoint_name
```

Here, *trustpoint_name* refers to the trustpoint name.

Note
Ensure that same names are used for key-pair (*label*) and *trustpoint_name*.

Step 4 Map RSA key with that of the trustpoint.

Example:

```
Device(ca-trustpoint)# rsakeypair RSA_key
```

Maps RSA key with that of the trustpoint.

- RSA_key—Refers to the RSA key pair label.
- key_size—Refers to the signature key length. The value ranges from 360 to 4096.

Step 5 Create subject name parameters for the trustpoint.

Example:

```
Device(ca-trustpoint)# subject-name subject_name
```

Specifies the subject name for the trustpoint.

Step 6 Check revocation.

Example:

```
Device(ca-trustpoint)# revocation-check none
```

Specifies whether to check for certificate revocation.

Step 7 Specify the hash algorithm.

Example:

```
Device(ca-trustpoint)# hash sha256
```

Specifies the hash algorithm to be used.

Step 8 Specify the serial number.

Example:

```
Device(ca-trustpoint)# serial-number
```

Specifies the serial number for the trustpoint.

Step 9 (Optional) Set certificate key-usage purpose.

Example:

```
Device(ca-trustpoint)# eku request server-auth client-auth
```

Sets the extended key usage for the certificate.

Step 10 Enable password for the trustpoint.

Example:

```
Device(ca-trustpoint)# password 0 password
```

Step 11 Enroll the URL for the CA server.

Example:

```
Device(ca-trustpoint)# enrollment url url
```

Replace the dummy IP with management VLAN interface IP of the controller where CA server is configured.

Step 12 Exit the configuration mode.

Example:

```
Device(ca-trustpoint)# end
```

The trustpoint is now configured and ready for use with the CA server.

Authenticate and enroll the PKI trustpoint with CA server

Authenticate and enroll the PKI trustpoint to establish a secure connection with the Certification Authority (CA) server.

This procedure is used in environments where a PKI trustpoint needs to be authenticated and enrolled with a Certification Authority (CA) server for certificate management.

Before you begin

Ensure that the Certification Authority (CA) server is reachable and the trustpoint is properly configured.

Follow these steps to authenticate and enroll the PKI trustpoint with CA server:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Authenticate the PKI trustpoint with the CA server.

Example:

```
Device(config)# crypto pki authenticate trustpoint-name
Certificate has the following attributes:
Fingerprint MD5: 64C5FC9A C581D827 C25FC3CF 1A7F42AC
Fingerprint SHA1: 6FAFF812 7C552783
6A8FB566 52D95849 CC2FC050
% Do you accept this certificate? [yes/no]: yes
Trustpoint CA certificate accepted.
```

Fetches the CA certificate.

Step 3 Enroll the PKI trustpoint for a client certificate.

Example:

```
Device(config)# crypto pki enroll trustpoint-name
Enter following answers for UI interaction:
% Include an IP address in the subject name? [no]: no
Request certificate from CA? [yes/no]: yes
```

Step 4 Exit global configuration mode.

Example:

```
Device(config)# end
```

Returns to privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

The PKI trustpoint is now authenticated and enrolled with the Certification Authority (CA) server, allowing for secure certificate management.

Tag wireless management trustpoint name

Tag a wireless management trustpoint name for identification and management purposes.

This configuration is used in environments where wireless management trustpoints need to be clearly identified for management and security.

Before you begin

Ensure you have the necessary privileges to enter global configuration mode.

Procedure

	Command or Action	Purpose
Step 1	Enter global configuration mode. **Example:** `Device# configure terminal`	
Step 2	Tag the wireless management trustpoint name. **Example:** `Device(config)# wireless management trustpoint trustpoint-name`	
Step 3	Exit global configuration mode. **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press Ctrl-Z to exit global configuration mode.

The wireless management trustpoint name is successfully tagged and can be used for management purposes.

Disable PKI server

Disable the PKI server to prevent it from issuing certificates.

This procedure is used in scenarios where the PKI server is no longer needed or must be temporarily disabled.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a new server for an external CA server.

Example:

```
Device(config)# crypto pki server certificate-server-name
```

The *certificate-server-name* refers to the server name.

Note
Here, server_name refers to the server name.

Step 3 Disable the certificate server.

Example:

```
Device(cs-server)# shutdown
```

Update purpose string to \

Step 4 Return to privileged EXEC mode.

Example:

```
Device(cs-server)# end
```

Alternatively, you can also press Ctrl-Z to exit global configuration mode.

The PKI server is now disabled and will not issue certificates.

Verify controller certificates for wireless AP join

Use these commands to verify controller certificates for wireless access point (AP) join.

To view the CA server details, use the command:

```
Device# show crypto pki server
Certificate Server WLC_CA:
Status: enabled
State: enabled
Server's configuration is locked (enter "shut" to unlock it)
Issuer name: O=Cisco Virtual Wireless LAN Controller, CN=CA-vWLC
CA cert fingerprint: 79A3DBD5 59A7E384 73ABD152 C133F4E2
Granting mode is: auto
Last certificate issued serial number (hex): 1
CA certificate expiration timer: 12:04:00 UTC Mar 8 2029
CRL NextUpdate timer: 18:04:00 UTC Mar 11 2019
Current primary storage dir: nvram:
Database Level: Minimum - no cert data written to storage
```

To view the trustpoint details, use this command:

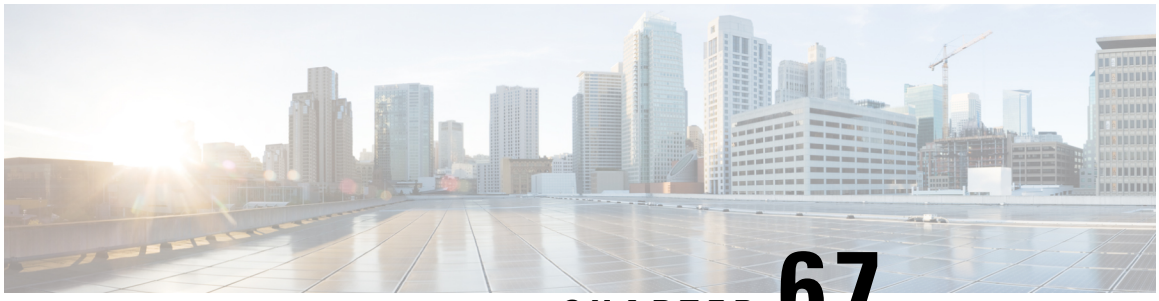
```
Device# show crypto pki trustpoint ewlc-tp1 status
Trustpoint ewlc-tp1:
...
State:
Keys generated ..... Yes (General Purpose, exportable)
Issuing CA authenticated ..... Yes
Certificate request(s) ..... Yes
```

To view the wireless management trustpoint details, use this command:

```
Device# do show wireless management trustpoint
Trustpoint Name : ewlc-tp1
Certificate Info : Available
Certificate Type : SSC
Certificate Hash : 4a5d777c5b2071c17faef376febc08398702184e
Private key Info : Available
FIPS suitability : Not Applicable
```

To view the Hypertext Transfer Protocol (HTTP) server status, use this command:

```
Device# show ip http server status | include server status
HTTP server status: Enabled
HTTP secure server status: Enabled
```



CHAPTER 67

Federal Information Processing Standard

- Federal Information Processing Standard , on page 661
- Guidelines and Restrictions for FIPS, on page 661
- FIPS Self-Tests, on page 662
- Configuring FIPS, on page 663
- Verifying FIPS Configuration, on page 663

Federal Information Processing Standard

Federal Information Processing Standard (FIPS) 140-2 is a security standard used to validate cryptographic modules. The cryptographic modules are produced by the private sector for use by the U.S. government and other regulated industries (such as financial and healthcare institutions) that collect, store, transfer, share and disseminate sensitive but unclassified (SBU) information.

Note Cisco TrustSec (CTS) is not supported when the controller is in FIPS mode.

For more information about FIPS, see

https://www.cisco.com/c/en/us/solutions/industries/government/global-government-certifications/fips-140.html.

Guidelines and Restrictions for FIPS

- In the controller, a legacy key is used to support the legacy APs. However, in FIPS mode, the crypto engine detects the legacy key as a weak key and rejects it by showing the following error message: "**% Error in generating keys: could not generate test signature.**" We recommend that you ignore such error messages that are displayed during the bootup of the controller (when operating in FIPS mode).
- SSH clients using SHA1 will not be able to access the controller when you enable FIPS. You need to use FIPS compliant SSH clients to access the controller.
- While configuring WLAN ensure that the SSID name contain a minimum of 15 characters. If not, the APs will not be able to join the controller after changing tags.
- TrustSec is not supported.

- PAC key configuration is not supported.
- APs would not reload immediately, if you change the FIPS status.
- With FIPS in enabled state, some passwords and pre-shared keys must have the minimum lengths, for example the ISAKMP key (Crypto ISAKMP key) must be at least 14 characters long.:
- We recommend a minimum RSA key size of 2048 bits under RADSEC when operating in FIPS mode. Otherwise, the RADSEC fails.

FIPS Self-Tests

A cryptographic module must perform power-up self-tests and conditional self-tests to ensure that it is functional.

Power-up self-tests run automatically after the device powers up. A device goes into FIPS mode only after all self-tests are successfully completed. If any self-test fails, the device logs a system message and moves into an error state. Also, if the power-up self test fails, the device fails to boot.

Using a known-answer test (KAT), a cryptographic algorithm is run on data for which the correct output is already known, and then the calculated output is compared to the previously generated output. If the calculated output does not equal the known answer, the known-answer test fails.

Power-up self-tests include the following:

- Software integrity
- Algorithm tests

Conditional self-tests must be run when an applicable security function or operation is invoked. Unlike the power-up self-tests, conditional self-tests are executed each time their associated function is accessed.

The device uses a cryptographic algorithm known-answer test (KAT) to test FIPS mode for each FIPS 140-2-approved cryptographic function (encryption, decryption, authentication, and random number generation) implemented on the device. The device applies the algorithm to data for which the correct output is already known. It then compares the calculated output to the previously generated output. If the calculated output does not equal the known answer, the KAT fails.

Conditional self-tests run automatically when an applicable security function or operation is invoked. Unlike the power-up self-tests, conditional self-tests are executed each time their associated function is accessed.

Conditional self-tests include the following:

- Pair-wise consistency test—This test is run when a public or private key-pair is generated.
- Continuous random number generator test—This test is run when a random number is generated.
- Bypass
- Software load

Configuring FIPS

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**fips authorization-key** [*option*] *key* **Example:** `Device(config)# fips authorization-key 0 12345678901234567890123456789012`	Enables the FIPS mode. The options are as follows: • **0**: Specifies that an UNENCRYPTED password will follow. • **7**: Specifies that an ENCRYPTED password will follow. • **LINE**: Use the cleartext 128-bits (16 octet) key. The *key* length should be of 32 hexadecimal characters. To disable FIPS mode on the device, use the **no** form of this command.
Step 3	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

What to do next

You must reboot the controller whenever you enable or disable the FIPS mode using the **reload** command.

After the system reloads, all the APs are FIPS enabled except the internal AP (Internal AP is the AP acting as the EWC). Therefore, reload the internal AP using the **wireless ewc-ap ap reload** command.

After the internal AP reload, the standby controller becomes the new active controller, and all APs are FIPS enabled.

Verifying FIPS Configuration

You can verify FIPS configuration using the following commands:

Use the following **show** command to display the installed authorization key:

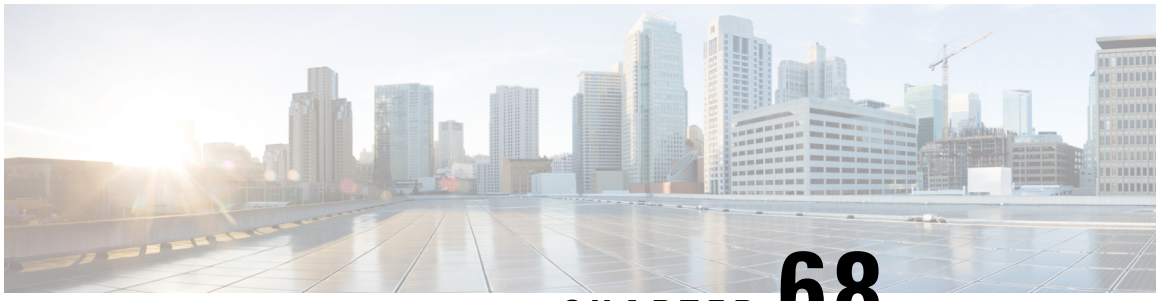
```
Device# show fips authorization-key
```

```
FIPS: Stored key (16) : 12345678901234567890123456789012
```

Use the following **show** command to display the status of FIPS on the device:

```
Device# show fips status

Chassis is running in fips mode
```



CHAPTER 68

Certificate Management

- About PKI management (GUI), on page 665
- Authenticate and enroll a Public Key Infrastructure (PKI) trustpoint (GUI), on page 666
- Add the CA server (GUI), on page 667
- Add an RSA or EC Key for PKI trustpoint (GUI), on page 668
- Add and manage certificates , on page 668

About PKI management (GUI)

A public key infrastructure (PKI) management is a network application tool that

- enables graphical configuration of PKI components using GUI.
- provides tabs for configuring and monitoring trustpoints, certificate authorities, keys, and certificates,
- allows administrators to generate, enroll, and manage cryptographic credentials for secure communications, and

Feature history

Feature Name	Release	Description
Enhanced Certificate Management Through GUI	Cisco IOS XE 17.3.1	The PKI Management page now includes tabs for Trustpoints, CA Server, Key Pair Generation, and Certificate Management operations.

Tabs for PKI management in GUI

- **Trustpoints tab:** Add, create, or enroll a new trustpoint, view the current trustpoints and their usage.
- **CA Server tab**: Enable or disable Certificate Authority (CA) server functionality. This is required for generating a self-signed certificate (SSC).
- **Key Pair Generation tab**: Generate key pairs.
- **Certificate Management tab**: Generate and manage certificates, and perform all certificate-related operations.

Restriction: CSR generation on the GUI may hang indefinitely

The controller's GUI-based certificate management feature relies on Embedded Event Manager (EEM) scripts. If TACACS command authorization is enabled, the user is authenticated on the GUI but the controller does not pass the user details to the EEM environment. As a result, the user is not authorized, and the user cannot enter the configuration mode using the EEM scripts.

The restriction applies if you have this command-authorization configuration:

```
aaa authorization commands 1 MethodName group GroupName local if-authenticated
aaa authorization commands 15 MethodName group GroupName local if-authenticated
ip http authentication aaa command-authorization 1 MethodName
ip http authentication aaa command-authorization 15 MethodName
```

To resolve this issue, enter this command before you generate the Certificate Signing Request (CSR) using the GUI. For proper authorization, configure the desired username.

```
event manager session cli username <username>
```

After you issue the CSR using the GUI, remove this configuration.

The restriction does not affect CSR generation through the CLI.

Authenticate and enroll a Public Key Infrastructure (PKI) trustpoint (GUI)

Use this procedure to add and authenticate a Public Key Infrastructure (PKI) trustpoint to enable certificate-based security for your device.

Before you begin

Obtain the enrollment URL and certificate authority information from your network administrator.

Procedure

Step 1 Choose **Configuration** > **Security** > **Public Key Infrastructure (PKI) Management**.

Step 2 In the **Public Key Infrastructure (PKI) Management** window, click the **Trustpoints** tab.

Step 3 In the **Add Trustpoint** dialog box, provide this information:

a) In the **Label** field, enter the RSA key label.
b) In the **Enrollment URL** field, enter the enrollment URL.
c) Check the **Authenticate** check box to authenticate the Public Certificate from the enrollment URL.
d) In the **Subject Name** section, enter the **Country Code**, **State**, **Location**, **Organization**, **Domain Name**, and **Email Address**.
e) Check the **Key Generated** check box to view the available RSA keypairs. Choose an option from the **Available RSA Keypairs** drop-down list.
f) Check the **Enroll Trustpoint** check box.
g) In the **Password** field, enter the password.
h) In the **Re-Enter Password** field, confirm the password.
i) Click **Apply to Device**.

The new trustpoint is added to the trustpoint name list.

The new trustpoint is now listed in the trustpoint name list and is ready for use.

What to do next

After enrolling the trustpoint, configure it for use with your security policies or certificate-based authentication features.

Generate an AP self-signed certificate (GUI)

Create a self-signed certificate (SSC) for APs on a virtual controller using the graphical interface.

Use this procedure only for virtual controllers.

- Cisco Catalyst 9800-CL Wireless Controller for Cloud
- Cisco Catalyst 9800-40 Wireless Controller
- Cisco Catalyst 9800-80 Wireless Controller
- Cisco Catalyst 9800-L Wireless Controller (Copper uplink)
- Cisco Catalyst 9800-L Wireless Controller (Fiber uplink)

Procedure

Step 1 Choose **Configuration** > **Security** > **PKI Management**.

Step 2 In the **AP SSC Trustpoint** area, click **Generate** to generate an AP SSC trustpoint.

Step 3 From the **RSA Key-Size** drop-down list, choose a key size.

Step 4 From the **Signature Algorithm** drop-down list, choose an option.

Step 5 From the **Password Type** drop-down list, choose a password type.

Step 6 In the **Password** field, enter a password. The valid range is between 8 and 32 characters.

Step 7 Click **Apply to Device**.

The controller creates and applies a new self-signed certificate for the AP.

Add the CA server (GUI)

Register a new certificate authority (CA) server in the system using the graphical user interface.

Perform this task when you need to establish a new certificate authority for PKI management.

Procedure

Step 1 Choose **Configuration** > **Security** > **PKI Management**.

Step 2 In the **PKI Management** window, click the **CA Server** tab.

Step 3 In the **CA Server** section, click the **Shutdown Status** to enable the status. If you choose the shutdown status as **Enabled**, enter and confirm the password.

Step 4 If you choose the shutdown status as **Disabled**, you must enter the **Country Code**, **State**, **Location**, **Organization**, **Domain Name**, and **Email Address**.

Step 5 Click **Apply** to add the CA server.

Step 6 Click **Remove CA Server** to delete the CA server.

The certificate authority server is added and configured as specified.

Add an RSA or EC Key for PKI trustpoint (GUI)

To enable certificate-based authentication, add an RSA or EC key to a PKI trustpoint.

Procedure

Step 1 Choose **Configuration > Security** > **PKI Management**.

Step 2 In the **PKI Management** window, click the **Key Pair Generation** tab.

Step 3 In the **Key Pair Generation** section, click **Add**.

Step 4 In the dialog box that is displayed, provide this information:

a) In the **Key Name** field, enter the key name.

b) In the **Key Type** options, select either **RSA Key** or **EC Key**.

c) In the **Modulus Size** field, enter the modulus value for the RSA key or the EC key. The default modulus size for the RSA key is 4096 and the default value for the EC key is 521.

d) Check the **Key Exportable** check box to export the key. By default, this is checked.

e) Click **Generate**.

A new RSA or EC key is created for the PKI trustpoint and is ready for use in certificate operations.

Add and manage certificates

To add and manage certificates, use one of these methods.

Generate and import a certificate signing request (CSR)

Secure the system by adding and managing device certificates.

Perform this task when onboarding a new device, renewing expiring certificates, or updating trust relationships.
Before you begin

- When configuring a password for the .pfx file, avoid using these ASCII characters: "*, ^, (), [], \, ", and +". Using these ASCII characters results in a configuration error and prevents the certificate from being imported to the controller.
- Ensure you have the required certificate files and CA information.

Before you begin

You can add and manage certificates using either of the following methods:

Procedure

Step 1 Choose **Configuration** > **Security** > **PKI Management** > **Add Certificate**.

Step 2 Click **Generate Certificate Signing Request**.

a) In the **Certificate Name** field, enter the certificate name.
b) From the **Key Name** drop-down list, choose an RSA key pair. (Click the plus (+) icon under the **Key Pair Generation** tab to create new RSA key pairs.).
c) Enter values in the **Country Code**, **Location**, **Organization**, **State**, **Organizational Unit**, and the **Domain Name** fields.
d) Click **Generate**.
The generated Certificate Signing Request (CSR) is displayed on the right. Click **Copy** to copy and save a local copy. Click **Save to Device** to save the generated CSR to the /bootflash/csr directory.

Note
If an IP address is used on the Domain Name field the controller creates the CSR without a Subject Alternative Name (SAN), since the IP address is not supported as an attribute in the SAN field of the CSR when the CSR is generated from the controller.

Step 3 Click **Authenticate Root CA**.

a) From the **Trustpoint** drop-down list, choose the trustpoint label generated in Step 2, or any other trustpoint label that you want to authenticate.
b) In the **Root CA Certificate (.pem)** field, copy and paste the certificate that you have received from the CA.

Note
Ensure that you copy and paste the PEM Base64 certificate of the issuing CA of the device certificate.

c) Click **Authenticate**.

Step 4 Click **Import Device Certificate**.

a) From the **Trustpoint** drop-down list, choose the trustpoint label that was generated in Step 2, or any other trustpoint label that you want to authenticate.
b) In the **Signed Certificate (.pem)** field, copy and paste the signed certificate that you received, from your CA.
c) Click **Import**.

This completes the device certificate import process and the certificate can now be assigned to features.

Import a PKCS12 certificate

Import a PKCS12 certificate into the system to enable secure authentication and encryption for network communications.

Use this task when you need to install a PKCS12 certificate file for system, server, or application authentication.

The certificate can be located on any of these sources: FTP, SFTP, TFTP, SCP, or Desktop (HTTPS).

Before you begin

Obtain the PKCS12 certificate file and its password.

Procedure

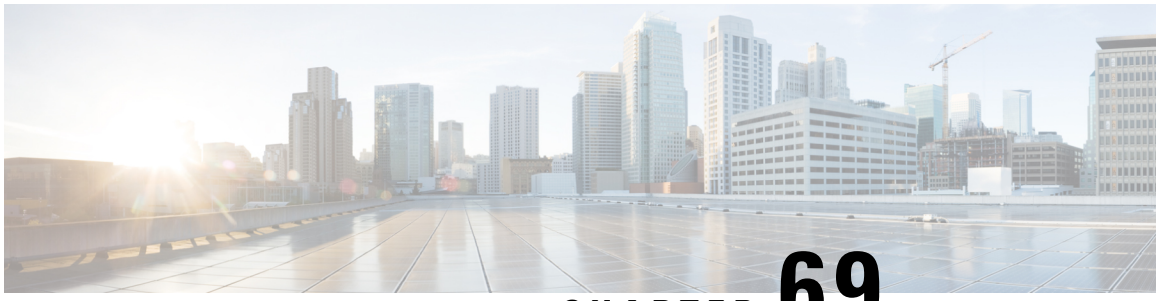
Step 1 Click **Import PKCS12 Certificate**.

Step 2 From the **Transport Type** drop-down list, choose either **FTP**, **SFTP**, **TFTP**, **SCP**, or **Desktop (HTTPS)**.

Transport Type	Action
For **FTP**, **SFTP**, and **SCP**	enter values in the **Server IP Address (IPv4/IPv6)**, **Username**, **Password**, **Certificate File Path**, **Certificate Destination File Name**, and **Certificate Password** fields.
For **TFTP**	enter values in the **Server IP Address (IPv4/IPv6)**, **Certificate File Path**, **Certificate Destination File Name**, and **Certificate Password** fields.
For **Desktop (HTTPS)**	enter values in the **Source File Path** and **Certificate Password** fields.

Step 3 Click **Import**.

The system imports the PKCS12 certificate. You see a confirmation message when the process completes successfully.



CHAPTER 69

User and Entity Behavior Analysis

•
• Information About User and Entity Behavior Analysis , on page 671
• Configuring User and Entity Behavior Analysis (Using UDP Collector), on page 671
• Configuring User and Entity Behavior Analysis (Using Stealthwatch Cloud), on page 672
• Mapping Stealthwatch Cloud to Flow Measurements, on page 673
• Example: Stealthwatch Cloud Configuration , on page 674
• Verifying Stealthwatch Cloud Details, on page 675

Information About User and Entity Behavior Analysis

User and Entity Behavior Analysis (UEBA) is a solution that has a number of security techniques, which allow you to profile and track the behavior of users and devices, in order to identify potential inside threats and targeted attacks in networks, when anomalies occur.

For instance, employees of an enterprise may unintentionally download a malicious piece of software that might include some backdoor or leakage in company secrets. This is detected by the change in the pattern of communication from one or more devices or users in the network, compared to an established baseline.

User and Entity Behavior Analysis can be deployed using two methods:

- User Datagram Protocol (UDP) collector (Cisco Digital Network Architecture (DNA) Center is a UDP collector)
- Stealthwatch Cloud (SwC) - The Embedded Wireless Controller (EWC) directly uploads data to SwC.

Configuring User and Entity Behavior Analysis (Using UDP Collector)

In a Cisco DNA Center-based deployment, the controller acts as the collector of NetFlow information that is sent to Cisco DNA Center. In turn, Cisco DNA Center compresses the information for SwC. The controller enables Application Visibility and Control (AVC) on the access points (APs) and maintains the communication channel with Cisco DNA Center.

In EWC, you can also send FnFv9 data through the UDP to a UDP collector.

In the Non-Cisco DNA-C based deployment, the FnF flow records are directly sent to SwC from the controller.

Configuring User and Entity Behavior Analysis (Using Stealthwatch Cloud)

The following sections provide information about configuring the User and Entity Behavior Analysis solution using Stealthwatch Cloud (GUI and CLI).

Configuring User and Entity Behavior Analysis Using Stealthwatch Cloud (GUI)

Procedure

Step 1 Choose **Configuration** > **Security** > **Threat Defense**.
Step 2 Click **Cisco StealthWatch Integration**.
Step 3 On the Stealthwatch page, in the **Service Key** field, enter the Stealthwatch cloud service key.
Step 4 Click the cloud icon to view the detailed statistics of Stealthwatch.
Step 5 In the **Sensor Name** field, enter a sensor name for Stealthwatch Cloud registration.
Step 6 In the **URL** field, enter the Stealthwatch Cloud server URL.
Step 7 Click **Apply**.
Step 8 (Optional) Click **Unconfigure StealthWatch**, to unconfigure Stealthwatch Cloud.

What to do next

You can view and verify the Stealthwatch Cloud's health status in the **Stealthwatch Health Status**

Configuring Stealthwatch Cloud (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**stealthwatch-cloud-monitor** **Example:** `Device(config)# stealthwatch-cloud-monitor`	Configures the Stealthwatch Cloud monitor. Enters the Stealthwatch Cloud Monitor configuration mode.

	Command or Action	Purpose
Step 3	**service-key** *swc-service-key* **Example:** `Device(config-stealthwatch-cloud-monitor)# service-key xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx`	(Optional) Sets the Stealthwatch Cloud service key. Service key is provided by the SwC portal. The alternative to service key is the authentication through the IP address allowed list. For more information about service key and allowed lists, see the appropriate SwC guide.
Step 4	**sensor-name** *swc-sensor-name* **Example:** `Device(config-stealthwatch-cloud-monitor)# sensor-name swc-sensor-name`	(Optional) Provides a sensor name for the Stealthwatch Cloud registration. The device serial number is the default value.
Step 5	**url** *SwC-server-url* **Example:** `Device(config-stealthwatch-cloud-monitor)# url https://sensors.eu-2.obsrvbl.com`	Sets the Stealthwatch Cloud server URL.

Mapping Stealthwatch Cloud to Flow Measurements

There are two options to map Stealthwatch Cloud to flow measurements, namely the flow-exporter configuration and the flow-monitor configuration.

Note At any given period, there can be only one internal and one external active flow exporter. An active flow exporter is an exporter that is bound to the flow monitor that is bound to a wireless profile.

Configuring Flow Exporter for Stealthwatch Cloud

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**flow exporter** *flow-exporter-name* **Example:** `Device(config)# flow exporter flow-exporter-name`	Defines the flow exporter. **Note** At a given moment, there can be only one internal and one external active flow exporter. An active flow exporter is an exporter that is bound to the flow monitor, which is bound to a wireless profile.

	Command or Action	Purpose
Step 3	**destination stealthwatch-cloud** **Example:** `Device(config-flow-exporter)# destination stealthwatch-cloud`	Exports the flow information to Stealthwatch Cloud.

Configuring Flow Monitor for Stealthwatch Cloud

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**flow monitor** *flow-monitor-name* **Example:** `Device(config)# flow monitor flow-monitor-name`	Defines the flow monitor.
Step 3	**exporter** *flow-exporter-name* **Example:** `Device(config-flow-monitor)# exporter flow-exporter-name`	Exports the flow information to the exporter.
Step 4	**record wireless avc basic** **Example:** `Device(config-flow-monitor)# record wireless avc basic`	Specifies the flow record with basic IPv4 wireless AVC template.
Step 5	**end** **Example:** `Device(config-flow-monitor)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Example: Stealthwatch Cloud Configuration

The following example shows a complete CLI configuration of Stealthwatch Cloud:

```
stealthwatch-cloud-monitor
  service-key XXXXXXXXXXXXXXXXXXXXXXXXXXXX
  sensor-name ewc-sensor
  url https://sensors.eu-2.obsrvbl.com

flow exporter fexp-swc
 destination stealthwatch-cloud
```

```
flow monitor fm-avc-swc
 exporter fexp-swc
 record wireless avc basic

wireless profile policy swc-policy-profile
 ipv4 flow monitor fm-avc-swc input
 ipv4 flow monitor fm-avc-swc output
 ipv6 flow monitor fm-avc-swc input
 ipv6 flow monitor fm-avc-swc output

wlan my-wlan 1 my-wlan

wireless tag policy swc-policy-tag
 wlan my-wlan policy swc-policy-profile

ap 0000.0000.0001
 policy-tag swc-policy-tag
```

Verifying Stealthwatch Cloud Details

To verify the state and statistics of Stealthwatch Cloud, use the **show stealthwatch-cloud wireless-shim** command:

```
Device# show stealthwatch-cloud wireless-shim
Stealthwatch-Cloud wireless shim

Total
 RX records        : 15
 RX bytes          : 2345
 TX records        : 10
 TX bytes          : 1234
 TX batches        : 1
 Failed batches    : 0
 Non-SWC records   : 5

Buffers
 Status        : TX
 Size          : 1272000
 Compressed    : 8
 Uncompressed  : 0
 Records       : 8

 Status        : Filling
 Size          : 1272000
 Compressed    : 2
 Uncompressed  : 0
 Records       : 2
```

To verify the Stealthwatch Cloud connection details, use the **show stealthwatch-cloud connection** command.

```
Device# show stealthwatch-cloud connection
Stealthwatch-Cloud details
  Registration
    #ID         : 0xe6000001
    URL         : https://sensors.eu-2.obsrvbl.com
    Service Key : XXXXXXXXXXXXXXXXXXXXXXXXXXXX
    Sensor Name : ewc-sensor
    Registered  : Yes
  Connection
    Status               : UP
    Last status update   : 03/17/2020 21:44:55
    # Flaps              : 0
```

```
    # Heartbeats         : 9
    # Lost heartbeats    : 1
    Total RX bytes       : 4567
    Total TX bytes       : 1234
    Upload Speed (B/s)   : 247
    Download Speed (B/s) : 269
    # Open sessions      : 0
    # Redirections       : 0
    # Timeouts           : 0

  HTTP Events
    GET response                  : 1
    GET request                   : 1
    GET Status Code 2XX           : 1
    PUT response                  : 1
    PUT request                   : 1
    PUT Status Code 2XX           : 1
    POST response                 : 12
    POST request                  : 12
    POST Status Code 2XX          : 11
    POST Status Code 4XX          : 1
API Events
    Abort                         : 1

  Event History
Timestamp               #Times   Event               RC Context
----------------------- -------- ------------------ --
----------------------------------------
03/21/2020 10:42:06.161 9        HEARTBEAT_OK         0

03/20/2020 06:49:05.717 1        HEARTBEAT_FAIL       0 HTTPCON_EV_TIMEOUT (6)

03/20/2020 06:47:05.717 1        SEND_START           0 ID:0001
03/20/2020 06:49:05.717 3        SIGNAL_DATA_FAIL     0 ID:0001, attempt : 3
03/18/2020 09:23:39.375 1        REGISTER_OK          0

03/18/2020 09:23:13.276 1        REGISTER_SEND        0

03/18/2020 09:23:12.154 1        SEND_ABORT_ALL       0 config change

03/18/2020 09:23:12.154 1       OPTIONS_CONFIG      0 URL https://sensor.staging.obsrvbl.com

03/18/2020 09:23:12.154 1       OPTIONS_CONFIG      0 Service-key XXXXXXXXXXXXXXXXXXXXXXXX
03/18/2020 09:23:12.154 1        OPTIONS_CONFIG       0 Host ewc-sensor => reset

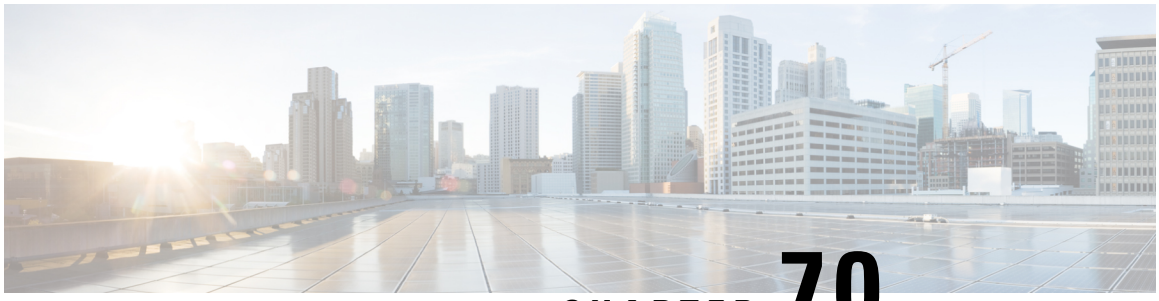
03/18/2020 09:23:12.154 1        OPTIONS_CONFIG       0 cfg-mode manual => reset
```



PART VII

Mobility

- NAT Support in Embedded Wireless Controllers, on page 679



CHAPTER 70

NAT Support in Embedded Wireless Controllers

- Information About NAT Support, on page 679
- Restrictions for NAT Support , on page 679
- Enabling Centralized NAT on a VLAN, on page 680
- Verifying NAT Support, on page 680

Information About NAT Support

Network Address Translation (NAT) allows a device to act as an agent between the Internet (public) and a local network (private). It maps the controller's intranet IP addresses to a corresponding external address. The AP-manager interface of the controller must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

The master AP in an Embedded Wireless Controller (EWC) network performs NAT on the wireless client traffic. This is achieved by translating the public and private IP addresses of the clients. Depending on the placement and number of NATs, the translation may be required at one or both ends of the tunnel.

The master AP performs NAT for the guest WLAN. However, this is not required for the employee WLAN. The IP address for the clients connected to the guest WLAN is provided by the internal DHCP server running on the master AP, whereas the clients connected to the employee WLAN gets the IP address from an external DHCP server.

The master AP acts as a gateway to the traffic coming from the clients connected to the NAT-ed WLAN and performs address translation. The clients connected to the non NAT-ed WLAN uses the gateway provided by the external DHCP server to send the traffic.

For centralized NAT WLANs, the controller provisions the VLAN mapping to the specific WLAN. When performing NAT, both the private IP address (address in the network before the NAT device) and the public IP address (address in the public network) has to be configured.

The external DHCP server provides the IP addresses for the APs. The master AP requires two IP addresses, one for the internal AP and one for when it is acting as a wireless controller. The internal DHCP server is not used to assign IP addresses to the APs connected to the network. The external DHCP server is used to provide the IP address to the clients on non- NAT-ed WLANs.

Restrictions for NAT Support

- When centralized NAT is enabled, wired to wireless client traffic on the same VLAN is not supported.

- The WLAN, where centralized NAT is enabled, must also be provisioned on the master AP.
- Client DHCP server must run on the EWC for centralized NAT to work. External DHCP servers are not supported.

Enabling Centralized NAT on a VLAN

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

Step 2	**wireless ewc-ap centralized-nat vlan** *vlan-id*
	Example:
	`Device(config)# wireless ewc-ap centralized-nat`
	`test-vlan 10`
		Enables centralized NAT on a VLAN.

Step 3	(Optional) **wireless ewc-ap centralized-nat vlan** *vlan-id* **peer-blocking**
	Example:
	`Device(config)# wireless ewc-ap centralized-nat`
	`test-vlan 10 peer-blocking`
		Configures peer to peer blocking.

Step 4	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

Verifying NAT Support

To view the history of the AP datapath programming for centralized NAT, use the below command:

```
Device# show wireless mob-exp centralized-nat history

Centralized NAT Global event history:
Timestamp Event RC Context
------------------------- ----------- ---- -------
06/17/2019 05:28:39.962760 Route add 0 100.100.100.0/255.255.255.0 0.0.0.0 2
06/17/2019 05:28:39.961794 VLAN update 0 0-4095 0,10 1,100 1
06/17/2019 05:28:39.961162 Route add 0 10.10.10.0/255.255.255.0 0.0.0.0 1
Centralized NAT AP DP plumbing client event history:
Timestamp Event RC Context
------------------------- ----------- ---- -------
06/17/2019 05:37:55.827602 Client del 0 10.10.10.3
06/17/2019 05:37:55.826296 Client del 0 10.10.10.3
```

```
06/17/2019 05:37:32.160737 Client add 0 MAC b8:27:eb:27:f3:f6, IP 10.10.10.4, WLAN 2
06/17/2019 05:37:31.454851 Client del 0 10.10.10.4
06/17/2019 05:37:31.453479 Client del 0 10.10.10.4
06/17/2019 05:36:25.659639 Client add 0 MAC b8:27:eb:27:f3:f6, IP 10.10.10.4, WLAN 1
06/17/2019 05:35:52.513500 Client add 0 MAC b8:27:eb:be:08:ea, IP 10.10.10.3, WLAN 1
```

To view the NAT status, use the below command on the AP:

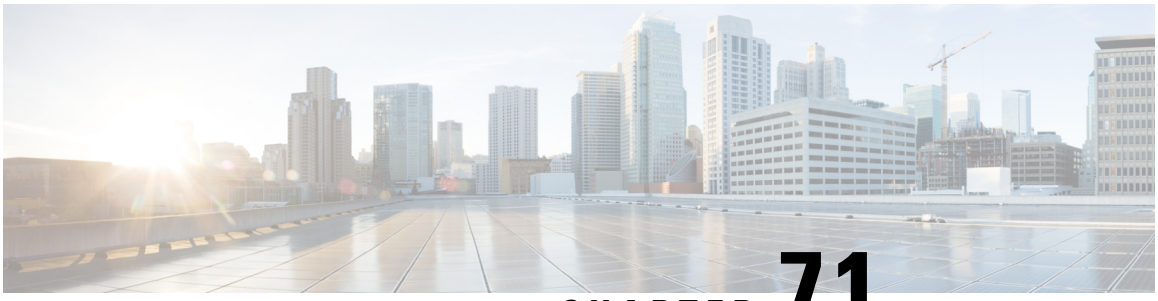
```
Device# show flexconnect ewc-ap nat status
Programmed WLC IP
9.9.71.50
Programmed Vlan Config
output 0: vlan 0-9,11-4095
output 1: vlan 10
Programmed Route Table
0.0.0.0/0 1.1.1.1                       0
10.10.10.0/24 -                         2
NAT and P2P Block Status:
WLAN    NAT-Enabled        P2P-Block
  0       false              false
  1       true               false
```



PART VIII

High Availability

- High Availability, on page 685



CHAPTER 71

High Availability

- High Availability Active and Standby, on page 685
- Active Access Point election Process, on page 686

High Availability Active and Standby

The Cisco Embedded Wireless Controller on Catalyst Access Points (EWC), is supported on the Cisco Catalyst 9100 series APs. The active AP election process determines which of the Cisco Catalyst 9100 series APs is elected to run the EWC controller function. Once the active AP is elected and other subordinate EWC-capable Cisco Catalyst 9100 series APs join the active AP, it selects a standby AP and redundancy is formed.

This High Availability (HA) architecture is based on the Cisco Catalyst 9800 HA architecture, with a few additions:

HA pairing is different in EWC. For the initial bring-up, the EWC active AP waits until all the APs join the controller. The active AP then selects the designated standby AP (either by auto-selection or configuration), and communicates the role and the HA parameters (local/peer IP, keepalive interval, priority) to the selected AP, through a CAPWAP control message.

Note After a power outage, the standby AP does not come up in the EWC HA pair. The standby AP tries to come up but fails. Then another EWC capable AP is selected as standby, which fails to come up. To avoid this situation, ensure that the APs have the same IP version to be elected as a HA pair.

Note With FIPS and HA configuration, to choose a preferred standby EWC, after running the command, switch off the current standby AP and wait for the chosen preferred AP to become the standby AP. Then switch on the old standby AP.

The selected standby AP starts and dynamically configures the HA parameters without manual intervention.

Monitoring Redundancy between Active and Standby Access Points

To view the redundancy between active AP and standby APs, follow the steps given below:

Procedure

Step 1 Open the Cisco Embedded Wireless Controller for Catalyst Access Points GUI.

Step 2 Choose **Monitoring** > **General** > **System**.

Step 3 Click the **Redundancy** tab.

In the **General** tab, you can view the current state, peer state, redundancy modes, and the chassis details of the active and standyby APs.

Active Access Point election Process

The EWC election process is used to choose the AP on which the controller is started. Virtual Router Redundancy Protocol (VRRP) is used to elect the active AP. The logic used to elect the EWC active AP and standby AP is described in the following sections.

Selecting the Active EWC Access Point

The following points are used to compare and select an Active EWC AP:

- If you have configured an AP to be a preferred controller, it takes the highest precedence.
- The AP type is compared next. The APs with higher model numbers have higher values. The AP having the highest value becomes the active AP.
- If the APs have the same AP type, the client load (number of associated clients) is compared, and the AP with the smallestclient load is selected.
- If all the methods mentioned above fail (all are equal among the APs), then the AP with the lowest MAC address becomes the active AP.

Selecting the Standby EWC Access Points

The standby EWC AP is not selected using VRRP. The following is the selection process for the standby EWC AP, on day-1:

- After the active EWC AP is selected, the active AP waits for the external APs to join, to begin the standby AP selection.
- Once the external APs join, the active AP assigns a priority to all the joined APs. The AP with the highest priority is selected as the standby AP. If multiple APs match the same highest priority, the AP with the lowest MAC address gets selected. Only EWC-capable APs with an EWC image installed are considered for the selection process.
- Priority is calculated based on the following parameters:
  - Explicit user configuration to choose a particular AP as the next preferred controller (highest priority)
  - AP type

- AP join time

Note There is no concept of standby on day 0. On day 0, you there is only one active EWC AP. If the active EWC AP goes down for some reason, the VRRP election takes place again, to elect a new active EWC AP.

Note If a controller is running on an AP, this AP will have a higher priority compared to the other APs not running as the controller. For example, if you bring-up a Cisco Catalyst 9115AX Series AP, since there are no other APs to choose from, this AP become the active AP and starts the controller. Later, if you bring-up a Cisco Catalyst 9117AX Series AP on this network, although the Cisco Catalyst 9117AX Series AP has a higher model number, it does not become the controller, since you already have a controller running in the network. Election will take place only if you bring-up two APs at the same time.

Selecting the Preferred Controller

To select the preferred controller and to make it the controller, follow the steps given below:

Before you begin

The active EWC AP and standby EWC APs are selected by the process described in the earlier topics. For some reason, if you want to select another AP as the standby, you can select any EWC-capable AP as a preferred controller, from the GUI.

Note When you select another AP that is not the current standby AP to be the preferred controller, the current standby AP goes down and the new EWC AP you have selected becomes the standby EWC AP.

Procedure

Step 1 Open the Cisco Embedded Wireless Controller for Catalyst Access Points GUI.

Step 2 Choose **Configuration** > **Wireless** > **Access Points**.

Step 3 Click the AP that you want to make as the preferred controller.
The **Edit AP** window is displayed.

Step 4 Click the **Advanced** tab.

Step 5 In the **Embedded Wireless Controller** section, check the **Preferred Controller** check box.

Step 6 Click **Update & Apply to Device**.

What to do next

Return to the **Advanced** tab, and click **Make Controller**. Then click **Update & Apply to Device**.



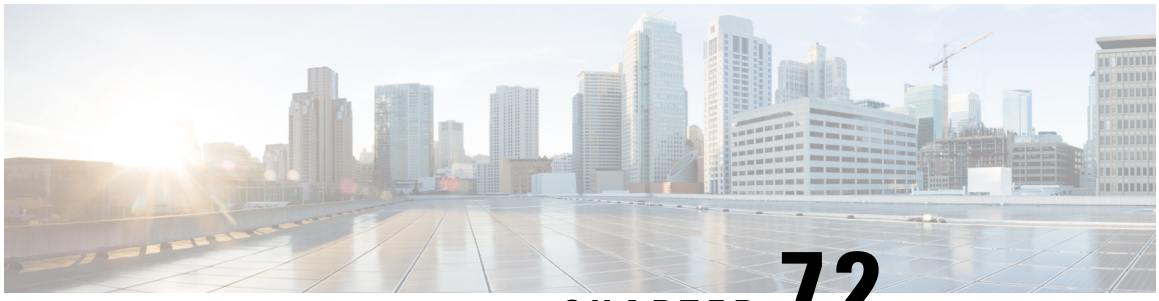
Note A warning message is displayed mentioning that this operation will disrupt the network, as the controller will reset.



PART IX

Quality of Service

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- Wireless Auto-QoS, on page 723
- Native Profiling, on page 729



CHAPTER 72

Quality of Service

- Wireless Quality of Service, on page 691
- Wireless QoS targets, on page 692
- Precious metal policies for wireless QoS, on page 693
- Prerequisites for wireless QoS, on page 694
- Restrictions for QoS on wireless targets, on page 694
- Metal Policy Format, on page 696
- How to apply Bi-Directional Rate Limiting, on page 706
- How to apply Per Client Bi-Directional Rate Limiting, on page 713
- How to Configure Wireless QoS, on page 716

Wireless Quality of Service

A wireless Quality of Service policy is a network management policy that

- prioritizes specific types of wireless traffic by giving preferential treatment
- applies different rules to SSID and client targets in both upstream and downstream directions, and
- supports traffic marking, rate limiting (policing), mobility features, and compatibility with advanced controller functions.

- Upstream traffic: The flow of data from a wireless source to a wired target.
- Downstream traffic: The flow of data from a wired source to a wireless target.
- Target: The entity (SSID or client) where the QoS policy is enforced.

Additional reference information

- Without QoS, network devices transmit packets with best-effort service, offering no guarantees for reliability, delay bounds, or throughput. Wireless QoS policies enhance the network by ensuring that traffic with higher priority receives preferential treatment. This policy improves overall performance for critical applications.
- Applying a wireless QoS policy to prioritize voice traffic on an SSID ensures that calls suffer less latency or jitter compared to general web browsing traffic.

- Rate limiting is used to prevent a single client from consuming excessive bandwidth and to maintain fair usage for all wireless clients.
- A network with no configured QoS policies treats all wireless traffic equally, which can lead to poor performance for delay-sensitive applications.
- QoS policies designed for wired networks do not automatically apply to wireless environments, as wireless traffic has unique constraints.

Wireless QoS targets

This section describes the various wireless QoS targets available on a device.

Service set identifiers policies

An Service Set Identifiers (SSID) policy is a wireless network configuration policy that

- controls the application of QoS settings to a wireless SSID in both ingress and egress directions
- applies per AP and per SSID, and
- allows configuration of policing and marking actions on SSID traffic.

If an SSID policy is not configured, no QoS policy is applied to the SSID.

Client policies

Client policies are applicable in the ingress and egress direction. You can configure policing and marking policies on clients. AAA override is also supported.

Supported QoS features on wireless targets

Wireless controllers support various QoS features to manage traffic and ensure optimal performance for both SSIDs and client devices. These tables show the supported features, applicable directions, and configuration modes for wireless targets.

This table describes the various features available on wireless targets.

Table 40: QoS features available on wireless targets

Target	Features	Direction where policies Are applicable
SSID	• Set • Police • Drop	Upstream and downstream

Target	Features	Direction where policies Are applicable
Client	• Set • Police • Drop	Upstream and downstream

Note For Drop support, the drop action is achieved by this configuration:

```
police <rate>
   conform-action drop
   exceed-action drop
```

Direct **action drop** is not supported.

Precious metal policies for wireless QoS

Precious metal policies for wireless QoS are system-defined QoS policies

- assign different service levels to wireless network traffic based on pre-set categories,
- remain unmodifiable, cannot be removed by administrators, and
- affect packet attributes, such as 802.11e (WMM) and DSCP fields, when policies are applied.
- Platinum: Used for VoIP clients, assigns the highest priority.
- Gold: Used for video clients, assigns high priority, lower than platinum.
- Silver: Used for best-effort traffic, assigns standard priority.
- Bronze: Used for Non-Real-Time (NRT) traffic, assigns the lowest priority.

Additional reference information

Preconfigured precious metal policies are available on wireless controllers. Administrators cannot modify or delete these policies. AAA mechanisms may push client metal policies. These policies determine packet scheduling and marking on the network.

In FlexConnect local switching mode, APs do not enforce QoS metal policy ceiling limits for upstream traffic. Limit enforcement occurs at the controller exit point. The AP does not change DSCP values.

See the Metal policy format, on page 696 section for more information about metal policy formats.

See the Metal policy map section for more information about metal policies.

Precious metal policies for wireless QoS

- Assigning the platinum policy to VoIP devices ensures minimal latency for voice communication.
- Assigning the gold policy to video streaming clients optimizes traffic for media applications.

- The silver policy applied to laptops browsing the internet handles general best-effort data.
- The bronze policy used for devices performing background updates minimizes their network priority.

- Custom user-defined QoS policies that administrators can modify or remove are not considered precious metal policies.
- Policies that do not map traffic types to platinum, gold, silver, or bronze levels are not included.

Prerequisites for wireless QoS

Before you configure wireless QoS, make sure you understand key concepts and network factors to ensure effective deployment.

The required prerequisites include:

- Understand wireless concepts and network topologies.
- Understand QoS implementation.
- Modular QoS CLI (MQC). To learn more about Modular QoS CLI, see the MQC guide.
- Understand the types of applications used and the traffic patterns on your network.
- Understand your network's bandwidth requirements and speed.

Restrictions for QoS on wireless targets

QoS policy application on wireless targets (such as SSIDs, BSSIDs, and wireless clients) has these key restrictions and considerations.

General Restrictions

- QoS policy application on wireless targets (such as Service Set Identifier (SSID), BSSID, and wireless clients) includes these key restrictions and considerations:

Hierarchical (parent policy and child policy) QoS is not supported.

- You can assign only one policy per target for each direction.
- You can use only BSSID and client targets for both directions.
- These policy formats are supported:
  - QoS Policy Action
    - Police:

      ```
      police [cir | rate] bps [conform-action action] [exceed-action action]
      ```

      You can set the policer action type to **transmit** or **drop**.

    - Set:

```
set dscp
set wlan user-priority
```

Note **set wlan user-priority** (downstream only; BSSID only)

- QoS Policy Classification

```
match [not] access-group
        match [not] dscp
        match [not] protocol
```

AP Side Restrictions

- In Cisco Embedded Wireless Controller, FlexConnect local switching, and Software-Defined Access (SDA) deployments, the AP enforces QoS policies and rate-limiting actions at the per-flow (5-tuple) level, not per client.
- For FlexConnect local switching with local authentication and AAA override enabled (using an external AAA server), you can use only air space VLAN and ACL as AAA overrides. QoS and other overrides are not available.
- Rate limiting per SSID is not supported in FlexConnect local switching mode. For rate limiting to work as expected, FlexConnect central switching mode should be used.

Control Plane Rate Limiting and Policing

You do not need to configure control plane rate limiting or policing. Built-in mechanisms, such as policers, protect the CPU from control plane traffic. Migrations from AireOS to IOS-XE handle this automatically.

Restriction: Client connectivity and TCP packet drops on SSIDs with AAA rate limiting

Do not configure rate limits or AAA overrides on Cisco ISE for any SSID where AAA rate limiting is applied. These settings can cause the APs in local mode to drop TCP packets. In such a scenario, use Modular QoS CLI (MCQ)-based method only for configuring Quality of Service (QoS) and rate limiting.

Behavior explanation

When a client connects to an SSID with AAA rate limiting configured on APs in local mode, the AP forwards ICMP, DHCP, and DNS packets to the controller but drops TCP packets. This issue is caused when rate limits are configured on Cisco ISE and AAA overrides are in place. You can verify that TCP packets are dropped using the **show datapath drop trace** comand.

Workaround

Review the configuration of rate limits and consider removing them or adjusting the settings to avoid dropping TCP packets. Use Modular QoS CLI (MCQ)-based method only for configuring Quality of Service (QoS) and rate limiting. For more information about the MCQ-based method, see Configure QoS Rate Limit on Catalyst 9800 Wireless Controllers.

Verify client connectivity

- To observe the AP configuration, use this command.

```
show ap dot11 5ghz network
```

- To verify the AP configuration, use this command.

```
show ap dot11 5ghz network
```

- To check the client summary, use this command.

```
show wireless client summary
```

- To verify client details and troubleshoot connectivity issues, use this command:

```
show wireless client mac-address MAC-address detail
```

Metal Policy Format

Metal policy format

Metal Policies are system defined, and you cannot change it or delete it.

Metal policies are system defined. You cannot change or delete them. There are four levels of metal policy - Platinum, Gold, Silver, and Bronze.

Note Each metal policy defines a DSCP ceiling so that the DSCP or the UP marking does not exceed a certain value.

For Platinum the value is 46, Gold is AF41, Silver is 22, and Bronze is CS1.

Table 41: Metal Policy Map Formats

Policy Name	Policy-map Format	Class-map Format
platinum	policy-map platinum class cm-dscp-34 set dscp af41 class cm-dscp-45 set dscp 45 class cm-dscp-46 set dscp ef class cm-dscp-47 set dscp 47	class-map match-any cm-dscp-34 match dscp af41 class-map match-any cm-dscp-45 match dscp 45 class-map match-any cm-dscp-46 match dscp ef class-map match-any cm-dscp-47 match dscp 47 class-map match-any cm-dscp-0 match dscp default
gold	policy-map gold class cm-dscp-45 set dscp af41 class cm-dscp-46 set dscp af41 class cm-dscp-47 set dscp af41	
silver	policy-map silver class cm-dscp-34 set dscp default class cm-dscp-45 set dscp default class cm-dscp-46 set dscp default class cm-dscp-47 set dscp default	
bronze	policy-map bronze class cm-dscp-0 set dscp cs1 class cm-dscp-34 set dscp cs1 class cm-dscp-45 set dscp cs1 class cm-dscp-46 set dscp cs1 class cm-dscp-47 set dscp cs1	

Table 42: Metal Policy Map Formats (UP)

Policy Name	Policy-map Format	Class-map Format
platinum-up	policy-map platinum-up class cm-dscp-set1-for-up-4 set dscp af41 class cm-dscp-set2-for-up-4 set dscp af41 class cm-dscp-for-up-5 set dscp af41 class cm-dscp-for-up-6 set dscp ef class cm-dscp-for-up-7 set dscp ef	class-map match-any cm-dscp-for-up-0 match dscp default match dscp cs2 class-map match-any cm-dscp-for-up-1 match dscp cs1 class-map match-any cm-dscp-set1-for-up-4 match dscp cs3 match dscp af31 match dscp af32 match dscp af33 class-map match-any cm-dscp-set2-for-up-4 match dscp af41 match dscp af42 match dscp af43 class-map match-any cm-dscp-for-up-5 match dscp cs4 match dscp cs5 class-map match-any cm-dscp-for-up-6 match dscp 44 match dscp ef class-map match-any cm-dscp-for-up-7 match dscp cs6 match dscp cs7
gold-up	policy-map gold-up class cm-dscp-for-up-6 set dscp af41 class cm-dscp-for-up-7 set dscp af41	
silver-up	policy-map silver-up class cm-dscp-set1-for-up-4 set dscp default class cm-dscp-set2-for-up-4 set dscp default class cm-dscp-for-up-5 set dscp default class cm-dscp-for-up-6 set dscp default class cm-dscp-for-up-7 set dscp default	
bronze-up	policy-map bronze-up class cm-dscp-for-up-0 set dscp cs1 class cm-dscp-for-up-1 set dscp cs1 class cm-dscp-set1-for-up-4 set dscp cs1 class cm-dscp-set2-for-up-4 set dscp cs1 class cm-dscp-for-up-5 set dscp cs1 class cm-dscp-for-up-6 set dscp cs1 class cm-dscp-for-up-7 set dscp cs1	

Table 43: Metal Policy Map Formats (CLWMM/CLNON)

Policy Name	Policy-map Format	Class-map Format
clwmm-platinum	policy-map clwmm-platinum class voice-plat set dscp ef class video-plat set dscp af41 class class-default set dscp default	class-map match-any voice-plat match dscp ef class-map match-any video-plat match dscp af41 class-map match-any voice-gold match dscp ef class-map match-any video-gold match dscp af41
clwmm-gold	policy-map clwmm-gold class voice-gold set dscp af41 class video-gold set dscp af41 class class-default set dscp default	
clnon-wmm-platinum	policy-map clnon-wmm-platinum class class-default set dscp ef	
clnon-wmm-gold	policy-map clnon-wmm-gold class class-default set dscp af41	
clsilver	policy-map clsilver class class-default set dscp default	
clbronze	policy-map clbronze class class-default set dscp cs1	

Auto QoS policy format

This section provides the Auto QoS policy format, including policy-map and class-map configurations.

Policy name	Policy-map format	Class-map format
enterprise-avc		

Policy name	Policy-map format	Class-map format
	policy-map AutoQos-4.0-wlan-ET-SSID-Input-AVC-Policy class AutoQos-4.0-wlan-Voip-Data-Class set dscp ef class AutoQos-4.0-wlan-Voip-Signal-Class set dscp cs3 class AutoQos-4.0-wlan-Multimedia-Conf-Class set dscp af41 class AutoQos-4.0-wlan-Transaction-Class set dscp af21 class AutoQos-4.0-wlan-Bulk-Data-Class set dscp af11 class AutoQos-4.0-wlan-Scavanger-Class set dscp cs1 class class-default set dscp default policy-map AutoQos-4.0-wlan-ET-SSID-Output-Policy class AutoQos-4.0-RT1-Class set dscp ef	class-map match-any AutoQos-4.0-wlan-Voip-Data-Class match dscp ef class-map match-any AutoQos-4.0-wlan-Voip-Signal-Class match protocol skinny match protocol cisco-jabber-control match protocol sip match protocol sip-tls class-map match-any AutoQos-4.0-wlan-Multimedia-Conf-Class match protocol cisco-phone-video match protocol cisco-jabber-video match protocol ms-lync-video match protocol webex-media class-map match-any AutoQos-4.0-wlan-Transaction-Class match protocol cisco-jabber-im match protocol ms-office-web-apps

Policy name	Policy-map format	Class-map format
	class AutoQos-4.0-RT2-Class set dscp af31 class class-default	match protocol salesforce match protocol sap class-map match-any AutoQos-4.0-wlan-Bulk-Data-Class match protocol ftp match protocol ftp-data match protocol ftps-data match protocol cifs class-map match-any AutoQos-4.0-wlan-Scavanger-Class match protocol netflix match protocol youtube match protocol skype match protocol bittorrent class-map match-any AutoQos-4.0-RT1-Class match dscp ef match dscp cs6

Policy name	Policy-map format	Class-map format
		class-map match-any AutoQos-4.0-RT2-Class match dscp cs4 match dscp cs3 match dscp af41
voice	policy-map platinum-up class dscp-for-up-4 set dscp 34 class dscp-for-up-5 set dscp 34 class dscp-for-up-6 set dscp 46 class dscp-for-up-7 set dscp 46 policy-map platinum class cm-dscp-34 set dscp 34 class cm-dscp-46 set dscp 46	-

Policy name	Policy-map format	Class-map format
guest	Policy Map AutoQos-4.0-wlan-GT-SSID-Output-Policy Class class-default set dscp default Policy Map AutoQos-4.0-wlan-GT-SSID-Input-Policy Class class-default set dscp default	-
port (only applies to Local Mode)	policy-map AutoQos-4.0-wlan-Port-Output-Policy class AutoQos-4.0-Output-CAPWAP-C-Class priority level 1 class AutoQos-4.0-Output-Voice-Class priority level 2 class class-default ip access-list extended AutoQos-4.0-Output-Acl-CAPWAP-C permit udp any eq 5246 16666 any	class-map match-any AutoQos-4.0-Output-CAPWAP-C-Class match access-group name AutoQos-4.0-Output-Acl-CAPWAP-C class-map match-any AutoQos-4.0-Output-Voice-Class match dscp ef

Architecture for voice, video and integrated data (AVVID)

The table lists how AVVID service classes map to the IETF DiffServ DSCP values and IEEE 802.11e categories. Use this information to classify traffic and assign appropriate QoS markings for voice, video, and integrated data services.

Table 44: Mapping of IETF diffServ, DSCP, and IEEE 802.11e

IETF diffServ service class	DSCP	IEEE 802.11e	
		User priority	Access category
Network Control	(CS7) CS6	0	AC_BE
Telephony	EF	6	AC_VO
VOICE-ADMIT	44	6	AC_VO
Signaling	CS5	5	AC_VI
Multimedia Conferencing	AF41 AF42 AF43	4	AC_VI
Real-Time Interactive	CS4	5	AC_VI
Multimedia Streaming	AF31 AF32 AF33	4	AC_VI
Broadcast Video	CS3	4	AC_VI
Low-Latency Data	AF21 AF22 AF23	3	AC_BE
OAM	CS2	0	AC_BE
High-Throughput Data	AF11 AF12 AF13	2	AC_BK
Standard	DF	0	AC_BE
Low-Priority Data	CS1	1	AC_BK
Remaining	Remaining	0	-

How to apply Bi-Directional Rate Limiting

Bidirectional rate limiting

A bidirectional rate limit is a wireless network traffic management feature that

- establishes configurable rate limits for both upstream and downstream traffic directions
- enables administrators to set individual limits per direction directly on the WLAN, overriding QoS profile values, and global controller configurations, and
- supports prioritization of client groups by assigning them to specific QoS profiles.

QoS profiles

There are four distinct QoS profiles to configure rate limits:

- Gold
- Platinum
- Silver
- Bronze

Additional reference information

- Apply rate limiting directly to a WLAN. This action overrides both global QoS settings and QoS profiles for the controller and clients.
- Bidirectional rate limits apply to all clients associated with a given SSID. Every client connected to the same SSID has identical rate restrictions.
- Set throughput limits to control wireless client performance for both traffic directions. Assign service priority to specific client sets for prioritization.

Configuration guidance

- Select a QoS profile and configure the rate limiting parameters for upstream and downstream directions. Setting a parameter to `0` disables rate limiting for that direction.
- Assign a QoS profile to each WLAN to determine the rate limits for all connected clients.

Scenario considerations

- Configure bidirectional rate limits on both the Anchor and Foreign controllers in mobility Anchor–Foreign controller setups. Use identical configuration across both controllers to prevent feature failure.
- The feature is supported in guest anchor scenarios, including IRCM guest deployments where AireOS devices function as guest anchor or guest foreign.
- Cisco Catalyst 9800 Series Wireless Controller uses a policing option to enforce bidirectional rate limits.

Bidirectional rate limiting

If a guest SSID uses the Bronze QoS profile and sets both upstream and downstream limits to specific values, all guests on that SSID have consistent rate restrictions, regardless of any global QoS or profile settings.

Requirements for bidirectional rate limiting configuration

Ensure you meet the essential requirements before configuring bidirectional rate limiting.

To configure bidirectional rate limiting, ensure these prerequisites are met:

- Apply the client metal policy through AAA override.
- Specify the metal policy on the Identity Services Engine (ISE) server.
- Enable AAA override on the policy profile.

Configure the metal policy on the SSID

Apply a metal service policy to a wireless SSID using a WLAN policy profile.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a WLAN policy profile and enter wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy policy-profile-name
```

Step 3 Add a user-defined description to the new wireless policy.

Example:

```
Device(config-wireless-policy)# description description
```

Step 4 Set the platinum policy for input.

Example:

```
Device(config-wireless-policy)# service-policy input input-policy
```

Step 5 Set the platinum policy for output.

Example:

```
Device(config-wireless-policy)# service-policy output output-policy
```

The system applies the configured policy profile to the SSID. It enforces platinum-level input and output service policies.

Configure a metal policy on your client device

Set up a wireless metal policy profile that uses AAA override on your client device.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN policy profile and enter wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy policy-profile-name
```

Step 3 Add a user-defined description to the new wireless policy.

Example:

```
Device(config-wireless-policy)# description description
```

Step 4 Enable AAA override on your WLAN.

Example:

```
Device(config-wireless-policy)# aaa-override
```

Note
After you enable AAA override and the ISE server starts sending policy, the client policy defined in the service-policy client does not take effect.

With AAA override enabled, your wireless policy profile allows external RADIUS authentication and policy control.

Configure bidirectional rate limiting for all traffic

Enforce bidirectional rate limiting on all traffic by using policy maps.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a named object to apply policies to traffic classes.

Example:

```
Device(config)# policy-map policy-map
```

Policy-map names can contain alphabetic, hyphen, or underscore characters. The names are case sensitive. Names can be up to 40 characters long.

Step 3 Associate a class map with the policy map and enter policy-map class configuration mode.

Example:

```
Device(config-pmap)# class class-map-name
```

Step 4 Configure traffic policing for your traffic class.

Example:

```
Device(config-pmap-c)# police rate
```

Valid values are 8,000 to 200,000,000 bps.

The bidirectional rate limiting policy limits all traffic that matches the class map.

Configure Bi-Directional Rate Limiting Based on Traffic Classification

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**policy-map** *policy-map* **Example:** `Device(config)# policy-map policy-sample2`	Creates a named object representing a set of policies that are to be applied to a set of traffic classes. Policy-map names can contain alphabetic, hyphen, or underscore characters, are case sensitive, and can be up to 40 characters.
Step 3	**class** *class-map-name* **Example:** `Device(config-pmap)# class class-sample-youtube`	Associates a class map with the policy map, and enters policy-map class configuration mode.
Step 4	**police** *rate* **Example:** `Device(config-pmap-c)# police 1000000`	Configures traffic policing (average rate, in bits per second). Valid values are 8000 to 200000000.
Step 5	**conform-action drop** **Example:**	Specifies the drop action to take on packets that conform to the rate limit.

	Command or Action	Purpose
	`Device(config-pmap-c-police)# conform-action drop`	
Step 6	**exceed-action drop** **Example:** `Device(config-pmap-c-police)# exceed-action drop`	Specifies the drop action to take on packets that exceeds the rate limit.
Step 7	**exit** **Example:** `Device(config-pmap-c-police)# exit`	Exits the policy-map class configuration mode.
Step 8	**set dscp default** **Example:** `Device(config-pmap-c)# set dscp default`	Sets the DSCP value to default.
Step 9	**police** *rate* **Example:** `Device(config-pmap-c)# police 500000`	Configures traffic policing (average rate, in bits per second). Valid values are 8000 to 200000000.
Step 10	**exit** **Example:** `Device(config-pmap-c)# exit`	Exits the policy-map class configuration mode.
Step 11	**exit** **Example:** `Device(config-pmap)# exit`	Exits the policy-map configuration mode.
Step 12	**class-map match-any** *class-map-name* **Example:** `Device(config)# class-map match-any class-sample-youtube`	Selects a class map.
Step 13	**match protocol** *protocol* **Example:** `Device(config-cmap)# match protocol youtube`	Configures the match criteria for a class map on the basis of the specified protocol.

Apply bidirectional rate limiting policy map to policy profile

Apply bidirectional rate limiting to your wireless network by attaching a policy map to a policy profile.

Procedure

Step 1 Enter global configuration mode to begin setup.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN policy profile to enter wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy policy-profile-name
```

Step 3 Add a user-defined description to your new wireless policy.

Example:

```
Device(config-wireless-policy)# description description
```

Step 4 Set the input client service policy to platinum.

Example:

```
Device(config-wireless-policy)# service-policy client input platinum-up
```

Step 5 Set the output client service policy to platinum.

Example:

```
Device(config-wireless-policy)# service-policy client output output-policy
```

Step 6 Set the input service policy to platinum.

Example:

```
Device(config-wireless-policy)# service-policy input input-policy
```

Step 7 Set the output service policy to platinum.

Example:

```
Device(config-wireless-policy)# service-policy output platinum
```

Your wireless policy profile applies bidirectional rate limiting based on the service policies you set.

Apply metal policy with bidirectional rate limiting

Use a metal policy to enforce bidirectional bandwidth limits on wireless traffic.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure WLAN policy profile and enter wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy policy-profile-name
```

Step 3 Add a description for the new wireless policy.

Example:

```
Device(config-wireless-policy)# description description
```

Step 4 Assign 'platinum' as the input client service policy.

Example:

```
Device(config-wireless-policy)# service-policy client input input-policy
```

Step 5 Assign 'platinum' as the output client service policy.

Example:

```
Device(config-wireless-policy)# service-policy client output output-policy
```

Step 6 Assign 'platinum' as the input service policy.

Example:

```
Device(config-wireless-policy)# service-policy input input-policy
```

Step 7 Assign 'platinum' as the output service policy.

Example:

```
Device(config-wireless-policy)# service-policy output platinum
```

Step 8 Exit the policy configuration mode.

Example:

```
Device(config-wireless-policy)# exit
```

Step 9 Create a named object to apply policies to traffic classes.

Example:

```
Device(config)# policy-map policy-sample 1
```

Policy map names can contain alphabetic characters, hyphens, or underscores. They are case sensitive and can be up to 40 characters long.

Step 10 Associate a class map with the policy map, and enter configuration mode for the specified system class.

Example:

```
Device(config-pmap)# class class-map-name
```

Step 11 Configure traffic policing.

Example:

```
Device(config-pmap-c)# police 500,000
```

Valid values range from 8,000 to 200,000,000 bytes.

The metal policy enforces bidirectional rate limiting so wireless traffic meets the input and output bandwidth limits you specified.

How to apply Per Client Bi-Directional Rate Limiting

Per-client bidirectional rate limiting

A per-client bidirectional rate limit is a wireless traffic control feature that

- enforces, for each wireless client, bandwidth caps separately on both upstream and downstream traffic,
- ensures that each client receives a single aggregate limit, no matter how many concurrent flows or streams are active,
- addresses limitations of legacy per-flow rate limiting on 802.11ac Wave 2 APs in Flex local switching mode.

Additional reference information

Previously, per-flow rate limiting capped each client stream, such as a YouTube stream or an FTP transfer, independently. As a result, clients could exceed the intended per-client bandwidth limit.

With per-client bidirectional rate limits, the total bandwidth used by all of a client's streams cannot exceed the configured limit. This restriction applies no matter how many streams are active.

Per-client bidirectional rate limiting

If a controller limits each client to 1000 Kbps (1 megabit per second), and a client initiates both a YouTube and an FTP stream, both streams together will share the 1000 Kbps (1 megabit per second) limit, ensuring the client cannot exceed the cap.

Prerequisites for per-client bidirectional rate limiting

- You can use this feature only with a QoS client policy. Ensure the policy profile contains only a QoS Policy or a policy target as client.
- If the policy map includes class default with a valid police rate value, the access point applies this rate limit to the the data traffic flow for the client.

Restrictions on per-client bidirectional rate limiting

- If the policy map has a class map other than the Default class map, the per-client rate limit does not work on the AP.

Configure per-client bidirectional rate limiting (GUI)

Set limits on upload and download data rates for each client. This ensures fair bandwidth distribution.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 Click the Policy Profile Name.

The **Edit Policy Profile** window is displayed.

Note
The **Edit Policy Profile** window is displayed and configured in default class map only.

Step 3 Choose the **QOS And AVC** tab.

Step 4 In the **QoS Client Policy** settings, choose the policies from the **Egress** and **Ingress** drop-down lists.

Note
You need to apply the default policy map to the QoS Client Policy.

Step 5 Click **Update & Apply to Device**.

The selected policies in the policy profile enforce bidirectional rate limiting for each client.

Verify per client bi-directional rate limiting

To verify whether per client is applied in AP, use this command:

```
Device# show rate-limit client
Config:
            mac vap rt_rate_out rt_rate_in rt_burst_out rt_burst_in nrt_rate_out nrt_rate_in
 nrt_burst_out nrt_burst_in
A0:D3:7A:12:6C:5E   0           0          0            0           0            0
   0             0            0
Statistics:
            name     up down
        Unshaped      0    0
  Client RT pass 697610 8200
 Client NRT pass      0    0
 Client RT drops      0    0
Client NRT drops      0   16
               9    180    0
Per client rate limit:
             mac vap rate_out rate_in            policy
A0:D3:7A:12:6C:5E   0       88      23 per_client_rate_2
```

Configure bi-directional rate limiting using AAA override (CLI)

Enable WLAN policy profiles to enforce upstream and downstream bandwidth limits based on RADIUS server (e.g., Cisco ISE) attributes through AAA override.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN policy profile and enter wireless policy configuration mode.

Example:

```
Device (config)# wireless profile policy profile-name
```

Step 3 Configure AAA override to apply policies coming from the AAA server or Cisco Identity Services Engine (ISE) server.

Example:

```
Device(config-wireless-policy)# aaa-override
```

These attributes are available in the RADIUS server:

- Airespace-Data-Bandwidth-Average-Contract: 8001
- Airespace-Real-Time-Bandwidth-Average-Contract: 8002
- Airespace-Data-Bandwidth-Burst-Contract: 8003
- Airespace-Real-Time-Bandwidth-Burst-Contract: 8004
- Airespace-Data-Bandwidth-Average-Contract-Upstream: 8005
- Airespace-Real-Time-Bandwidth-Average-Contract-Upstream: 8006
- Airespace-Data-Bandwidth-Burst-Contract-Upstream: 8007
- Airespace-Real-Time-Bandwidth-Burst-Contract-Upstream: 8008

Note
8001, 8002, 8003, 8004, 8005, 8006, 8007, and 8008 are example rate-limit values.

The WLAN policy profile is configured to honor bi-directional rate limiting instructions received via AAA override from the RADIUS server.

Verify bi-directional rate-limit

To verify the bi-directional rate limit, use this command:

```
Device# show wireless client mac-address E8-8E-00-00-00-71 detailClient MAC Address :
e88e.0000.0071
Client MAC Type     : Universally Administered Address
Client IPv4 Address : 192.0.2.1
Client Username     : e88e00000071
AP MAC Address      : 0a0b.0c00.0200
AP Name             : AP6B8B4567-0002
AP slot             : 0
```

```
Client State        : Associated
Policy Profile      : dnas_qos_profile_policy
Flex Profile        : N/A
Wireless LAN Id     : 10
WLAN Profile Name   : QoS_wlan
Wireless LAN Network Name (SSID): QoS_wlan
BSSID : 0a0b.0c00.0200
Connected For       : 28 seconds
Protocol            : 802.11n - 2.4 GHz
Channel             : 1
Client IIF-ID       : 0xa0000034
Association Id      : 10
Authentication Algorithm : Open System
Idle state timeout  : N/A
Session Timeout     : 1800 sec (Remaining time: 1777 sec)
Session Warning Time : Timer not running
Input Policy Name    : None
Input Policy State   : None
Input Policy Source  : None
Output Policy Name   : None
Output Policy State  : None
Output Policy Source : None
WMM Support          : Enabled
U-APSD Support       : Disabled
Fastlane Support     : Disabled
Client Active State  : In-Active
Power Save           : OFF
Supported Rates : 1.0,2.0,5.5,6.0,9.0,11.0,12.0,18.0,24.0,36.0,48.0,54.0
AAA QoS Rate Limit Parameters:
  QoS Average Data Rate Upstream             : 8005 (kbps)
  QoS Realtime Average Data Rate Upstream    : 8006 (kbps)
  QoS Burst Data Rate Upstream               : 8007 (kbps)
  QoS Realtime Burst Data Rate Upstream      : 8008 (kbps)
  QoS Average Data Rate Downstream           : 8001 (kbps)
  QoS Realtime Average Data Rate Downstream  : 8002 (kbps)
  QoS Burst Data Rate Downstream             : 80300 (kbps)
  QoS Realtime Burst Data Rate Downstream    : 8004 (kbps)
```

To verify the rate-limit details from the AP terminal, use this command

```
Device# show rate-limit client
Config:
mac vap rt_rate_out rt_rate_in rt_burst_out rt_burst_in nrt_rate_out nrt_rate_in nrt_burst_out
 nrt_burst_in
00:1C:F1:09:85:E7 0 8001 8002 8003 8004 8005 8006 8007 8008
Statistics:
name up down
Unshaped 0 0
Client RT pass 0 0
Client NRT pass 0 0
Client RT drops 0 0
Client NRT drops 0 0
Per client rate limit:
mac vap rate_out rate_in policy
```

How to Configure Wireless QoS

Configure a policy map with class map (GUI)

Define and apply a QoS policy map with associated class maps to control network traffic behavior.

Use this task when you need to create or update a QoS policy map containing class maps, specifying how different types of network traffic are marked, policed, or dropped.

Before you begin

Use these steps to configure a policy map with class map using the GUI.

Procedure

Step 1 Choose **Configuration** > **Services** > **QoS**.

Step 2 Click **Add** to view the **Add QoS** window.

Step 3 In the text box next to **Policy Name**, enter the name of the new policy map.

Step 4 Click **Add Class-Maps**.

Step 5 Configure **AVC** based policies or **User Defined** policies. To enable **AVC** based policies, and configure the following:

a) Choose either **Match Any** or **Match All**.

b) Choose the required **Mark Type**. If you choose **DSCP** or **User Priority**, you must specify the appropriate **Mark Value**.

c) Check the **Drop** check box to drop traffic from specific sources.

Note
When **Drop** is enabled, the **Mark Type** and **Police(kbps)** options are disabled.

d) Select the required protocols from the **Available Protocol(s)** list based on the chosen **Match Type**. Move them to the **Selected Protocol(s)** list. The system drops traffic from these selected protocols.

e) Click **Save**.

Note
To add more Class Maps, repeat steps 4 and 5.

Note
To add more Class Maps, repeat steps 4 and 5.

Step 6 To enable the **User-Defined** QoS policy, configure these options:

a) Choose either **Match Any** or **Match All**.

b) From the drop-down list, choose either **ACL** or **DSCP** as the **Match Type**. Specify the appropriate **Match Value**.

c) Choose the required **Mark Type** to associate with the mark label. If you choose *DSCP*, you must specify an appropriate **Mark Value**.

d) Check the **Drop** check box to drop traffic from specific sources.

Note
When **Drop** is enabled, the **Mark Type** and **Police(kbps)** options are disabled.

e) Click **Save**.

Note
To define actions for all the remaining traffic, in the Class Default, choose either **Mark**, **Police(kbps)**, or both as appropriate.

Step 7 Click **Save & Apply to Device**.

The system deploys the defined policy map with its class maps and associated actions. QoS settings are enforced on network traffic as specified.

Configure a class map (CLI)

Define and customize a class map to identify and match specific network traffic, such as voice and video, using CLI commands.

Use this procedure to configure class maps for voice and video traffic:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a class map.

Example:

```
Device(config)# class-map class-map-name
```

Step 3 Match the DSCP value in IPv4 and IPv6 packets.

Example:

```
Device(config-cmap)# match dscp dscp-value
```

Note
By default, the class map uses match-all.

Step 4 Exit class map configuration mode and return to privileged EXEC mode.

Example:

```
Device(config-cmap)# end
```

Step 5 Verify class map details.

Example:

```
Device# show class-map class_map_name
```

You have configured the class map with the specified matching criteria. It is ready for use in traffic policies.

Configuring Policy Profile to Apply QoS Policy (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 On the **Policy Profile** page, click the name of the policy profile.

Step 3 In the **Edit Policy Profile** window, click the **QoS and AVC** tab.

Step 4 Under **QoS SSID Policy**, choose the appropriate **Ingress** and **Egress** policies for WLANs.

Note
The ingress policies can be differentiated from the egress policies by the suffix *-up*. For example, the Platinum ingress policy is named *platinum-up*.

Step 5 Under **QoS Client Policy**, choose the appropriate **Ingress** and **Egress** policies for clients.

Step 6 Click **Update & Apply to Device**.

Note
Only custom policies are displayed under **QoS Client Policy**. AutoQoS policies are auto generated and not displayed for user selection.

Configure policy profile to apply QoS policy (CLI)

Apply a QoS policy to a WLAN policy profile using CLI.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the WLAN policy profile. Enter the wireless policy configuration mode.

Example:

```
Device(config)# wireless profile policy profile-policy
```

Step 3 Apply the policy.

Example:

```
Device(config-wireless-policy)# service-policy client input policy-map-client
```

These options are available:

- **input**—Assigns the client policy for ingress direction on the policy profile.
- **output**—Assigns the client policy for egress direction on the policy profile.

Step 4 Apply the policy to the Basic Service Set Identifier (BSSID).

Example:

```
Device(config-wireless-policy)# service-policy input output policy-name
```

These options are available:

- **input**—Assigns the policy-map to all clients in WLAN.
- **output**—Assigns the policy-map to all clients in WLAN.

Step 5 Enable the wireless policy profile.

Example:

```
Device(config-wireless-policy)# no shutdown
```

The specified QoS policy is applied to the WLAN policy profile, and all clients associated with the WLAN receive the defined QoS treatment.

Apply policy profile to policy tag (GUI)

Associate a policy profile with a policy tag to manage network behavior for specific WLANs.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Tags**.

Step 2 On the **Manage Tags** page in the **Policy** tab, click **Add**.

Step 3 In the **Add Policy Tag** window, enter a name and description for the policy tag.

Step 4 Map the required WLAN IDs and WLAN profiles with appropriate policy profiles.

Step 5 Click **Update & Apply to Device**.

The device applies the specified policy profile to the policy tag and controls WLAN behavior based on the configuration.

Apply policy profile to policy tag (CLI)

Associate a policy profile with a policy tag through command-line configuration to enforce desired wireless policy settings.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure policy tag and enter the policy tag configuration mode.

Example:

```
Device(config-policy-tag)# wireless tag policy policy-tag-name
```

Step 3 Map a policy profile to a WLAN profile.

Example:

```
Device(config-policy-tag)# wlan test policy profile-policy-name
```

Step 4 Save the configuration, exit configuration mode, and return to privileged EXEC mode.

Example:

```
Device(config-policy-tag)# end
```

Step 5 Display the configured policy tags.

Example:

```
Device# show wireless tag policy summary
```

Note
To view the detailed information of a policy tag, use the **show wireless tag policy detailed** *policy-tag-name* command.

The policy profile is applied to the policy tag. You can verify the configuration through summary and detailed display commands.

Attach policy tag to an AP

Assign a policy tag to a wireless AP to determine its network and functional behavior.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the AP, then enter the AP profile configuration mode.

Example:

```
Device(config)# ap F866.F267.7DFB
```

Step 3 Map a policy tag to the AP.

Example:

```
Device(config-ap-tag)# policy-tag policy-tag-name
```

Step 4 Save the configuration. Exit configuration mode. Return to privileged EXEC mode.

Example:

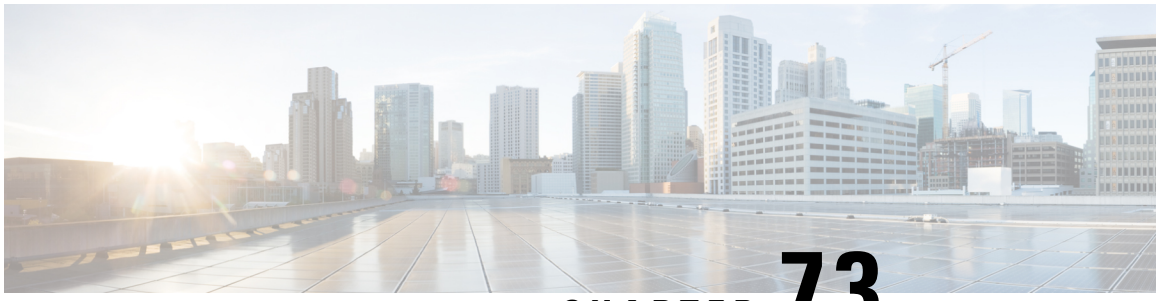
```
Device(config-ap-tag)# end
```

Step 5 Display the AP details and the tags associated with it.

Example:

```
Device# show ap tag summary
```

The specified AP is associated with the chosen policy tag. You can verify the mapping by displaying the AP details.



CHAPTER 73

Wireless Auto-QoS

- Information About Auto QoS, on page 723
- How to Configure Wireless AutoQoS, on page 724

Information About Auto QoS

Wireless Auto QoS automates deployment of wireless QoS features. It has a set of predefined profiles which can be further modified by the customer to prioritize different traffic flows. Auto-QoS matches traffic and assigns each matched packet to qos-groups. This allows the output policy map to put specific qos-groups into specific queues, including into the priority queue.

AutoQoS Policy Configuration

Table 45: AutoQoS Policy Configuration

Mode	Client Ingress	Client Egress	BSSID Ingress	BSSID Egress	Port Ingress	Port Egress	Radio
Voice	N/A	N/A	P3	P4	N/A	P7	ACM on
Guest	N/A	N/A	P5	P6	N/A	P7	
Fastlane	N/A	N/A	N/A	N/A	N/A	P7	edca-parameters fastlane
Enterprise-avc	N/A	N/A	P1	P2	N/A	P7	

P1	AutoQos-4.0-wlan-ET-SSID-Input-AVC-Policy
P2	AutoQos-4.0-wlan-ET-SSID-Output-Policy
P3	platinum-up
P4	platinum
P5	AutoQos-4.0-wlan-GT-SSID-Input-Policy
P6	AutoQos-4.0-wlan-GT-SSID-Output-Policy

P7	AutoQos-4.0-wlan-Port-Output-Policy

How to Configure Wireless AutoQoS

Configuring Wireless AutoQoS on Profile Policy

You can enable AutoQoS on a profile policy.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**wireless autoqos policy-profile** *policy-name* **mode { enterprise-avc | fastlane | guest | voice}** **Example:** `Device# wireless autoqos policy-profile test-profile mode voice`	Configures AutoQoS wireless policy. • **enterprise-avc**—Enables AutoQoS Wireless Enterprise AVC Policy. • **fastlane**—Enable AutoQoS Wireless Fastlane Policy. • **guest**—Enable AutoQoS Wireless Guest Policy. • **voice**—Enable AutoQoS Wireless Voice Policy. **Note** AutoQoS MIB attribute does not support full functionality with service policy. Service policy must be configured manually. Currently, there is only support for AutoQoS mode.

What to do next

Note After enabling AutoQoS, we recommend that you wait for a few seconds for the policy to install and then try and modify the AutoQoS policy maps if required; or retry if the modification is rejected.

Disabling Wireless AutoQoS

To globally disable Wireless AutoQoS:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**shutdown** **Example:** `Device# shutdown`	Shuts down the policy profile.
Step 3	**wireless autoqos disable** **Example:** `Device# wireless autoqos disable`	Globally disables wireless AutoQoS.
Step 4	**[no] shutdown** **Example:** `Device# no shutdown`	Enables the wireless policy profile. **Note** Disabling Auto QoS does not reset global radio configurations like CAC and EDCA parameters.

Rollback AutoQoS Configuration (GUI)

Procedure

Step 1 Choose **Configuration** > **Services** > **QoS**.

Step 2 Click **Disable AutoQoS**.

Step 3 Click **Yes** to confirm.

Rollback AutoQoS Configuration

Before you begin

Note AutoQoS MIB attribute does not support the full functionality with service policy. Currently, there is only support for AutoQoS mode. Service policy must be configured manually.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**clear platform software autoqos config template { enterprise_avc | guest}** **Example:** `Device# clear platform software autoqos config template guest`	Resets AutoQoS configuration. • enterprise-avc—Resets AutoQoS Enterprise AVC Policy Template. • guest—Resets AutoQoS Guest Policy Template.

Clearing Wireless AutoQoS Policy Profile (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.
Step 2 Click on the **Policy Profile Name**.
Step 3 Go to **QOS and AVC** tab.
Step 4 From the **Auto Qos** drop-down list, choose **None**.
Step 5 Click **Update & Apply to Device**.

Clearing Wireless AutoQoS Policy Profile

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**shutdown** **Example:** `Device# shutdown`	Shuts down the policy profile.
Step 3	**wireless autoqos policy-profile** *policy-name* **mode clear**	Clears the configured AutoQoS wireless policy.

	Command or Action	Purpose
	Example: `Device# wireless autoqos policy-profile test-profile mode clear`	
Step 4	**[no] shutdown** **Example:** `no shutdown`	Enables the wireless policy profile.

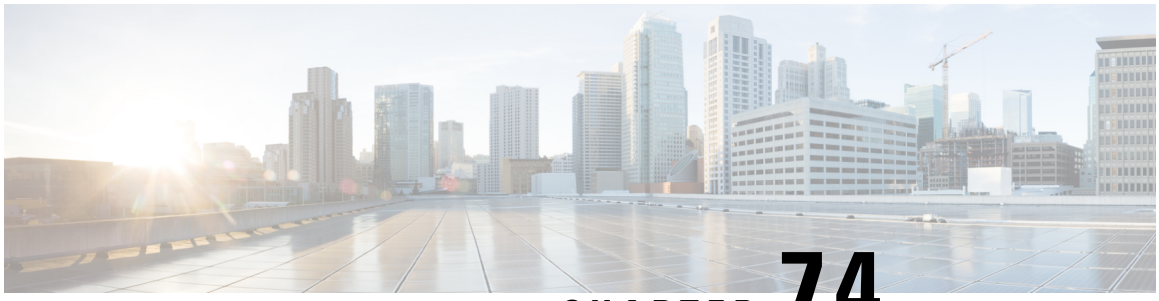
Viewing AutoQoS on policy profile

Before you begin

AutoQoS is supported on the local mode and flex mode. AutoQoS configures a set of policies and radio configurations depending on the template. It is possible to override the service-policy that is configured by AutoQoS. The latest configuration takes effect, with AAA override policy being of highest priority.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Deviceenable`	Enables privileged EXEC mode. Enter your password if prompted.
Step 2	**show wireless profile policy detailed** *policy-profile-name* **Example:** `Device# show wireless profile policy detailed testqos`	Shows policy-profile detailed parameters.



CHAPTER 74

Native Profiling

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- Creating a Class Map (CLI), on page 730
- Creating a Service Template (GUI), on page 732
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- Creating a Parameter Map, on page 734
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- Configuring Native Profiling in Local Mode, on page 737
- Verifying Native Profile Configuration, on page 737

Information About Native Profiling

You can profile devices based on HTTP and DHCP to identify the end devices on the network. You can configure device-based policies and enforce these policies per user or per device policy on the network.

Policies allow profiling of mobile devices and basic onboarding of the profiled devices to a specific VLAN. They also assign ACL and QoS or configure session timeouts.

You can configure policies as two separate components:

- Defining policy attributes as service templates that are specific to clients joining the network and applying policy match criteria
- Applying match criteria to the policy.

Note Before proceeding with the native profile configuration, ensure that HTTP Profiling and DHCP Profiling are enabled.

To configure Native Profiling, use one of the following procedures:

- Create a service template
- Create a class map

Note You can apply a service template using either a class map or parameter map.

- Create a parameter-map and associate the service template to parameter-map
  - Create a policy map
    1. If class-map has to be used: Associate the class-map to the policy-map and associate the service-template to the class-map.
    2. If parameter-map has to be used: Associate the parameter-map to the policy-map
  - Associate the policy-map to the policy profile.

Creating a Class Map (GUI)

Procedure

Step 1 Click **Configuration** > **Services** > **QoS**.

Step 2 In the **QoS – Policy** area, click **Add** to create a new QoS Policy or click the one you want to edit.

Step 3 Add **Add Class Map** and enter the details.

Step 4 Click **Save**.

Step 5 Click **Update and Apply to Device**.

Creating a Class Map (CLI)

Note Configuration of class maps via CLI offer more options and can be more granular than GUI.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**class-map type control subscriber match-any** *class-map-name*	Specifies the class map type and name.

	Command or Action	Purpose
	Example: `Device(config)# class-map type control subscriber match-any cls_user`	
Step 3	**match username** *username* **Example:** `Device(config-filter-control-classmap)# match username ciscoise`	Specifies the class map attribute filter criteria.
Step 4	**class-map type control subscriber match-any** *class-map-name* **Example:** `Device(config)# class-map type control subscriber match-any cls_userrole`	Specifies the class map type and name.
Step 5	**match user-role** *user-role* **Example:** `Device(config-filter-control-classmap)# match user-role engineer`	Specifies the class map attribute filter criteria.
Step 6	**class-map type control subscriber match-any** *class-map-name* **Example:** `Device(config)# class-map type control subscriber match-any cls_oui`	Specifies the class map type and name.
Step 7	**match oui** *oui-address* **Example:** `Device(config-filter-control-classmap)# match oui 48.f8.b3`	Specifies the class map attribute filter criteria.
Step 8	**class-map type control subscriber match-any** *class-map-name* **Example:** `Device(config)# class-map type control subscriber match-any cls_mac`	Specifies the class map type and name.
Step 9	**match mac-address** *mac-address* **Example:** `Device(config-filter-control-classmap)# match mac-address 0040.96b9.4a0d`	Specifies the class map attribute filter criteria.
Step 10	**class-map type control subscriber match-any** *class-map-name* **Example:** `Device(config)# class-map type control subscriber match-any cls_devtype`	Specifies the class map type and name.

	Command or Action	Purpose
Step 11	**match device-type** *device-type* **Example:** `Device(config-filter-control-classmap)# match device-type windows`	Specifies the class map attribute filter criteria.
Step 12	**match join-time-of-day** *start-time end-time* **Example:** `Device(config-filter-control-classmap)# match join-time-of-day 10:30 12:30`	Specifies a match to the time of day. Here, join time is considered for matching. For example, if the match filter is set from 11:00 am to 2:00 pm, a device joining at 10:59 am is not considered, even if it acquires credentials after 11:00 am. Here, *start-time* and *end-time* specifies the 24-hour format. Use the **show class-map type control subscriber name** *name* command to verify the configuration. **Note** You should also disable AAA override for this command to work.

Creating a Service Template (GUI)

Procedure

Step 1 Choose **Configuration** > **Security** > **Local Policy**.

Step 2 On the **Local Policy** page, **Service Template** tab, click **ADD**.

Step 3 In the **Create Service Template** window, enter the following parameters:

- **Service Template Name:** Enter a name for the template.
- **VLAN ID:** Enter the VLAN ID for the template. Valid range is between 1 and 4094.
- **Session Timeout (secs):** Sets the timeout duration for the template. Valid range is between 1 and 65535.
- **Access Control List:** Choose the Access Control List from the drop-down list.
- **Ingress QOS:** Choose the input QoS policy for the client from the drop-down list
- **Egress QOS:** Choose the output QoS policy for the client from the drop-down list.

Step 4 Click **Save & Apply to Device**.

Creating a Service Template (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**service-template** *service-template-name* **Example:** `Device(config)# service-template svc1`	Enters service template configuration mode.
Step 3	**access-group** *access-list-name* **Example:** `Device(config-service-template)# access-group acl-auto`	Specifies the access list to be applied.
Step 4	**vlan** *vlan-id* **Example:** `Device(config-service-template)# vlan 10`	Specifies VLAN ID. Valid range is from 1-4094.
Step 5	**absolute-timer** *timer* **Example:** `Device(config-service-template)# absolute-timer 1000`	Specifies session timeout value for a service template. Valid range is from 1-65535.
Step 6	**service-policy qos input** *qos-policy* **Example:** `Device(config-service-template)# service-policy qos input in_qos`	Configures an input QoS policy for the client.
Step 7	**service-policy qos output** *qos-policy* **Example:** `Device(config-service-template)# service-policy qos output out_qos`	Configures an output QoS policy for the client.

Creating a Parameter Map

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**parameter-map type subscriber attribute-to-service** *parameter-map-name* **Example:** `Device(config)# parameter-map type subscriber attribute-to-service param`	Specifies the parameter map type and name.
Step 3	*map-index***map device-type eq***filter-name* **Example:** `Device(config-parameter-map-filter)# 1 map device-type eq "windows" mac-address eq 3c77.e602.2f91 username eq "cisco"`	Specifies the parameter map attribute filter criteria. Multiple filters are used in the example provided here.
Step 4	*map-index***service-template***service-template-name* **precedence** *precedence-num* **Example:** `Device(config-parameter-map-filter-submode)# 1 service-template svc1 precedence 150`	Specifies the service template and its precedence.

Creating a Policy Map (GUI)

Procedure

Step 1 Choose **Configuration** > **Security** > **Local Policy** > **Policy Map** tab..

Step 2 Enter a name for the Policy Map in the **Policy Map Name** text field.

Step 3 Click **Add**

Step 4 Choose the service template from the **Service Template** drop-down list.

Step 5 For the following parameters select the type of filter from the drop-down list and enter the required match criteria

- Device Type
- User Role

- User Name
- OUI
- MAC Address

Step 6 Click **Add Criteria**

Step 7 Click **Update & Apply to Device**.

Creating a Policy Map (CLI)

Before you begin

Before removing a policy map or parameter map, you should remove it from the target or shut down the WLAN profile or delete the session.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**policy-map type control subscriber** *policy-map-name* **Example:** `Device(config)# policy-map type control subscriber polmap5`	Specifies the policy map type.
Step 3	**event identity-update match-all** **Example:** `Device(config-event-control-policymap)# event identity-update match-all`	Specifies the match criteria to the policy map.
Step 4	You can apply a service template using either a class map or a parameter map, as shown here. • *class-num* **class** *class-map-name* **do-until-failure** • *action-index* **activate service-template** *service-template-name* • *action-index* **map attribute-to-service table** *parameter-map-name* **Example:** The following example shows how a class-map with a service-template has to be applied:	Configures the local profiling policy class map number and specifies how to perform the action or activates the service template or maps an identity-update attribute to an auto-configured template.

	Command or Action	Purpose

	`Device(config-class-control-policymap)# 10 class cls_mac do-until-failure`
	`Device(config-action-control-policymap)# 10 activate service-template svc1`
	Example:
	The following example shows how a parameter map has to be applied (service template is already associated with the parameter map 'param' while creating it):
	`Device(config-action-control-policymap)#1 map attribute-to-service table param`	

Step 5	**end** **Example:** `Device(config-action-control-policymap)# end`	Exits configuration mode.
Step 6	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 7	**wireless profile policy** *wlan-policy-profile-name* **Example:** `Device(config)# wireless profile policy wlan-policy-profilename`	Configures a wireless policy profile. **Caution** Do not configure aaa-override for native profiling under a named wireless profile policy. Native profiling is applied at a lower priority than AAA policy. If aaa-override is enabled, the AAA policies will override native profile policy.
Step 8	**description** *profile-policy-description* **Example:** `Device(config-wireless-policy)# description "default policy profile"`	Adds a description for the policy profile.
Step 9	**dhcp-tlv-caching** **Example:** `Device(config-wireless-policy)# dhcp-tlv-caching`	Configures DHCP TLV caching on a WLAN.
Step 10	**http-tlv-caching** **Example:** `Device(config-wireless-policy)# http-tlv-caching`	Configures client HTTP TLV caching on a WLAN.
Step 11	**subscriber-policy-name** *policy-name* **Example:**	Configures the subscriber policy name.

	Command or Action	Purpose
	`Device(config-wireless-policy)# subscriber-policy-name polmap5`	
Step 12	**vlan** *vlan-id* **Example:** `Device(config-wireless-policy)# vlan 1`	Configures a VLAN name or VLAN ID.
Step 13	**no shutdown** **Example:** `Device(config-wireless-policy)# no shutdown`	Saves the configuration.

Configuring Native Profiling in Local Mode

To configure native profiling in the local mode, you must follow the steps described in #unique_919. In the policy profile, you must enable central switching as described in the step given below in order to configure native profiling.

Procedure

	Command or Action	Purpose
Step 1	**central switching** **Example:** `Device(config-wireless-policy)# central switching`	Enables central switching.

Verifying Native Profile Configuration

Use the following **show** commands to verify the native profile configuartion:

```
Device# show wireless client device summary

Active classified device summary
MAC Address       Device-type                     User-role
Protocol-map
-----------------------------------------------------------------------------------------------
1491.82b8.f94b    Microsoft-Workstation           sales
          9
1491.82bc.2fd5    Windows7-Workstation            sales
          41


Device# show wireless client device cache

Cached classified device info

MAC Address       Device-type                     User-role
Protocol-map
```

```
-------------------------------------------------------------------------------------------------
2477.031b.aa18    Microsoft-Workstation
           9
30a8.db3b.a753    Un-Classified Device
           9
4400.1011.e8b5    Un-Classified Device
           9
980c.a569.7dd0    Un-Classified Device
```

```
Device# show wireless client mac-address 4c34.8845.e32c detail | s
Session Manager:
  Interface :
  IIF ID            : 0x90000002
  Device Type       : Microsoft-Workstation
  Protocol Map      : 0x000009
  Authorized        : TRUE
  Session timeout   : 1800
  Common Session ID: 783802090000000174BF2B5B9
  Acct Session ID   : 0
  Auth Method Status List
   Method : MAB
    SM State         : TERMINATE
    Authen Status    : Success
  Local Polices:
   Service Template : wlan_svc_C414.3CCA.0A51 (priority 254)
    Absolute-Timer   : 1800
  Server Polices:
  Resultant Policies:
  Filter-ID         : acl-auto
  Input QOS         : in_qos
  Output QOS        : out_qos
  Idle timeout      : 60 sec
  VLAN               : 10
  Absolute-Timer    : 1000
```

Use the following **show** command to verify the class map details for a class map name:

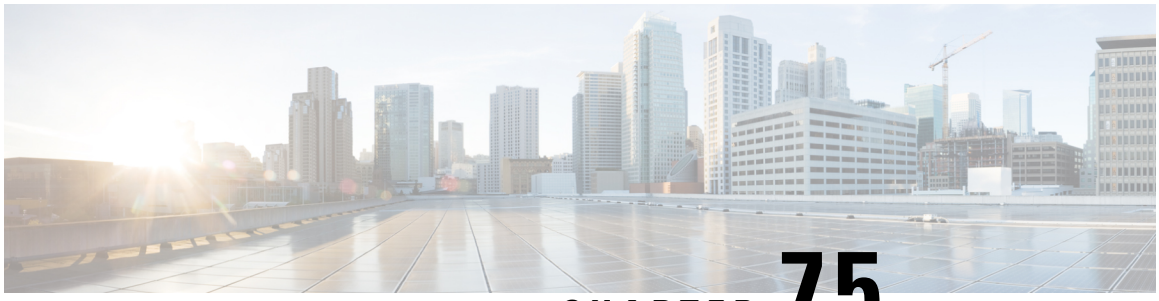
```
Device# show class-map type control subscriber name test
Class-map               Action                        Exec  Hit  Miss  Comp
---------                ------                       ----  ---  ----   ---
match-any test     match day Monday                     0     0    0     0
match-any test     match join-time-of-day 8:00 18:00    0     0    0     0
Key:
  "Exec" - The number of times this line was executed
  "Hit"  - The number of times this line evaluated to TRUE
  "Miss" - The number of times this line evaluated to FALSE
  "Comp" - The number of times this line completed the execution of its
       condition without a need to continue on to the end
```



PART X

IPv6

- IPv6 Client Address Learning, on page 741
- IPv6 ACL, on page 751
- IPv6 Ready Certification, on page 761



CHAPTER 75

IPv6 Client Address Learning

- Information About IPv6 Client Address Learning, on page 741
- Prerequisites for IPv6 Client Address Learning, on page 744
- Configuring IPv6 on Embedded Wireless Controller Interface, on page 744
- Native IPv6, on page 745

Information About IPv6 Client Address Learning

Client Address Learning is configured on embedded wireless controller to learn the IPv4 and IPv6 address of wireless client, and the client's transition state maintained by the embedded wireless controller on association and timeout.

There are three ways for an IPv6 client to acquire IPv6 addresses:

- Stateless Address Auto-Configuration (SLAAC)
- Stateful DHCPv6
- Static Configuration

In all of these methods, the IPv6 client always sends a neighbor solicitation Duplicate Address Detection (DAD) request to ensure that there is no duplicate IP address on the network. The embedded wireless controller snoops on the Neighbor Discovery Protocol (NDP) and DHCPv6 packets of the client to learn about its client IP addresses.

Address Assignment Using SLAAC

The most common method for IPv6 client address assignment is SLAAC, which provides simple plug-and-play connectivity, where clients self-assign an address based on the IPv6 prefix.

SLAAC is configured as follows:

- A host sends a Router Solicitation message.
- The host waits for a Router Advertisement message.
- The host take the first 64 bits of the IPv6 prefix from the Router Advertisement message and combines it with the 64 bit EUI-64 address (in the case of Ethernet, this is created from the MAC address) to create a global unicast message. The host also uses the source IP address, in the IP header, of the Router Advertisement message, as its default gateway.

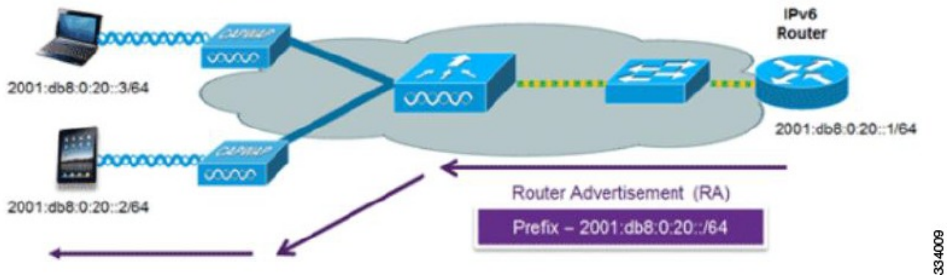
- Duplicate Address Detection is performed by the IPv6 clients to ensure that random addresses that are picked do not collide with other clients.

Note The choice of algorithm is up to the client and is often configurable.

The last 64 bits of the IPv6 address can be learned by using one of the following algorithms:

- EUI-64, which is based on the MAC address of the interface
- Private addresses that are randomly generated

Figure 10: Address Assignment Using SLAAC



The following Cisco IOS configuration commands from a Cisco-capable IPv6 router are used to enable SLAAC addressing and router advertisements:

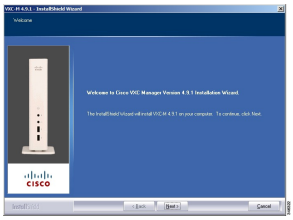
```
ipv6 unicast-routing
interface Vlan20
description IPv6-SLAAC
ip address 192.168.20.1 255.255.255.0
ipv6 address FE80:DB8:0:20::1 linklocal
ipv6 address 2001:DB8:0:20::1/64
ipv6 enable
end
```

Stateful DHCPv6 Address Assignment

The use of DHCPv6 is not required for IPv6 client connectivity if SLAAC is already deployed. There are two modes of operation for DHCPv6, that is, Stateless and Stateful.

The DHCPv6 Stateless mode is used to provide clients with additional network information that is not available in the router advertisement, but not an IPv6 address, becuase this is already provided by SLAAC. This information includes the DNS domain name, DNS servers, and other DHCP vendor-specific options.

Figure 11: Stateful DHCPv6 Address Assignment



The following interface configuration is for a Cisco IOS IPv6 router implementing stateless DHCPv6 with SLAAC enabled:

```
ipv6 unicast-routing
ipv6 dhcp pool IPV6_DHCPPOOL
address prefix 2001:db8:5:10::/64
domain-name cisco.com
dns-server 2001:db8:6:6::1
interface Vlan20
description IPv6-DHCP-Stateless
ip address 192.168.20.1 255.255.255.0
ipv6 nd other-config-flag
ipv6 dhcp server IPV6_DHCPPOOL
ipv6 address 2001:DB8:0:20::1/64
end
```

Static IP Address Assignment

Statically configured address on a client.

Router Solicitation

A Router Solicitation message is issued by a host controller to facilitate local routers to transmit a Router Advertisement from which the controller can obtain information about local routing, or perform stateless auto configuration. Router Advertisements are transmitted periodically and the host prompts with an immediate Router Advertisement using a Router Solicitation such as - when it boots or following a restart operation.

Router Advertisement

A Router Advertisement message is issued periodically by a router or in response to a Router Solicitation message from a host. The information contained in these messages is used by a host to perform stateless auto configuration and to modify its routing table.

Neighbor Discovery

IPv6 Neighbor Discovery is a set of messages and processes that determine relationships between neighboring nodes. Neighbor Discovery replaces the Address Resolution Protocol (ARP), Internet Control Message Protocol (ICMP) Router Discovery, and ICMP Redirect used in IPv4.

IPv6 Neighbor Discovery inspection analyzes neighbor discovery messages in order to build a trusted binding table database, and IPv6 Neighbor Discovery packets that do not comply, are dropped. The neighbor binding table in the tracks each IPv6 address and its associated MAC address. Clients are removed from the table according to neighbor-binding timers.

Neighbor Discovery Suppression

The IPv6 addresses of wireless clients are cached by a device. When the device receives an NS multicast looking for an IPv6 address, and if the target address is known to the device and belongs to one of its clients, the device will reply with an NA message on behalf of the client. At the end of this process, the equivalent of the ARP table of IPv4 is generated, but is more efficient because it uses fewer messages.

Note The device acts as a proxy and responds with NA, only when the **ipv6 nd suppress** command is configured.

If the device does not have the IPv6 address of a wireless client, the device does not respond with NA; instead, it forwards the NS packet to the wireless side. To resolve this, an NS Multicast Forwarding knob is provided. If this knob is enabled, the device gets the NS packet for the IPv6 address that it does not have (cache miss) and forwards it to the wireless side. This packet reaches the intended wireless client, and the client replies with NA.

Note that this cache miss scenario occurs rarely, and only very few clients who do not implement complete IPv6 stack may not advertise their IPv6 address during NDP.

Router Advertisement Guard

- Port on which the frame is received
- IPv6 source address
- Prefix list
- Trusted or Untrusted ports for receiving the router advertisement guard messages
- Trusted/Untrusted IPv6 source addresses of the router advertisement sender
- Trusted/Untrusted Prefix list and Prefix ranges
- Router preference

Router Advertisement Throttling

RA throttling allows the controller to enforce limits to the RA packets headed toward the wireless network. By enabling RA throttling, routers that send multiple RA packets can be trimmed to a minimum frequency that will still maintain an IPv6 client connectivity. If a client sends an RS packet, an RA is sent back to the client. This RA is allowed through the controller and unicast to the client. This process ensures that the new clients or roaming clients are not affected by the RA throttling.

Prerequisites for IPv6 Client Address Learning

Before configuring IPv6 client address learning, configure the embedded wireless controller clients to support IPv6.

Configuring IPv6 on Embedded Wireless Controller Interface

Follow the procedure given below to configure IPv6 on an interface:

Before you begin

Enable IPv6 on the client and IPv6 support on the wired infrastructure.

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 GigabitEthernet0** **Example:** `Device(config)# interface GigabitEthernet0`	Creates the GigabitEthernet interface and enters interface configuration mode.

Step 4	**ip address fe80::1 link-local**
	Example:
	`Device(config-if)# ip address 198.51.100.1 255.255.255.0`
	`Device(config-if)# ipv6 address fe80::1 link-local`
	`Device(config-if)# ipv6 address 2001:DB8:0:1:FFFF:1234::5/64`
	`Device(config-if)# ipv6 address 2001:DB8:0:0:E000::F/64`
		Configures IPv6 address on the GigabitEthernet interface using the link-local option.

Step 5	**ipv6 enable** **Example:** `Device(config)# ipv6 enable`	(Optional) Enables IPv6 on the GigabitEthernet interface.
Step 6	**end** **Example:** `Device(config)# end`	Exits interface mode.

Native IPv6

IPv6

IPv6 (Internet Protocol version 6) is a

- packet-based communications protocol developed to exchange data, voice, and video traffic over digital networks, and

- successor to IPv4, offering a much larger address space and several functional enhancements to support the growing requirements of modern networks.

IPv6 is based on IP, but adds a much larger address space and improvements such as a simplified main header and extension headers. The architecture of IPv6 helps existing IPv4 users transition to IPv6. It allows continued use of services such as end-to-end security, quality of service (QoS), and globally unique addresses. The larger IPv6 address space allows networks to scale and provide global reachability.



Note Features and functions that work on IPv4 networks with IPv4 addresses also work on IPv6 networks with IPv6 addresses.

Configure IPv6 addressing (CLI)

Enable IPv6 communication and routing capabilities on physical and VLAN interfaces using commands.



Note All features and functions that operate on IPv4 networks with IPv4 addresses also function on IPv6 networks with IPv6 addresses.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure IPv6 for unicasting.

Example:

```
Device(config)# ipv6 unicast-routing
```

Step 3 Create the GigabitEthernet interface and enter the interface configuration mode.

Example:

```
Device(config)# interface GigabitEthernet0
```

Step 4 Specify a global IPv6 address.

Example:

```
Device(config-if)# ipv6 address FD09:9:2:49::53/64
```

Step 5 Enable IPv6 on the interface.

Example:

```
Device(config-if)# ipv6 enable
```

Step 6 Suppress IPv6 router advertisement transmissions on the interface.

Example:

```
Device(config-if)# ipv6 nd ra suppress all
```

Step 7 Return to the global configuration mode and configure the ports that are connected to the supported APs with the wireless management interface.

Example:

```
Device(config-if)# exit
Device(config)# wireless management interface gigabitEthernet vlan 64
```

Step 8 Specify IPv6 static routes.

Example:

```
Device(config)# ipv6 route ::/0 FD09:9:2:49::1
```

Create an AP join profile (GUI)

Set up an AP join profile that controls AP joining behavior and preferences using the GUI.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **AP Join**.

Step 2 On the **AP Join Profile** window, click the **General** tab and click **Add**.

Step 3 In the **Name** field, enter a name for the AP join profile.

Step 4 (Optional) Enter a description for the AP join profile.

Step 5 Choose **CAPWAP** > **Advanced**.

Step 6 Select **IPv6** from the **Preferred Mode** drop-down list under the **Advanced** tab to set the preferred mode of APs to IPv6.

Step 7 Click **Save & Apply to Device**.

Create an AP join profile (CLI)

Create an AP join profile using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an AP profile and enter the AP profile configuration mode.

Example:

```
Device(config)# ap profile ap-profile
```

Step 3 Add a description for the AP profile.

Example:

```
Device(config-ap-profile)# description ap-profile-name
```

Step 4 Set the preferred mode of APs as IPv6.

Example:

```
Device(config-ap-profile)# preferred-mode ipv6
```

Configure the primary and backup Embedded Wireless Controller (GUI)

Set up a reliable wireless network by designating primary and backup controllers to ensure continuous connectivity in case of failures using the GUI.

Before you begin

Ensure that you have configured an AP join profile prior to configuring the primary and backup embedded wireless controllers.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **AP Join**.

Step 2 On the **AP Join Profile** window, click the AP join profile name.

Step 3 In the **Edit AP Join Profile** window, click the **CAPWAP** tab.

Step 4 In the **High Availability** tab, under **Backup Controller Configuration**, check the **Enable Fallback** check box.

Step 5 Enter the primary and secondary controller names and IP addresses.

Step 6 Click **Update & Apply to Device**.

Configure primary and backup controller (CLI)

Set up failover by designating primary and backup controllers on an AP to ensure continuous operation if the primary controller becomes unavailable using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure an AP profile and enter the AP profile configuration mode.

Example:

```
Device(config)# ap profile profile-name
```

Step 3 Configure AP CAPWAP parameters with the primary backup controller's name.

Example:

```
Device(config)# capwap backup primary primary-controller-name primary-controller-ip
```

Note
Enable fast heartbeat so that **capwap backup primary** and **capwap backup secondary** work.

The AP may disconnect if the link between the controller and the AP is unreliable and fast heartbeat is enabled.

Step 4 Configure AP CAPWAP parameters with the secondary backup controller's name.

Example:

```
Device(config)# capwap backup secondary secondary-controller-name secondary-controller-ip
```

Step 5 Configure the system logging settings for the APs.

Example:

```
Device(config)# syslog host ip-address
```

Step 6 Initiate AP image downgrade from a TFTP server for all the APs.

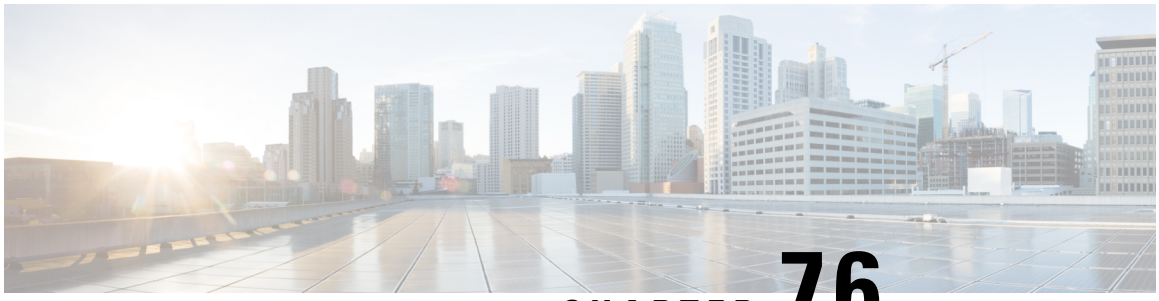
Example:

```
Device(config)# tftp-downgrade tftp-server-ip imagename
```

Verify IPv6 configuration

Use these **show** command to verify the IPv6 configuration:

```
Device# show wireless interface summary
Interface Name   Interface Type VLAN ID IP Address   IP Netmask     NAT-IP Address   MAC
Address
-----------------------------------------------------------------------------------------------
GigabitEthernet0 Management     0       0.0.0.0     255.255.255.0  0.0.0.0
d4c9.3ce6.b854
                                      fd09:9:2:49::54/64
```



CHAPTER 76

IPv6 ACL

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Information About IPv6 ACL

An access control list (ACL) is a set of rules used to limit access to a particular interface (for example, if you want to restrict a wireless client from pinging the management interface of the embedded wireless controller). ACLs are configured on the devicend applied to the management interface, the AP-manager interface, any of the dynamic interfaces, or a WLAN to control data traffic to and from wireless clients or to the embedded wireless controller central processing unit (CPU) to control all traffic destined for the CPU.

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.

Note You can enable only IPv4 traffic in your network by blocking IPv6 traffic. That is, you can configure an IPv6 ACL to deny all IPv6 traffic and apply it on specific or all WLANs.

Understanding IPv6 ACLs

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).

The ACE is not configured on the Controller Embedded Wireless Controller. The ACE is sent to the device in the `ACCESS-Accept` attribute and applies it directly for the client. When a wireless client roams into an foreign device, the ACEs are sent to the foreign device as an AAA attribute in the mobility Handoff message. Output direction, using per-user ACL is not supported.

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.

The `filter-id` is sent to the device in the ACCESS-Accept attribute, and the device looks up the filter-id for the ACEs, and then applies the ACEs to the client. When the client L2 roams to the foreign device, only the filter-id is sent to the foreign device in the mobility Handoff message. Output filtered ACL, using per-user ACL is not supported. The foreign device has to configure the filter-id and ACEs beforehand.

Downloadable IPv6 ACL

For the downloadable ACL (dACL), all the full ACEs and the `dacl` name are configured only on the Cisco Secure ACS.

The Cisco Secure ACS sends the `dacl` name to the device in its `ACCESS-Accept` attribute, which takes the `dacl` name and sends the `dACL` name back to the Cisco Secure ACS for the ACEs, using the `ACCESS-request` attribute.

Prerequisites for Configuring IPv6 ACL

You can filter IP Version 6 (IPv6) traffic by creating IPv6 access control lists (ACLs) and applying them to interfaces similarly to the way that you create and apply IP Version 4 (IPv4) named ACLs. You can also create and apply input router ACLs to filter Layer 3 management traffic when the switch is running the Network Essentials license.

Restrictions for Configuring IPv6 ACL

With IPv4, you can configure standard and extended numbered IP ACLs, named IP ACLs, and MAC ACLs. IPv6 supports only named ACLs.

The device supports most of the Cisco IOS-supported IPv6 ACLs with some exceptions:

- The device does not support matching on these keywords: **flowlabel**, **routing header**, and **undetermined-transport**.
- The device does not support reflexive ACLs (the **reflect** keyword).
- The device does not apply MAC-based ACLs on IPv6 frames.
- When configuring an ACL, there is no restriction on keywords entered in the ACL, regardless of whether or not they are supported on the platform. When you apply the ACL to an interface that requires hardware forwarding (physical ports or SVIs), the device checks to determine whether or not the ACL can be supported on the interface. If not, attaching 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 device does not allow the ACE to be added to the ACL that is currently attached to the interface

Configuring IPv6 ACLs

Follow the procedure given below to filter IPv6 traffic:

1. Create an IPv6 ACL, and enter IPv6 access list configuration mode.
2. Configure the IPv6 ACL to block (deny) or pass (permit) traffic.
3. Apply the IPv6 ACL to the interface where the traffic needs to be filtered.
4. Apply the IPv6 ACL to an interface. For router ACLs, you must also configure an IPv6 address on the Layer 3 interface to which the ACL is applied.

Default IPv6 ACL Configuration

There are no IPv6 ACLs configured or applied.

Interaction 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 or switch stack, 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, 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

Creating an IPv6 ACL

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	**ipv6 access-list** *acl_name* **Example:** `Device# ipv6 access-list access-list-name`	Use a name to define an IPv6 access list and enter IPv6 access-list configuration mode.
Step 4	**{deny|permit} protocol** **Example:** `{deny | permit} protocol {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]][dscp value] [fragments][log] [log-input] [routing][sequence value] [time-range name]`	Enter deny or permit to specify whether to deny or permit the packet if conditions are matched. These are the conditions: • For protocol, enter the name or number of an Internet protocol: 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

	Command or Action	Purpose
		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. • (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 routing to specify that IPv6 packets be routed. • (Optional) Enter sequence value to specify the sequence number for the access list statement. The acceptable range is from 1 to 4294967295 • (Optional) Enter time-range name to specify the time range that applies to the deny or permit statement.

	Command or Action	Purpose
Step 5	**{deny|permit} tcp** **Example:** `{deny | permit} tcp {source-ipv6-prefix/prefix-length | any | hostsource-ipv6-address} [operator [port-number]]{destination-ipv6-prefix/prefix-length | any |hostdestination-ipv6-address} [operator [port-number]][ack] [dscp value][established] [fin] [log][log-input] [neq {port |protocol}] [psh] [range{port | protocol}] [rst][routing] [sequence value] [syn] [time-range name][urg]`	(Optional) Define a TCP access list and the access conditions. Enter tcp for Transmission Control Protocol. The parameters are the same as those described in Step 3, 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	**{deny|permit} udp** **Example:** `{deny | permit} udp {source-ipv6-prefix/prefix-length | any | hostsource-ipv6-address} [operator [port-number]]{destination-ipv6-prefix/prefix-length | any | hostdestination-ipv6-address} [operator [port-number]][dscp value] [log][log-input] [neq {port |protocol}] [range {port |protocol}] [routing][sequence value][time-range name]`	(Optional) Define a UDP access list and the access conditions. Enter udp for the User Datagram Protocol. 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 established parameter is not valid for UDP.
Step 7	**{deny|permit} icmp** **Example:** `{deny | permit} icmp {source-ipv6-prefix/prefix-length | any | hostsource-ipv6-address} [operator [port-number]] {destination-ipv6-prefix/prefix-length | any | hostdestination-ipv6-address} [operator [port-number]][icmp-type`	(Optional) Define an ICMP access list and the access conditions. Enter icmp for Internet Control Message Protocol. The ICMP parameters are the same as those described for most IP protocols in Step 3a, with the addition of the ICMP message type and code parameters. These optional keywords have these meanings:

	Command or Action	Purpose
	`[icmp-code] |icmp-message] [dscpvalue] [log] [log-input] [routing] [sequence value][time-range name]`	• 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. To see a list of ICMP message type names and code names, use the ? key or see command reference for this release.
Step 8	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.
Step 9	**show ipv6 access-list** **Example:** `show ipv6 access-list`	Verify the access list configuration.
Step 10	**copy running-config startup-config** **Example:** `copy running-config startup-config`	(Optional) Save your entries in the configuration file.

Create WLAN IPv6 ACL (CLI)

Create and apply a WLAN IPv6 Access Control List (ACL) to define traffic rules and enforce security for wireless clients using commands.

Verify IPv6 ACL

Display IPv6 ACLs (CLI)

View all IPv6 access lists or a specific access list by name for verification and troubleshooting using commands.

Procedure

Step 1 Enable the privileged EXEC mode.

Example:

```
Device# enable
```

Enter your password if prompted.

Step 2 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 3 Display all access lists configured on the device

Example:

```
Device# show access-lists
```

Step 4 Display all configured IPv6 access list or the access list specified by name.

Example:

```
Device# show ipv6 access-list acl_name
```

Configuration Examples for IPv6 ACL

Example: Create an IPv6 ACL

This example configures the IPv6 access list named CISCO. The first deny entry denies all packets with a destination TCP port number greater than 5000. The second deny entry denies packets with a source UDP port number less than 5000. The second deny entry also logs all matches to the console. The first permit entry permits all ICMP packets. The second permit entry permits all other traffic. The second permit entry is necessary because each IPv6 access list ends with an implicit deny all condition.

Note Logging is supported only on Layer 3 interfaces.

```
Device(config)# ipv6 access-list CISCO
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
```

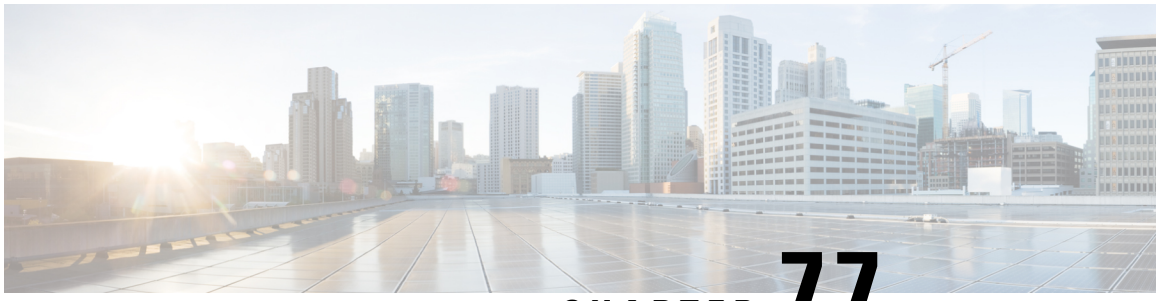
Example: Display IPv6 ACLs

This is an example of the output from the **show access-lists** privileged EXEC command. The output shows all access lists that are configured on the switch or switch stack .

```
Device# show access-lists
Extended IP access list hello
10 permit ip any any
IPv6 access list ipv6
permit ipv6 any any sequence 10
```

This is an example of the output from the **show ipv6 access-lists** privileged EXEC command. The output shows only IPv6 access lists configured on the switch or switch stack.

```
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
```



CHAPTER 77

IPv6 Ready Certification

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IPv6 ready certification

A functionality is a network capability that

- enables compliance with the latest RFC specifications for IPv6
- supports key IPv6 packet and protocol operations, and
- ensures robust and secure IPv6 communication in modern network environments

Starting with Cisco IOS XE Bengaluru, 17.6.1, these IPv6 functionalities are implemented:

- **Fragment Processing and Reassembly (RFC8200)**: The first fragment must contain the mandatory extension header up to the first upper level protocol (ULP) header as specified in RFC 8200.
- **Handling Atomic Fragments in Neighbor Discovery (RFC6980)**: Fragmented neighbor discovery packets must be dropped.
- **Packet too Big (RFC8201)**: Atomic fragmentation is not supported. Packets that do not meet the IPv6 MTU requirement of 1280 bytes are dropped.
- **Route Information Options (RIO) in IPv6 Router Advertisements (RFC4191)**: A new RIO is added to the IPv6 Router Advertisement message to communicate specific routes from routers to hosts. Explicit route configuration ensures that only necessary routes are advertised.
- **IPv6 Hop-by-Hop Processing (RFC 8200)**: This enhancement allows explicit configuration of nodes along the delivery path for packets that require hop-by-hop options header processing.

Feature History for IPv6 ready certification

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

This feature is available in all the releases subsequent to the one in which it is introduced in, unless noted otherwise.

Table 46: Feature History for IPv6 ready certification

Release	Feature	Feature Information
Cisco IOS XE Bengaluru 17.6.1	IPv6 ready certification	This feature is enhanced with the implementation of various IPv6 functionalities that are required to comply with the latest RFC specifications.

Configure IPv6 route information (CLI)

Ensure that IPv6 hosts, especially those on multihomed networks, receive required explicit routes to improve their ability to select the appropriate default router.

The Route Information Option (RIO) in the IPv6 router advertisement messages helps in communicating specific routes from routers to hosts. This improvement enables a host to select an appropriate default router when it is multihomed and the routers are on different links. Only necessary routes are advertised to the hosts because of the explicit route configuration.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify the interface and enter the interface configuration mode.

Example:

```
Device(config)# interface gigabitethernet1.1
```

Step 3 Configure RIO in IPv6 router advertisement messages.

Example:

```
Device(config-if)# ipv6 nd ra specific-route prefix/length lifetime lifetime/infinity [
preference preference]
```

For more information, see the ipv6 nd ra specific route command.

Verify IPv6 route information

To identify the specific routes that are sent in the router advertisements, use this command:

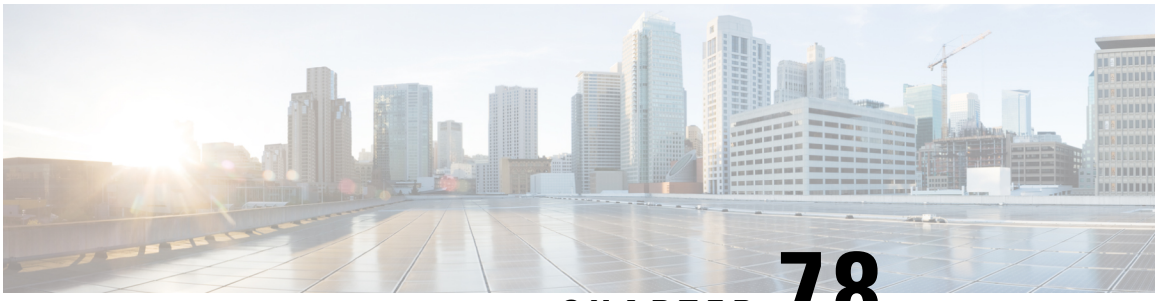
```
Device# show ipv6 nd ra specific-route
IPv6 Prefix/Length Lifetime Preference Interface
---------------------------------------- -------- ---------- ---------
1234::12/127 1000 High GigabitEthernet2
```



PART XI

CleanAir

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CHAPTER 78

Cisco CleanAir

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Cisco ISE systems

A Cisco ISE system is a wireless spectrum management solution that

- proactively monitors and manages challenges caused by interference in a shared wireless spectrum
- uses Cisco CleanAir-enabled access points and controllers to detect and analyze native and foreign interference sources, and
- enables both manual and automated remediation to optimize wireless network operation.

Table 47: Feature history for CleanAir

Release	Feature	Feature Information
Cisco IOS XE 17.13.1	EDRRM Support for 6-GHz Band Radio	The Event-Driven Radio Resource Management (EDRRM) is enabled in the 6-GHz band radio of AP.

Components of Cisco ISE systems

Cisco CleanAir systems are comprised of several key hardware and software elements:

- Cisco CleanAir-**enabled APs**: These devices actively scan the wireless spectrum for all active transmitters.
- **Wireless controllers**: , Cisco Embedded Wireless Controller on Catalyst Access Points, and .
- **Management platforms**: provide centralized management and visualization of spectrum and interference data forwarded by the controllers.

How Cisco CleanAir systems detect and respond to interference

1. **Always-On spectrum awareness**: Cisco ISE-enabled APs scan the industrial, scientific, and medical (ISM) bands, identifying and evaluating all radio devices that may cause interference.
2. **Unified control and interference intelligence**: The controller embedded wireless controller controls the access points.
3. **Actionable Insight for Every Interferer**: For every device operating in the unlicensed band, Cisco ISE provides information about what it is, how it is impacting your wireless network, and what actions you or your network should take. It simplifies RF.

Benefits of Cisco ISE systems

- **Simplifies spectrum management**: Provides visibility into interference without requiring advanced RF expertise.
- **Improves network reliability**: Automatically detects and resolves issues affecting Wi-Fi performance.
- **Supports advanced WLAN services**: Ensures quality for voice over wireless and IEEE 802.11 operations by minimizing RF interference.

Wireless LAN systems use unlicensed 2.4-GHz and 5-GHz ISM bands, which are also shared by devices such as microwave ovens, cordless phones, and Bluetooth equipment. These non-Wi-Fi devices can disrupt network services including voice-over-wireless and IEEE 802.11 communications. Cisco CleanAir systems detect such interference and help mitigate its effects.

Cisco ISE-related terms

Table 48: Cisco CleanAir-related terms

Term	Description
AQI	Air Quality Index. The AQI indicates air quality based on RF interference. An AQI of zero is considered poor, and an AQI greater than eighty-five is considered good.
AQR	Air Quality Report. An AQR shows total interference from all sources, including major categories. The system sends an AQR every 15 minutes and every 30 seconds in Rapid mode.
DC	Duty Cycle. Indicates the percentage of time your device uses the channel.
EDRRM	Event-Driven RRM. When needed, EDRRM enables your access point to skip normal RRM intervals and immediately change channels.
IDR	Interference Device Reports that an AP sends to the embedded wireless controller.
ISI	Interference Severity Index. The ISI is an indicator of the severity of the interference.
RSSI	Received Signal Strength Indicator. RSSI measures the power in a received signal. It indicates the level detected by an access point from an interfering device.

Cisco CleanAir components

Summary

Cisco CleanAir technology uses a coordinated set of hardware and software components to detect, report, and address wireless interference. Each part of the system contributes to maintaining optimal air quality and reliable wireless performance.

The key components involved in the process are:

- Cisco CleanAir-enabled AP: Collects information about Wi-Fi interference sources processes it. The AP sends the Air Quality Report (AQR) and Interference Device Report (IDR) to the embedded wireless controller.
- Controller: Controls and configures CleanAir-capable access points, collects and processes spectrum data, provides user interfaces (GUI and CLI), and detects, merges, and mitigates interference devices. The also detects, merges, and mitigates interference devices using RRM TPC and DCA For details, see Interference Device Merging.

CleanAir technology ensures wireless networks remain reliable by automatically detecting sources of interference and providing tools for administrators to analyze and respond to RF threats.

Workflow

These stages describe the operation of Cisco CleanAir components in the system.

1. Configuration: Configures Cisco CleanAir capabilities on the APs.
2. Detection: Cisco CleanAir-enabled APs continuously scan the wireless environment for interference sources and assess air quality.
3. Reporting: APs generate reports such as Air Quality Reports (AQRs) and Interference Device Reports (IDRs), which summarize detected interference and air quality indexes.
4. Aggregation: Wireless controllers collect AQRs and IDRs from all APs, process the data, and store it in relevant databases.
5. Analysis and Response: Controllers use built-in mechanisms (like Radio Resource Management) to mitigate interference and maintain optimal RF conditions.
6. Advanced Services: MSE tracks interference devices over time and location, merges data from multiple controllers, and provides comprehensive threat detection with adaptive Wireless Intrusion Prevention System (WIPS).
7. Specialized Troubleshooting (optional): For in-depth RF analysis, an administrator can connect a CleanAir-enabled AP directly to a PC running Cisco Spectrum Expert.

Result

The Cisco CleanAir system delivers end-to-end automated detection, analysis, and mitigation of wireless interference, enabling proactive network management and high-quality wireless performance.

Difference between Wi-Fi chip-based RF Management and Cisco CleanAir

Feature	Wi-Fi Chip–Based RF Management	Cisco CleanAir
Noise identification	Reports broad, often vague RF noise without pinpointing sources	Precisely identifies interference type, source, potential impact to a WLAN

Feature	Wi-Fi Chip–Based RF Management	Cisco CleanAir
Noise measurement method	Relies on long-term averaging, which smooths out important details and reduces resolution of measurements	Captures real-time events with full granularity
Response style	Primarily reacts after interference is noticed	Enables proactive, context-aware mitigation allowing for intelligent, proactive decisions.
Transient interference handling	Averaging measurements reduces resolution of measurements, and disruptive signals do not appear to need mitigation.	Flags brief, interference events immediately

Cisco CleanAir .

Note Spectrum event-driven RRM can be triggered only by Cisco CleanAir-enabled access points in local mode.

Persistence interference

A persistent device avoidance is a wireless interference mitigation feature that

- identifies and continuously tracks intermittent interference sources such as microwave ovens,
- maintains channel avoidance for affected APs even if the interference is not constantly present, and
- automatically updates Radio Resource Management (RRM) whenever the interfering device or related access points are moved.

For example, if a microwave oven operates in a break room only for a few minutes at a time, Cisco CleanAir identifies the microwave as an interference source, locates the affected portion of the band and APs most severely affected, and directs RRM to avoid those channels persistently. Even if the microwave is not active all day, the system maintains avoidance as long as the device is periodically detected. If you move either the microwave oven or the surrounding access points, the algorithm updates RRM automatically

Classes of persistent interference sources

Certain devices, once detected, are likely to remain in place and may cause ongoing interference. Cisco CleanAir can bias the affected channel in Radio Resource Management (RRM) so that CleanAir “remembers” the potential for interference. See Radio Resource Management White Paper.

These device classes qualify as persistent interference sources:

- Microwave ovens
- Outdoor Ethernet bridges
- WiMax fixed and mobile devices
- Motorola Canopy systems

Special case: Bluetooth devices

Bluetooth devices are detected and reported as interference only when actively transmitting. They often enter power-save modes, so interference may only be noticed during active streaming of data or voice.

Persistent devices detection

CleanAir-capable Monitor Mode AP collects information about persistent devices on all configured channels and store the information in embedded wireless controller. Local or Bridge mode AP detects interference devices on the serving channels only.

Persistent device avoidance

When a Persistent Device (PD) is detected in the CleanAir module, it is reported to the RRM module on the MA. This information is used in the channel selection by the subsequent EDRRM Event Driven RRM (ED-RRM) signal sent to the RRM module.

Spontaneous interference

Spontaneous interference is interference that appears suddenly on a network and may jam one or more channels. With Cisco CleanAir spectrum, event-driven RRM, you can set a threshold for air quality, abbreviated as AQ. If air quality drops below this threshold, the system immediately changes the affected AP's channel. Although most RF management systems avoid interference, they require time for information to spread before channels update. Cisco CleanAir uses AQ measurements to continually check the spectrum and can switch channels within **30 seconds**.

For example, if your AP detects interference from a device such as a video camera, it switches channels within **30 seconds** after the interference begins. Cisco CleanAir also helps you identify and locate the interference source so you can take permanent steps to resolve the issue later.

EDRRM and AQR update mode

An EDRRM and AQR update mode is a wireless network feature set that

- enables APs experiencing severe interference ("in distress") to bypass normal RRM intervals and immediately change channels,
- requires CleanAir technology for monitoring and reporting classified interference devices, and
- provides fast action and remote configuration through control messages and local spectrum management.
- **EDRRM (Event Driven Radio Resource Management):** A function that allows an AP to react instantly to excessive interference by changing channels immediately instead of waiting for scheduled RRM intervals.
- **AQR (Air Quality Reporting) update mode**: A process by which CleanAir APs monitor air quality and report classified interference devices every 15 minutes; when interference causes substantial air quality degradation, EDRRM is triggered.

If a classified interference device severely degrades the air quality on an active channel, EDRRM triggers an immediate channel change so that no clients are stranded on an unusable channel.

Think of a city's scheduled traffic lights as the normal RRM intervals, allowing cars (data) to move in an orderly, timed way. Normally, everyone waits for the green light, moving only at the set intervals. EDRRM is like having an emergency override for ambulances (APs in distress): if there's a medical emergency (severe

interference), the control center can change the lights to green immediately—regardless of the normal schedule—so the ambulance can take an alternate, clear route (new channel). Air Quality Reporting (AQR) acts like real-time traffic cameras detecting and reporting sudden blockages (classified interference devices) so that the emergency override can be triggered if road conditions (channel quality) deteriorate unexpectedly.

Restrictions for EDRRM and AQR update mode

- EDRRM is not enabled by default; you must first enable CleanAir and then enable EDRRM.
- If an interfering device is operating on an active channel and causes enough AQ degradation to trigger an EDRRM, then no clients will be able to use that channel or the AP. You must remove the AP from the channel.

Prerequisites for CleanAir

You can configure Cisco CleanAir only on CleanAir-enabled access points.

Only Cisco CleanAir-enabled access points in these access point modes can perform Cisco CleanAir spectrum monitoring:

- **Local** —In this mode, each Cisco CleanAir-enabled access point radio provides air quality and interference detection reports for the current operating channel only. An AP measures air quality and interference only when it is not transmitting Wi-Fi frames. When channel utilization is high, CleanAir detects less interference.
- **FlexConnect** —When a FlexConnect access point is connected to the embedded wireless controller , its Cisco CleanAir functionality is identical to local mode.
- **Monitor** —When Cisco CleanAir is enabled in monitor mode, the access point provides air quality and interference detection reports for all monitored channels.
  - **All** —All channels
  - **DCA** —Channel selection governed by the DCA list
  - **Country** —All channels are legal within a regulatory domain
- **SE-Connect** : Use this mode to connect Spectrum Expert on a Microsoft Windows XP or Vista PC to a Cisco CleanAir-enabled access point and display detailed spectrum data. The application connects directly to the AP and bypasses the device. In SE-Connect mode, the AP does not provide Wi-Fi, RF, or spectrum data; it does not serve clients. Use this mode only for remote troubleshooting. You can have up to three active Spectrum Expert connections.

Only Cisco Catalyst 3850 and Switches can function as Mobility Agents.

Cisco Catalyst 3850 Switches, and Cisco 5760 Wireless LAN Controllers can function as Mobility Controllers.

Restrictions for CleanAir

Access points in monitor mode do not transmit Wi-Fi traffic or 802.11 packets. They are excluded from radio resource management (RRM) planning and are not included in the neighbor AP list. IDR clustering depends

on the device 's ability to detect neighboring in-network APs. Correlating interference device detections from multiple APs is limited between monitor-mode APs.

-
- In the 4800 AP, slot 1 is dedicated to 5 GHz and cannot be moved to monitor mode. Slot 0 is an XOR slot and can be set to monitor mode, 2.4 GHz, or 5 GHz. Slot 2 is dedicated to monitor mode and will operate in 5 GHz. When AP monitor mode is enabled, slot 2 is disabled because a monitor radio is already available for both 2.4 and 5 GHz. The 3700 AP has dedicated 2.4 GHz (slot 0) and 5 GHz (slot 1) radios.

Do not connect APs in SE connect mode directly to any physical port on the controller.

CleanAir is not supported where the channel width is 160 MHz.

How to configure CleanAir

Enable CleanAir for the 2.4-GHz band (GUI)

Enable CleanAir on 2.4-GHz band radios for real-time interference detection.

Use this procedure to activate Cisco CleanAir technology on APs operating in the 2.4-GHz spectrum using the GUI.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **CleanAir**.

Step 2 On the **CleanAir** window, click the **2.4 GHz Band** > **General** tab.

Step 3 Check the **Enable CleanAir** checkbox.

Step 4 Click **Apply**.

CleanAir is enabled on all selected 2.4-GHz radios, and spectrum analysis begins for those devices.

Enable CleanAir for the 2.4-GHz band (CLI)

Enable CleanAir technology on APs operating in the 2.4-GHz band radios for real-time interference detection using commands.

Procedure

Enable the CleanAir feature on the 802.11b network.

Example:

```
Device(config)#ap dot11 24ghz cleanair
Device(config)#no ap dot11 24ghz cleanair
```

Run the **no** form of this command to disable CleanAir on the 802.11b network.

CleanAir is enabled on all selected 2.4-GHz radios, and spectrum analysis begins for those devices.

Configure a CleanAir alarm for 2.4-GHz air-quality and devices (CLI)

Set up alarms that notify you when air quality drops or when certain device types are detected on the 2.4-GHz band using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the alarm for the threshold value for air-quality for all the 2.4-GHz devices.

Example:

```
Device(config)# ap dot11 24ghz cleanair alarm air-quality threshold threshold_value
```

Add the **no** form of this command to disable the alarm.

Step 3 Configure the alarm for the 2.4-GHz devices using this command.

Example:

```
Device(config)# ap dot11 24ghz cleanair alarm device {bt-discovery | bt-link | canopy |
cont-tx | dect-like | fh | inv | jammer | mw-oven | nonstd | report | superag | tdd-tx |
video | wimax-fixed | wimax-mobile | xbox | zigbee}
```

Add the **no** form command to disable the alarm.

- bt-discovery: Bluetooth Discovery and bt-link: Bluetooth Link.
- canopy: Canopy devices and cont-tx: Continuous Transmitter.
- dect-like: Digital Enhanced Cordless Communication (DECT)-like phone and fh: 802.11 frequency hopping devices.
- inv: Devices using spectrally inverted WiFi signals and jammer: Jammer.
- mw-oven: Microwave oven and nonstd: Devices using non standard Wi-Fi channels.
- report: Interference device reporting and superag: 802.11 SuperAG devices.
- tdd-tx: TDD Transmitter and video: Video cameras.
- wimax-fixed: WiMax Fixed and wimax-mobile: WiMax Mobile.
- xbox: Xbox and zigbee: 802.15.4 devices.

Step 4 Return to the privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configure interference reporting for a 2.4-GHz device (GUI)

Configure which types of interference are detected by a 2.4-GHz device using the CleanAir GUI. This task guides you through selecting and applying specific interference types to monitor.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **CleanAir**.

Step 2 Click the **2.4 GHz Band** tab.

Step 3 Choose the interference types and add them to the **Interference Types to detect** section.

These interference types are available:

- BLE Beacon: Bluetooth low energy beacon and Bluetooth Discovery.
- Bluetooth Link and Canopy.
- Continuous Transmitter and DECT-like Phone: Digital Enhanced Cordless Technology phone.
- 802.11 FH: 802.11 frequency hopping device and WiFi Inverted: Device using spectrally inverted Wi-Fi signals.
- Jammer and Microwave Oven.
- WiFi Invalid Channel: Device using nonstandard Wi-Fi channels and TDD Transmitter.
- Video Camera and SuperAG: 802.11 SuperAG device.
- WiMax Mobile and WiMax Fixed.
- 802.15.4, Microsoft Device and SI_FHSS.

Step 4 Click **Apply**.

Configure interference reporting for a 2.4-GHz device (CLI)

Configure a 2.4-GHz device to report interference using commands. This process enables devices to detect and provide information about various sources of wireless interference.

Procedure

Step 1 Configure the 2.4-GHz interference devices to report to the device using the command.

Example:

```
Device(config)# ap dot11 24ghz cleanair device {ble-beacon | bt-discovery | bt-link | canopy
 | cont-tx | dect-like | fh | inv | jammer | mw-oven | nonstd | report | superag | tdd-tx
| video | wimax-fixed | wimax-mobile | xbox | zigbee | alarm}
```

Run the **no** form of this command to disable the configuration.

These are the list of the keyword descriptions:

- bt-discovery: Bluetooth discovery and bt-link: Bluetooth link.
- canopy: Canopy device and cont-tx: Continuous transmitter.
- dect-like: Digital Enhanced Cordless Communication-like phone and fh: 802.11-frequency hopping device.
- inv: Device using spectrally inverted Wi-Fi signals and jammer: Jammer.
- mw-oven: Microwave oven, nonstd: Device using nonstandard Wi-Fi channels and report: Interference device reporting.
- superag: 802.11 SuperAG device, tdd-tx: TDD transmitter and video: Video camera.
- wimax-fixed: WiMax Fixed and wimax-mobile: WiMax Mobile.
- microsoft xbox: Microsoft Xbox device and zigbee: 802.15.4 device.

Step 2 Return to the privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Enable CleanAir for the 5-GHz band (GUI)

Enable CleanAir to improve 5-GHz wireless interference detection and spectrum analysis using the GUI.

Perform this task when you need enhanced monitoring and automated mitigation of interference on 5-GHz wireless networks.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **CleanAir**.

Step 2 On the **CleanAir** page, choose the **5 GHz Band** > **General** tab.

Step 3 Check the **Enable CleanAir** checkbox.

Step 4 Click **Apply**.

CleanAir is enabled for the 5-GHz band, enhancing the detection and mitigation of wireless interference.

Enable CleanAir for the 5-GHz band (CLI)

Enable the CleanAir feature to monitor and mitigate wireless interference on 5-GHz wireless networks using commands.

Procedure

Enable the CleanAir feature on a 802.11a network.

Example:

```
Device(config)# ap dot11 5ghz cleanair
```

Run the **no** form of this command to disable CleanAir on the 802.11a network.

CleanAir is enabled for the 5-GHz band, enhancing the detection and mitigation of wireless interference.

Configure interference reporting for a 5-GHz device (GUI)

Enable detection and reporting of selected interference types for better network performance.

Use this procedure when you need to monitor wireless interference on 5-GHz band devices using CleanAir technology.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **CleanAir**.

Step 2 Click the **5 GHz Band** tab.

Step 3 Choose the interference types and add them to the **Interference Types to detect** section.

These interference types are available:

- Canopy
- Continuous Transmitter
- DECT-like Phone—Digital Enhanced Cordless Technology phone
- 802.11 FH—802.11 frequency hopping device
- WiFi Inverted—Device using spectrally inverted Wi-Fi signals
- Jammer
- WiFi Invalid Channel—Device using nonstandard Wi-Fi channels
- SuperAG—802.11 SuperAG device
- TDD Transmitter
- WiMax Mobile
- WiMax Fixed

- Video Camera

Step 4 Click **Apply**.

Your 5-GHz device now detects and reports the selected interference types.

Configure interference reporting for a 5-GHz device (CLI)

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a 5-GHz interference device to report to the **ap dot11 5ghz cleanair device**{**canopy | cont-tx | dect-like | inv | jammer | nonstd | report | superag | tdd-tx | video | wimax-fixed | wimax-mobile**} command.

Example:

```
Device(config)#ap dot11 5ghz cleanair device canopy
Device(config)#ap dot11 5ghz cleanair device cont-tx
Device(config)#ap dot11 5ghz cleanair device dect-like
Device(config)#ap dot11 5ghz cleanair device inv
Device(config)#ap dot11 5ghz cleanair device jammer
Device(config)#ap dot11 5ghz cleanair device nonstd

Device(config)#ap dot11 5ghz cleanair device report
Device(config)#ap dot11 5ghz cleanair device superag
Device(config)#ap dot11 5ghz cleanair device tdd-tx
Device(config)#ap dot11 5ghz cleanair device video
Device(config)#ap dot11 5ghz cleanair device wimax-fixed
Device(config)#ap dot11 5ghz cleanair device wimax-mobile
Device(config)#ap dot11 5ghz cleanair device si_fhss
Device(config)#ap dot11 5ghz cleanair device alarm
```

Device. Run the **no** form of this command to disable interference device reporting.

This is a list of the keyword descriptions:

- **canopy**—Canopy device

- **cont-tx**—Continuous transmitter
- **dect-like**—Digital Enhanced Cordless Communication-like phone
- **fh**—802.11-frequency hopping device
- **inv**—Device using spectrally-inverted Wi-Fi signals
- **jammer**—Jammer
- **nonstd**—Device using nonstandard Wi-Fi channels
- **superag**—802.11 SuperAG device
- **tdd-tx**—TDD transmitter
- **video**—Video camera
- **wimax-fixed**—WiMax fixed
- **wimax-mobile**—WiMax mobile

Step 3 Return to the privileged EXEC mode.

Example:

```
Device(config)# end
```

Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configure event driven RRM for a CleanAir event (GUI)

Configure event driven Radio Resource Management (RRM) to respond to CleanAir-detected interference.

Use this feature to optimize channel assignment automatically when a CleanAir-enabled access point detects significant interference.

Procedure

Step 1 Choose **Configuration** > **Radio Configurations** > **RRM**.
The **Radio Resource Management** window is displayed.

Step 2 Click the **DCA** tab.

Step 3 In the **Event Driven RRM** section, check the **EDRRM** check box to run RRM when CleanAir-enabled AP detects a significant level of interference.

Step 4 Configure the **Sensitivity Threshold** level at which RRM has to be invoked from the following options:

- **Low**: Represents a decreased sensitivity to changes in the environment and its value is set at 35.
- **Medium**: Represents medium sensitivity to changes in the environment at its value is set at 50.
- **High**: Represents increased sensitivity to changes in the environment at its value is set at 60.
- **Custom**: If you choose this option, you must specify a custom value in the **Custom Threshold** box.

Step 5 To configure rogue duty cycle, check the **Rogue Contribution** check box and then specify the **Rogue Duty-Cycle** in terms of percentage. The default value of rogue duty cycle is 80 percent.

Note
Rogue Contribution is a new component in ED-RRM functionality. It enables ED-RRM to respond to Rogue Channel Utilization, which operates independently from CleanAir metrics. Rogue Duty Cycle is derived from standard off-channel RRM metrics and triggers a channel change when neighboring rogue interference is detected. Since this process relies on RRM metrics rather than CleanAir, the timing depends on normal 180-second off-channel intervals, with a maximum delay of three minutes. Rogue Contribution is configured separately from CleanAir ED-RRM and is disabled by default. This feature allows each AP to respond to Wi-Fi interference originating outside the local network, with measurements taken at every individual AP.

Rogue Contribution is a new component in ED-RRM functionality. It enables ED-RRM to respond to detected Rogue Channel Utilization, which functions separately from CleanAir metrics.

Step 6 Save the configuration.

The controller now automatically triggers RRM based on CleanAir or optionally, rogue channel utilization events.

Configure EDRRM for a CleanAir event (CLI)

Enable automated, event-driven dynamic RRM adjustments in response to CleanAir events.

EDRRM allows the AP to adjust its channel management dynamically in response to detected interference or CleanAir events. This ensures better wireless performance and mitigation of interference.

Before you begin

Verify the AP supports CleanAir and EDRRM features.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# conf t
```

Run the **no** form of this command to disable EDRRM.

Step 2 Enable EDRRM CleanAir event.

Example:

```
Device (config)#ap dot11 24ghz rrm channel cleanair-event
```

```
Device(config)#no ap dot11 24ghz rrm channel cleanair-event
```

Run the **no** form of this command to disable EDRRM.

Step 3 Configure the EDRRM sensitivity of the CleanAir event.

Example:

```
Device(config)#ap dot11 24ghz rrm channel cleanair-event sensitivity high
```

This a list of the keyword descriptions:

- High—Specifies the most sensitivity to non-Wi–Fi interference as indicated by the AQ value.
- Low—Specifies the least sensitivity to non-Wi–Fi interference as indicated by the AQ value.
- Medium—Specifies medium sensitivity to non-Wi–Fi interference as indicated by the AQ value.

EDRRM CleanAir event detection and response is enabled with your selected sensitivity, improving dynamic channel management during interference events.

Verify CleanAir parameters

You can verify CleanAir parameters using these commands:

Table 49: Commands for verifying CleanAir

Command Name	Description
show ap dot11 24ghz cleanair device type all	Displays all the CleanAir interferers for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type bt-discovery	Displays CleanAir interferers of type BT Discovery for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type bt-link	Displays CleanAir interferers of type BT Link for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type canopy	Displays CleanAir interferers of type Canopy for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type cont-tx	Displays CleanAir interferers of type Continuous transmitter for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type dect-like	Displays CleanAir interferers of type Digital Enhanced Cordless Telecommunications (DECT) Like for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type fh	Displays CleanAir interferers of type 802.11FH for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type inv	Displays CleanAir interferers of type Wi-Fi Inverted for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type jammer	Displays CleanAir interferers of type Jammer for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type mw-oven	Displays CleanAir interferers of type MW Oven for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type nonstd	Displays CleanAir interferers of type Wi-Fi inverted channel for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type superag	Displays CleanAir interferers of type SuperAG for the 2.4-GHz band.

Command Name	Description
show ap dot11 24ghz cleanair device type tdd-tx	Displays CleanAir interferers of type TDD Transmit for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type video	Displays CleanAir interferers of type Video Camera for the 2.4-GHz band.
show ap dot11 24ghz cleanair device type wimax-fixed	Displays CleanAir interferers of type WiMax Fixed for the 2.4-GHz band.

Configure air quality traps (CLI)

Set up SNMP traps so that you receive alerts when the air quality falls below a specified threshold.

Procedure

Step 1 Configure the trap **ciscoLwappSiAqLowSeverityHigh** to generate an alert when air quality goes beyond a given threshold.

On the controller GUI, navigate to **Configuration** > **Radio Configurations** > **Configuration** > **CleanAir** > **Trap configuration**.

The trap **ciscoLwappSiAqLowSeverityHigh** (OID: 1.3.6.1.4.1.9.9.513.1.6.1.0.5) is used to monitor air quality and generate alerts when the air quality index exceeds a specified threshold.

Step 2 Send the trap from the controller CLI. From the global configuration mode, enable SNMP traps for air quality index (AQI).

Example:

```
Device# snmp-server enable traps wireless SI
```

SNMP traps are configured, and the device sends alerts when air quality index thresholds are exceeded.

What to do next

Monitor SNMP alerts to ensure notifications are received as expected.

Monitor with CleanAir device clusters

A CleanAir device cluster is a spectrum monitoring feature that

- merges detections of the same interference device from multiple sensors into a single cluster,
- assigns and maintains a unique cluster ID for each device, and
- preserves device history by keeping cluster IDs active during temporary lapses in detection.

How CleanAir handles interference device monitoring

Some devices conserve power by limiting the transmit time until actually needed, which results in the spectrum sensor to stop detecting the device temporarily. This device is then correctly marked as down and removed from the spectrum database.

In cases when all the interferer detections for a specific device are reported, the cluster ID is kept alive for an extended period of time to prevent possible device-detection bouncing. If the same device is detected again, it is merged with the original cluster ID and the device-detection history is preserved.

: Bluetooth headset power management

Some Bluetooth headsets operate on battery power and employ methods to reduce power consumption, such as turning off the transmitter when not needed. Such devices can appear to come and go from the classification. To manage these devices, CleanAir keeps the cluster IDs for longer and they are remerged into a single record upon detection. This process smoothens the user records and accurately represents the device history.

Configuration examples for CleanAir

This example shows how to enable CleanAir on the 2.4-GHz band and an AP operating in the channel:

```
Device#configure terminal
Device(config)#ap dot11 24ghz cleanair
Device(config)#exit
Device#ap name TAP1 dot11 24ghz cleanair
Device#end
```

This example shows how to enable an EDRRM CleanAir event in the 2.4-GHz band and configure high sensitivity to non-Wi–Fi interference:

```
Device#configure terminal
Device(config)#ap dot11 24ghz rrm channel cleanair-event
Device(config)#ap dot11 24ghz rrm channel cleanair-event sensitivity high
Device(config)#end
```

CleanAir FAQs

Q. Multiple access points detect the same interference device. However, the device shows them as separate clusters or different suspected devices clustered together. Why does this happen?

A. Access points must be RF neighbors for the device to consider merging the devices that are detected by these access points. An access point takes time to establish neighbor relationships. A few minutes after the device reboots or after there is a change in the RF group, and similar events, clustering will not be very accurate.

Q. How do I view neighbor access points?

A. To view neighbor access points, use the **show ap** *ap_name* **auto-rf dot11** { **24ghz** | **5ghz** } command.

This example shows how to display the neighbor access points:

```
Device#show ap name AS-5508-5-AP3 auto-rf dot11 24ghz

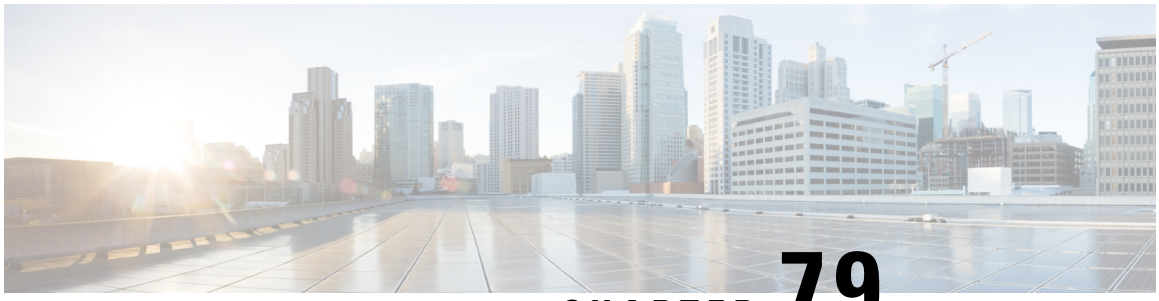
<snippet>
```

```
Nearby APs
  AP 0C85.259E.C350 slot 0                          :  -12 dBm on   1 (10.10.0.5)
  AP 0C85.25AB.CCA0 slot 0                          :  -24 dBm on   6 (10.10.0.5)
  AP 0C85.25C7.B7A0 slot 0                          :  -26 dBm on  11 (10.10.0.5)
  AP 0C85.25DE.2C10 slot 0                          :  -24 dBm on   6 (10.10.0.5)
  AP 0C85.25DE.C8E0 slot 0                          :  -14 dBm on  11 (10.10.0.5)
  AP 0C85.25DF.3280 slot 0                          :  -31 dBm on   6 (10.10.0.5)
  AP 0CD9.96BA.5600 slot 0                          :  -44 dBm on   6 (10.0.0.2)
  AP 24B6.5734.C570 slot 0                          :  -48 dBm on  11 (10.0.0.2)
<snippet>
```

Q. What are the AP debug commands available for CleanAir?

A. The AP debug commands for CleanAir are:

-
-



CHAPTER 79

Spectrum Intelligence

- Spectrum Intelligence, on page 783

Spectrum Intelligence

A spectrum intelligence feature is a radio analysis tool that

- scans 2.4-GHz and 5-GHz bands for non-Wi-Fi radio interference
- detects and classifies interference types such as microwave, continuous wave (like video bridge and baby monitor), Wi-Fi, and frequency hopping (Bluetooth and frequency-hopping spread spectrum (FHSS) cordless phone), and
- provides detailed radio utilization, noise, air quality, and interference reports for compatible Cisco APs.

For information about APs that support this feature, see the relevant documentation. https://www.cisco.com/c/en/us/td/docs/wireless/access_point/feature-matrix/ap-feature-matrix.html.

Note You must enable the Spectrum Intelligence feature on Cisco Aironet 1832 and 1852 series APs to view radio details such as noise, air quality, interference, and radio utilization in Cisco Catalyst Center Assurance AP health.

Restrictions

- SI APs report only a single interference type in Local mode.
- SI does not support high availability for air quality or interference reports. High availability is not supported because the interference report or device report will not be copied to standby after switchover. The AP is expected to send the report again if the interfering device is still present.
- Spectrum Intelligence detects only three types of devices:
  - Microwave
  - continuous wave (such as video recorder, baby monitor)
  - SI-FHSS (Bluetooth and frequency hopping Digital European Cordless Telecommunications [DECT] phones).

Configure spectrum intelligence (CLI)

Enable network administrators to monitor and analyze the radio frequency (RF) environment by configuring the Spectrum Intelligence (SI) feature on Cisco APs.

Follow the procedure given below to configure spectrum intelligence:

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the 2.4-GHz or 5-GHz spectrum intelligence feature on the 802.11a or 802.11b network.

Example:

```
Device(config)# ap dot11 {24ghz | 5ghz} SI
```

Add **no** form of the command to disable SI on the 802.11a or 802.11b network.

Verify spectrum intelligence information

Use these commands to verify spectrum intelligence information:

To display the SI information for a 2.4-GHz or 5-GHz band, use this command:

```
Device# show ap dot11 24ghz SI config

SI Solution..................................... : Enabled
Interference Device Settings:
SI_FHSS............................... : Enabled
Interference Device Types Triggering Alarms:
SI_FHSS............................... : Disabled
```

To display SI interferers of type continuous transmitter for a 2.4-GHz band, use this command:

```
Device# show ap dot11 24ghz SI device type cont_tx

DC    = Duty Cycle (%)
ISI = Interference Severity Index (1-Low Interference, 100-High Interference)
RSSI  = Received Signal Strength Index (dBm)
DevID = Device ID
AP type = CA, clean air, SI spectrum intelligence
No  ClusterID       DevID  Type     AP Type AP Name                ISI  RSSI  DC   Channel
--- --------------- ------ -------- ------- ------------------ ---- ----- ----  ---  ------
xx:xx:xx:xx  0014  BT     CA    myAP1              --   -69 00  133
xx:xx:xx:xx  0014  BT     SI    myAP1              --   -69 00  133
```

To display 802.11a interference devices information for the given AP for 5-GHz, use this command:

```
Device# show ap dot11 5ghz SI device type ap

DC    = Duty Cycle (%)
ISI   = Interference Severity Index (1-Low Interference, 100-High Interference)
RSSI  = Received Signal Strength Index (dBm)
```

```
DevID = Device ID
AP type = CA, clean air, SI spectrum intelligence
No  ClusterID/BSSID    DevID  Type    AP Type AP Name                ISI  RSSI  DC   Channel
--- ------------------ ------ ------- ------  ---------------------- ---- ----- ---- ----------
```

To display all Cisco CleanAir interferers for a 2.4-GHz band, use this command:

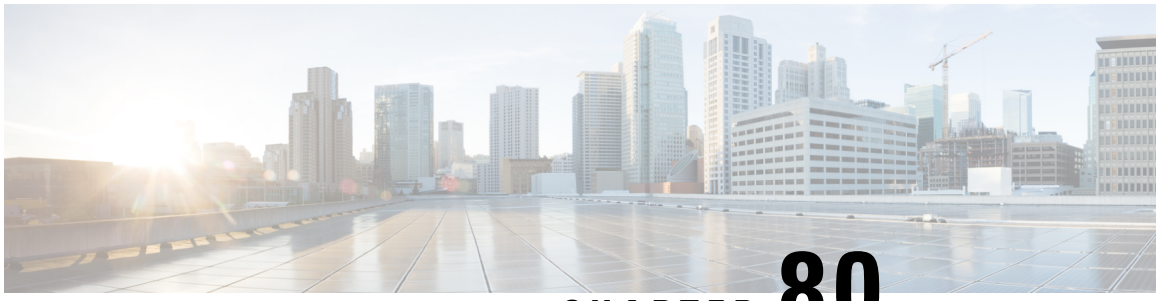
```
Device# show ap dot11 24ghz cleanair device type all
```



PART XII

Mesh Access Points

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CHAPTER 80

Mesh Access Points

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Introduction to Mesh

In Cisco IOS XE 17.6.1 Release, the Cisco Embedded Wireless Controller (EWC) runs on the Cisco Catalyst 9124AX Series outdoor access points, acting as a Root Access Point (RAP) in a mesh deployment. Mesh networking employs Cisco Aironet outdoor mesh access points along with Cisco Embedded Wireless Controller (EWC) to provide scalability, central management, and mobility between deployments. Control and Provisioning of Wireless Access Points (CAPWAP) protocol manages the connection of mesh access points to the network.

Access points within a mesh network operate in one of the following ways:

- Root access point (RAP)
- Mesh access point (MAP)

EWC works on RAPs. RAPs have wired connections, whereas MAPs have wireless connection to the controller. Mesh APs communicate with their parent and child mesh APs using wireless connections over the 802.11a/n radio backhaul. MAPs use the Cisco Adaptive Wireless Path Protocol (AWPP) to determine the best path through the other mesh access points to the controller. A mesh access point establishes AWPP link with a parent Mesh AP, which is already connected to the controller before starting CAPWAP discovery.

The wireless mesh terminates on two points on the wired network. The first location is where the root access point (RAP) is attached to the wired network, and where all bridged traffic connects to the wired network. The second location is where the CAPWAP controller connect to the wired network; this location is where the WLAN client traffic from the mesh network is connected to the wired network. The WLAN client traffic from CAPWAP is tunneled to Layer 2. Matching WLANs should terminate on the same switch VLAN on which the wireless controllers are co-located. The security and network configuration for each of the WLANs on the mesh depend on the security capabilities of the network to which the wireless controller is connected.

End-to-end security within the mesh network is supported by employing Advanced Encryption Standard (AES) encryption between wireless mesh access points and Wi-Fi Protected Access 2 (WPA2) clients. For connections to a mesh access point (MAP) wireless client, such as MAP-to-MAP and MAP-to-root access point, WPA2 is applicable.

In the new configuration model, the controller has a default mesh profile. This profile is mapped to the default AP-join profile, which is in turn is mapped to the default site tag. If you are creating a named mesh profile, ensure that these mappings are put in place, and the corresponding AP is added to the corresponding site-tag.

Note If you change the configuration for Security Mode, BGN, Client-Access, and Range change in mesh profile, the mesh APs will reload. In EWC, you can not reload the internal AP to an active EWC, automatically. You must reload the internal AP manually, after the standby EWC node begins to work after the reload.

From this release, mesh support is included in the Cisco Catalyst 9130AX Series Access Points. All traditional capabilities of mesh are included in the Cisco Catalyst 9130AX Series APs operating in Cisco IOS XE Dublin 17.12.1.

Scale Numbers

Cisco Catalyst 9124 Series Outdoor Access Points support a scale of 100 APs and 2000 clients.

Restrictions and Limitations

- The mesh feature is supported only in Cisco Catalyst 9124 series Access Points, for Cisco Embedded Wireless Controllers.
- EWC supports AP roaming between parent mesh APs within the same controller, only.
- In an EWC mesh topology, any FlexConnect EWC capable AP should be in the CAPWAP mode, when deployed as a child to a MAP, for extending wireless network. The controller will be spawned, if the AP is not in the CAPWAP mode.

Mesh Deployments

Following are the mesh deployments:

- **Wireless Bridging**: Wireless bridging can be point-to-point or point-to-multipoint. Wireless bridges extend the network over the air when a cable is not available. The over-the-air link between the RAP and MAP(s) is treated as a pipe. This type of deployment is usually with RAP and one level of MAP. There are no child MAPs present under the first level of MAP. SSIDs are not deployed.
  - **Point-to-Point Wireless Bridging**: In a point-to-point bridging scenario, a Cisco Catalyst 9124 Series Mesh AP can be used to extend a remote network by using the backhaul radio to bridge two segments of a switched network. This is fundamentally a wireless mesh network with one MAP and no WLAN clients. Just as in point-to-multipoint networks, client access can still be provided with Ethernet bridging enabled, although if bridging between buildings, MAP coverage from a high rooftop might not be suitable for client access.
  - **Point-to-Multipoint**: In the point-to-multipoint bridging scenario, a RAP acting as a root bridge connects multiple MAPs as non-root bridges with their associated wired LANs. By default, this feature is disabled for all MAPs. If Ethernet bridging is used, you must enable it on the controller for the respective MAP and for the RAP.
- **Mesh with Wi-Fi Clients**: Mesh deployments with multilevel MAPs and wireless clients, for extending Wi-Fi network. In a Cisco wireless outdoor mesh network, multiple mesh access points comprise a network that provides secure, scalable outdoor wireless LAN.

MAC authorization

A MAC authorization is a security mechanism that

- restricts MAPs from joining a controller unless their MAC address is pre-approved
- ensures only authorized mesh APs participate in the wireless network, and
- can be handled using either an internal list or an external AAA server.

You must enter the MAC address of an AP in the controller for a MAP to join the controller. The controller responds only to CAPWAP requests from MAPs listed in its authorization list. Remember to use the MAC address provided on the back of the AP.

MAC authorization for MAPs connected to the controller over Ethernet occurs during the CAPWAP join process. For MAPs joining the controller over radio, MAC authorization occurs when the corresponding AP attempts to secure an adaptive wireless path protocol (AWPP) link with the parent MAP. AWPP operates as the protocol for Cisco mesh networks.

The Cisco Catalyst 9800 Series Wireless Controller supports MAC authorization internally as well as using an external AAA server.

Configure MAC authorization (GUI)

Enable MAC-based authorization for wireless mesh networks. Specify which devices can connect by entering their MAC addresses.

Procedure

Step 1 Choose **Configuration** > **Security** > **AAA** > **AAA Advanced** > **Device Authentication**.

Step 2 Click **Add**.
The **Quick Step: MAC Filtering** page is displayed.

Step 3 In the **Quick Step: MAC Filtering** page, complete these steps:

a) Enter the **MAC Address** .
b) Choose the **Attribute List Name** from the drop-down list.
c) Choose the **WLAN Profile Name** from the drop-down list.
d) Click **Apply to Device**.

Both WebUI and CLI support MAC user configuration in these formats: xxxxxxxxxxxx, xx:xx:xx:xx:xx:xx, xx-xx-xx-xx-xx-xx, or xxxx.xxxx.xxxx. The AP sends the default MAC address without any delimiter. If the MAC address is configured with a delimiter, AP authorization fails unless it uses the xxxxxxxxxxxx format.

Step 4 Choose **Configuration** > **Security** > **AAA** > **AAA Method List** > **Authorization**.

Step 5 Click **Add**.
The **Quick Step: AAA Authorization** window is displayed.

Step 6 In the **Quick Step: AAA Authorization** page, complete these actions:

a) Enter the **Method List Name**.
b) Choose the **Type** from the drop-down list.
c) Choose the **Group Type** from the drop-down list.

d) Check the **Fallback to Local** check box.
e) Check the **Authenticated** check box.
f) Move the required servers from the **Available Server Groups** to the **Assigned Server Groups.**
g) Click **Apply to Device**.

Step 7 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 8 Click the mesh profile.
The **Edit Mesh Profile** page is displayed.

Step 9 Click the **Advanced** tab.

Step 10 In the **Security** settings, from the **Method** drop-down list, choose **EAP**.

Step 11 Choose the **Authentication Method** from the drop-down list.

Step 12 Choose the **Authorization Method** from the drop-down list.

Step 13 Click **Update & Apply to Device**.

Authorized devices with the specified MAC addresses can connect to the wireless mesh network.

Configure MAC authorization (CLI)

Enable MAC authorization for bridge mode APs by configuring the credentials and authorization methods needed.

Add the MAC address of a bridge mode AP to the controller to allow authentication.

Before you begin

- MAC filtering for bridge mode APs is enabled by default on the controller. Configure only the MAC address. Find the MAC address on the back of the AP.
- MAC authorization is supported using both internal and external AAA servers.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure username authentication for MAC filtering, using the MAC address as the username.

Example:

```
Device(config)# username user-name
```

Step 3 Set the authorization method list to use local credentials.

Example:

```
Device(config)# aaa authorization credential-download method-name local
```

Step 4 Set the authorization method list to use a RADIUS server group. The command supports up to 14 lines.

Example:

```
Device(config)# aaa authorization credential-download method-name radius group
server-group-name
```

Step 5 Configure a mesh profile to access mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh mesh-profile-name
```

Step 6 Configure the authorization method for mesh APs.

Example:

```
Device(config-wireless-mesh-profile)# method authorization method-name
```

You have successfully configured MAC authorization for bridge mode access points using the CLI on the controller.

```
Device# configure terminal
Device(config)# username username1
Device(config)# aaa authorization credential-download list1 local
Device(config)# aaa authorization credential-download auth1 radius group radius-server-1
Device(config)# wireless profile mesh mesh-profile
Device(config-wireless-mesh-profile)# method authorization auth1
```

Preshared key provisioning

A preshared key (PSK) is a mesh security credential that

- provides authentication between Mesh Access Points (MAPs), RAPs, and controllers
- allows for custom configuration to restrict network access, and
- enhances security compared to default or wildcard provisioning based on MAC addresses.

In mesh deployments, the MAPs might leave the network and join other mesh networks if both mesh deployments use AAA with wildcard MAC filtering to allow MAP association.

Since MAPs might use EAP-FAST, you cannot control this because EAP uses a combination of MAC address and AP type for authentication, and there are no controlled configuration options available. If you use the PSK option with a default pass phrase, you create a security risk.

This issue frequently occurs in overlapping deployments of two service providers when MAPs are used in moving vehicles, such as ferries, ships, or other public transportation.

In these scenarios, your MAPs are not restricted to your service provider mesh network. As a result, another service provider's network can hijack MAPs, preventing them from serving your customers.

The PSK key provisioning feature enables network administrators to assign unique preshared keys from the controller to MAPs. This ensures that only authorized MAPs can authenticate to specific RAPs and controllers. These measures prevent accidental or malicious association with unauthorized mesh networks and protect service provider deployments.

Configuring PSK Provisioning (GUI)

To configure PSK provisioning, follows these steps:

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** .

Step 2 Click the **Global Config** tab.

Step 3 In the **Security** settings, check the **PSK Provisioning** check box and complete the following steps:

a) Choose the **PSK Inuse Index** from the numbers in the drop-down list.
b) In the **Keys Configuration** settings, click the add icon '+' to configure the keys.
c) Choose the **Key** from the drop-down list.
d) Enter the **Name** and the **Description** of the key that is to be configured.
e) Choose the **Password Type** as **UNENCRYPTED** or **AES Encrypted**.
f) Click **Apply**. The key is listed in the list of configured keys.

Step 4 Check the **Default PSK** check box.

Step 5 Click **Apply**.

Configure PSK provisioning (CLI)

When you enable PSK provisioning, your APs join using the default PSK. After you set the PSK provisioning key, the system pushes the configured key to each newly joined AP.

Complete these steps to configure a PSK:

Before you begin

Confirm that you have pushed the provisioned PSK to every AP configured with PSK as mesh security.

Note

- PSKs are saved across reboots in the controller as well as on the corresponding mesh AP.
- A controller can have a total of five PSKs and one default PSK.
- A mesh AP deletes the provisioned PSK only during a factory reset.
- A mesh AP never uses the default PSK after receiving the first provisioned PSK.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the security method for wireless as PSK.

Example:

```
Device(config)# wireless mesh security psk provisioning
```

Note
The controller pushes the provisioned PSK only to APs configured with PSK as the mesh security method.

Step 3 Configure a new PSK for mesh APs.

Example:

```
Device(config)# wireless mesh security psk provisioning key index {0 | 8} preshared-key
description
```

Step 4 Enable default PSK-based authentication.

Example:

```
Device(config)# wireless mesh security psk provisioning default-psk
```

Step 5 Specify the PSK to be actively used.

Example:

```
Device(config)# wireless mesh security psk provisioning inuse index
```

Note
You should explicitly specify the in-use key index in the global configuration to point to the PSK index.

The controller provisions the specified pre-shared key on the mesh APs, sets the active key, and distributes it accordingly.

```
Device# configure terminal
Device(config)# wireless mesh security psk provisioning
Device(config)# wireless mesh security psk provisioning key 1 0 secret secret-key
Device(config)# wireless mesh security psk provisioning default-psk
Device(config)# wireless mesh security psk provisioning inuse 1
```

EAP authentication

A EAP authentication is a wireless network authentication method that

- allows users and wireless clients to be authenticated locally on a controller
- removes dependence on external authentication servers, and
- supports additional modules such as LSC-based authentication for enhanced security.

Use Local EAP in remote offices to maintain connectivity during backend disruptions. The controller acts as both a server and a user database, retrieving user credentials locally or through LDAP. Local EAP supports the EAP-FAST method for MAP authentication.

An LDAP backend database allows the controller to query an LDAP server for the credentials (username and password) of a particular user. The controller uses these credentials to authenticate the user.

Note If you configure RADIUS servers on the controller, it will first authenticate the wireless clients using those servers. Local EAP is attempted only if RADIUS servers are not found, timed out, or were not configured.

Locally significant certificate-based (LSC) EAP authentication

A locally significant certificate-based authentication is a WLAN security method that

- authenticates network devices (such as APs and controllers) using locally generated digital certificates
- allows both locally significant certificates (LSCs) and manufacturing installed certificates (MICs) to coexist (with LSCs taking precedence), and
- supports advanced security features, like mesh EAP authentication and master session key generation.

LSC-based EAP authentication requires a public key infrastructure (PKI). This establishes certification authorities, defines policies, and sets validity periods and restrictions.

Certificates (LSCs) must be generated and installed on Access Points and controllers. If an Access Point is provisioned with an LSC, the MIC certificate is not used during boot-up. Changes from LSC to MIC require the Access Point to reboot. LSC-based EAP authentication is supported for mesh Access Points (MAPs). The controller supports mesh security with EAP authentication to a designated server to authenticate mesh child Access Points and generate master session keys for packet encryption.

If a customer installs an LSC (certificate they generate), the AP will use that certificate for authentication and not the factory-installed MIC. Mesh child APs can use LSC EAP authentication to securely join the network and establish encrypted sessions.

The controller also supports mesh security with EAP authentication to a designated server in order to:

- Authenticate the mesh child AP
- Generate a master session key (MSK) for packet encryption.

Bridge group names

A bridge group name (BGN) is a mesh network configuration parameter that

- controls the association of Mesh Access Points (MAPs) to a parent mesh AP
- allows logical grouping of radios to isolate different networks on the same channel, and
- allows MAPs to join networks before you assign a custom BGN.

BGNs can logically group radios to avoid two networks on the same channel from communicating with each other. The setting is useful when your network contains multiple RAPs in the same sector (area). A BGN is a string containing up to 10 characters.

A BGN of *NULL VALUE* is assigned by default during manufacturing. This value is not visible to you, but it allows a MAP to join the network before you assign a network-specific BGN.

If you have two RAPs in your network in the same sector, we recommend that you configure the two RAPs with the same BGN, on different channels.

When Strict Match BGN is enabled on a MAP, the MAP scans ten times to find a matching BGN parent. If the AP does not find a parent with a matching BGN after ten scans, it connects to a nonmatching BGN and maintains the connection for 15 minutes. After 15 minutes, the AP scans ten times again, and this cycle continues. The default BGN functionality does not change when Strict Match BGN is enabled.

In Cisco Catalyst 9800 Series Wireless Controller, the BGN is configured on the mesh profile. When a MAP joins the controller, the system pushes the configured BGN on the mesh profile to the AP.



Note In the EWC HA pair, the system initiates switchover if you change the BGN configuration. If you remove the configured BGN from the mesh profile, a switchover is triggered.

Preferred parent selection

A preferred parent selection is a mesh network configuration method that

- enables enforcement of linear topology in a mesh environment
- allows administrators to override the AWPP-defined (Adaptive Wireless Path Protocol) parent selection algorithm, and
- supports explicit specification of the uplink path for the MAP in mesh deployments.

For Cisco Wave 1 APs, when you configure a preferred parent, ensure that you specify the MAC address of the actual mesh neighbor for the desired parent. This MAC address is the base radio MAC address that has the letter "f" as the final character. For example, if the base radio MAC address is 00:24:13:0f:92:00, then you must specify 00:24:13:0f:92:0f as the preferred parent.

```
Device# ap name ap1 mesh parent preferred 00:24:13:0f:92:0f
```

For Cisco Wave 2 APs, when you configure a preferred parent, the MAC address is the base radio MAC address that has "0x11" added to the last two characters. For example, if the base radio MAC address is 00:24:13:0f:92:00, then you must specify 00:24:13:0f:92:11 as the preferred parent.

```
Device# ap name ap1 mesh parent preferred 00:24:13:0f:92:11
```

Configure a bridge group name (GUI)

Configure a bridge group name to organize and manage wireless mesh network profiles efficiently.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**

Step 2 Click **Add**.

Step 3 In the **Advanced** tab, under the **Bridge Group** settings, enter the **Bridge Group Name**.

Step 4 Under the **Bridge Group** settings, check the **Strict Match** check box to enable the feature. The MAP scans ten times to find a matching BGN parent when you enable **Strict Match** BGN.

Step 5 Click **Apply to Device**.

The system assigns and applies a new bridge group name to the mesh profile you selected.

Configure a bridge group name (CLI)

Configure a bridge group name (BGN) for a mesh profile on a wireless LAN controller using CLI commands.

- If a BGN is configured on a mesh profile, whenever a MAP joins the controller, it pushes the BGN configured on the mesh profile to the AP.
- Whenever a mesh AP moves from AireOS controller to the Cisco Catalyst 9800 Series Wireless Controller, the BGN configured on the mesh profile is pushed to that AP and stored there.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh mesh-profile-name
```

Step 3 Configure a bridge group name.

Example:

```
Device(config-wireless-mesh-profile)# bridge-group name bridge-grp-name
```

Step 4 Configure bridge group strict matching.

Example:

```
Device(config-wireless-mesh-profile)# bridge-group strict-match
```

The bridge group name is assigned to the mesh profile and applied to all associated mesh APs.

```
Device# configure terminal
Device(config)# wireless profile mesh mesh-profile-bgn
Device(config-wireless-mesh-profile)# bridge-group name bgn-grp-name
Device(config-wireless-mesh-profile)# bridge-group strict-match
```

Mesh backhaul at 2.4 GHz and 5 GHz

A backhaul is a wireless network interface that

- creates the connection between Mesh Access Points (MAPs)
- operates over 802.11a/n/ac/g, depending on the AP, and
- typically defaults to the 5-GHz frequency band.

Selecting the appropriate backhaul rate is important for efficient spectrum use. It can directly affect client device throughput, a critical metric in evaluating wireless performance.

Mesh backhaul is supported at 2.4 GHz and 5 GHz. By default, the backhaul interface for mesh APs uses 802.11a/ac/ax. In some countries, mesh networks cannot use a 5 GHz backhaul. In countries where 5 GHz is allowed, using 2.4 GHz radio frequencies achieves more extensive mesh or bridge distances.

When a RAP receives a slot-change configuration, the RAP propagates it to all child MAPs. All MAPs disconnect and join the newly configured backhaul slot.

For information about APs that support mesh backhaul, see https://www.cisco.com/c/en/us/td/docs/wireless/access_point/feature-matrix/ap-feature-matrix.html .



Note In Israel, you must ensure that you run the **ap country IO** command to enable the outdoor country code for the selected radio. After you configure using the **ap country IO** command, the 2.4-GHz radio is enabled and 5-GHz radio is disabled.

Configure mesh backhaul (CLI)

Set the mesh backhaul frequency for an access AP using CLI commands.

Procedure

Change the mesh backhaul to 2.4 GHz.

Example:

```
Device # ap name test-ap mesh backhaul radio dot11 24ghz
```

The specified access point now uses 2.4 GHz as its mesh backhaul radio frequency.

Mesh backhaul RRM

Root access points (RAPs) choose backhaul channels to operate in mesh networks. Until Cisco IOS XE Cupertino 17.8.1, this operation occurred by an explicit configuration, a least congested scan during RAP boot time, during the initial radio resource management (RRM) run without mesh access points (MAPs) connected, or a backhaul channel that was chosen at random. As a result, a poor backhaul channel selection resulted in poor performance.

From Cisco IOS XE Cupertino 17.9.1 onwards, RRM DCA is run on mesh backhaul, in auto mode, in FlexConnect or centralized networks. For APs that do not have dedicated (RHL) radios, DCA is triggered by running commands in the privilege EXEC mode.

RRM continuously evaluates the channel conditions to ensure that the network utilizes the least congested channels. The network uses the transmission static power if it is configured, or falls back to the default level. This is supported on APs that have dedicated radios to scan channel conditions, without any user perceptible interruption to the mesh network traffic.

In the mesh backhaul RRM feature, the RRM DCA decides all the downlink channels in a steady network. However, if an AP detects a change in its uplink roam or radar detection response, the AP chooses the best downlink to converge faster.

Note APs choosing the best possible downlink is limited to serial backhaul enabled APs only.

Configure RRM channel assignment for an AP

Assign RRM channels to an AP. This action helps you optimize wireless channel usage and reduce interference.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Trigger the RRM DCA process for your AP.

Example:

```
Device# ap name Cisco-ap-name dot11 {24ghz | 5ghz | 6ghz} rrm channel update mesh
```

After you trigger the process, the system starts the RRM DCA process and updates the channel assignment for your selected radio band.

```
Device> enable
Device# ap name Cisco-ap-name dot11 5ghz rrm channel update mesh
```

Configure RRM channel assignment for root access points globally

Configure Radio Resource Management (RRM) channel assignment policies for all root access points. This configuration optimizes wireless performance, minimizes interference, and maintains network stability across your deployment.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure RRM for mesh backhaul.

Example:

```
Device(config)# wireless mesh backhaul rrm
```

Step 3 (Optional) Configure auto DCA for RF Application Specific Integrated Circuit (ASIC) integrated RAPs.

Example:

```
Device(config)# wireless mesh backhaul rrm auto-dca
```

All RAPs adopt the configured RRM channel assignment settings globally. This change results in improved channel distribution, reduced interference, and more reliable wireless connectivity across the network.

```
Device# configure terminal
Device(config)# wireless mesh backhaul rrm
Device(config)# wireless mesh backhaul rrm auto-dca
```

Complete these steps to configure the initial channel assignment of the RAP in privileged EXEC mode through RRM and to initiate channel selection for each bridge group.

Procedure

	Command or Action	Purpose
Step 1	Enter privileged EXEC mode. **Example:** `Device> enable`	
Step 2	Initiate the update of the 802.11, 802.11a, or 802.11b channel selection for every mesh Cisco AP. **Example:** `Device# ap dot11 {24ghz | 5ghz | 6ghz} rrm channel-update mesh`	
Step 3	Initiate the update of the 802.11, 802.11a, or 802.11b channel selection for mesh AP in the bridge group. **Example:** `Device# ap dot11 {24ghz | 5ghz | 6ghz} rrm channel-update mesh bridge-group` *`bridge-group-name`*	

RRM completes the channel assignment for the RAP in privileged EXEC mode.

```
Device> enable
Device# ap dot11 5ghz rrm channel-update mesh
Device# ap dot11 5ghz rrm channel-update mesh bridge-group cisco-bridge-group
```

Verify the RRM DCA status

To view the status of the DCA that is run for mesh APs, run this command:

```
Device# show ap name Cisco-AP config general | inc Mesh
Mesh profile name                               : default-mesh-profile
Mesh DCA Run Status:                            : Not Running
Last Mesh DCA Run                               : 02/07/2022 01:21:56
```

To verify the status of the last DCA run per radio, run this command:

```
Device# show wireless mesh rrm dca status
```

Dynamic frequency selection

A dynamic frequency selection (DFS) is a wireless communication protocol that

- enables radio devices to detect radar signals
- requires devices to cease transmission when radar is detected, and
- requires selecting and monitoring a new channel before resuming transmission.

Regulatory bodies enforce DFS to prevent interference with radar services in shared frequency bands by unlicensed wireless devices.

To protect radar services, regulatory bodies require devices on newly opened frequency sub-bands to operate using DFS. Your radio device must detect radar signals as required. If a radar event is detected in any AP within a sector, mesh access points immediately switch channels to maintain compliance.

For instance, When a radio detects a radar signal, the radio should stop transmitting for at least 30 minutes to protect that service. The radio should then select a different channel to transmit on, but only after monitoring it. If no radar is detected on the projected channel for at least one minute, the new radio service device can begin transmissions on that channel.

Configuring Dynamic Frequency Selection (GUI)

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Click **Add**.
The **Add Mesh Profile** window is displayed.

Step 3 In the **Add Mesh Profile** window, click the **General** tab.

Step 4 Enter a profile name.

Step 5 Check the **Full sector DFS status** check box to enable dynamic frequency selection.

Step 6 Click **Apply to Device**.

Configure dynamic frequency selection (CLI)

Configure dynamic frequency selection (DFS) on your device to enable radar detection and meet DFS requirements.

DFS specifies the types of radar waveforms that should be detected and the timers that must be used for operation in the DFS channel.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Enable DFS.

Example:

```
Device(config-wireless-mesh-profile)# full-sector-dfs
```

Note
DFS functionality allows a MAP that detects a radar signal to transmit this information to the RAP. The RAP treats this as a radar detection and moves the sector. This process is called the coordinated channel change. The coordinated channel change feature is always enabled on Cisco Wave 2 and newer APs. You can disable this feature only on Cisco Wave 1 APs.

Dynamic Frequency Selection is enabled for your mesh profile. Your mesh profile is now ready to operate and meets radar detection requirements.

```
Device# configure terminal
Device(config)# wireless profile mesh dfs-mesh-profile
Device(config-wireless-mesh-profile)# full-sector-dfs
```

Country codes

A country code is a regulatory compliance setting that

- allows specification of the intended country of operation for controllers and APs
- ensures adherence to local regulations about broadcast frequencies, channels, and power levels, and
- maintains correct assignment of regulatory domains for each device.

In certain countries, there is a difference for indoor and outdoor APs in these areas:

- Regulatory domain code
- Set of channels supported
- Transmit power level

Controllers and APs are designed for use in many countries with varying regulatory requirements. At the factory, the radios within the APs are assigned to a specific regulatory domain (such as -E for Europe). The country code then enables you to specify a particular country of operation (such as FR for France or ES for Spain). Configuring a country code ensures that the broadcast frequency bands, interfaces, channels, and transmit power levels of each radio are compliant with country-specific regulations.

Intrusion detection system

Cisco Intrusion Detection System/Intrusion Prevention System (CIDS/CIPS) is a network security solution that

- monitors network traffic and system activities for signs of suspicious behavior
- detects and classifies potential security threats such as malware or unauthorized access, and
- responds to attacks or alerts administrators to enable prevention or mitigation actions.

CIDS can block specific clients from your wireless network if it detects attacks involving them in network layers 3 to 7. This feature helps you detect, classify, and stop threats such as worms, spyware, adware, network viruses, and application abuse.

Configuring the Intrusion Detection System (GUI)

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Click **Add**.
The **Add Mesh Profile** window is displayed.

Step 3 In the **Add Mesh Profile** window, click the **General** tab.

Step 4 Enter a profile name.

Step 5 Check the **IDS (Rogue/Signature Detection)** check box to enable the Intrusion Detection System.

Step 6 Click **Apply to Device**.

Configure the intrusion detection system (CLI)

Enable intrusion detection system monitoring and reporting on mesh APs to enhance network security.

When enabled, the intrusion detection system generates reports for all client access traffic. This feature does not apply to backhaul traffic.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Configure intrusion detection system reporting for mesh APs.

Example:

```
Device(config-wireless-mesh-profile)# ids
```

The device is now configured to report intrusion detection events for mesh APs.

```
Device# configure terminal
Device(config)# wireless profile mesh mesh-ids
Device(config-wireless-mesh-profile)# ids
```

Mesh interoperability between controllers

Mesh interoperability between controllers is a wireless mesh network capability that

- enables MAPs to join an AireOS controller through a mesh network formed by APs connected to a Cisco Catalyst 9800 Series Wireless Controller
- allows MAPs to join a Cisco Catalyst 9800 Series Wireless Controller through a mesh network formed by APs connected to an AireOS controller, and
- supports MAP roaming between parent mesh APs connected to AireOS and Cisco Catalyst 9800 Series Wireless Controller using PMK cache.

Note For seamless interoperability, the AireOS controller and the Cisco Catalyst 9800 Series Wireless Controller must be in the same mobility group. Both controllers should use image versions that support Inter-Release Controller Mobility (IRCM).

Mesh convergence

A mesh convergence event is a network recovery mechanism that

- allows MAPs to re-establish connection with a controller after losing the backhaul link to the current parent
- enables the use of a maintained subset of channels for future scanning and parent identification, and
- supports multiple convergence methods to optimize reconnection time.

The table presents the supported convergence methods.

Table 50: Mesh convergence

Mesh convergence	Parent Loss Detection / Keepalive Timers
Standard	21 seconds / 3 seconds
Fast	7 seconds / 3 seconds
Very Fast	4 seconds / 2 seconds
Noise-tolerant-fast	21 seconds / 3 seconds

Noise-tolerant fast detection

A noise-tolerant fast detection is a detection method that

- monitors the response to Adaptive Wireless Path Protocol (AWPP) neighbor requests at specified intervals
- identifies parent connectivity loss through missed responses, and
- initiates network recovery actions such as roaming or full scans when loss is detected.

Noise-tolerant fast detection occurs when there is no response to an AWPP neighbor request. In the standard method, the system evaluates the current parent every 21 seconds. Each neighbor receives a unicast request every three seconds, and the parent also receives a request. If the parent does not respond, the device either roams to an available neighbor on the same channel or performs a full scan to find a new parent.

Configure mesh convergence (CLI)

This section provides information about how to configure mesh convergence.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Create a mesh profile.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Configure mesh convergence method in a mesh profile.

Example:

```
Device(config-wireless-mesh-profile)# convergence {fast | noise-tolerant-fast | standard |
 very-fast}
```

You have successfully configured mesh convergence for the specified mesh profile on the device.

```
Device# configure terminal
Device(config)# wireless profile mesh mesh1
Device(config-wireless-mesh-profile)# convergence fast
```

Ethernet bridging

An Ethernet bridge is a network device that

- enables you to secure activation of Ethernet ports on MAPs
- supports both tagged and untagged packets for flexible deployment, and
- allows segmenting application traffic with VLAN tagging between wireless and wired LANs.

For security, the Ethernet port on all MAPs is disabled by default. They can be enabled only through Ethernet bridging configuration on both the root and respective MAP.

Secondary Ethernet interfaces support both tagged and untagged packets.

In a point-to-point bridging, a Cisco Aironet 1500 Series MAP can extend remote networks by using the backhaul radio to bridge multiple segments of a switched network. This is fundamentally a wireless mesh network with one MAP and no WLAN clients.

In point-to-multipoint networks, client access can still be provided with Ethernet bridging enabled, although if bridging between buildings, MAP coverage from a high rooftop might not be suitable for client access. To use an Ethernet-bridged application, enable the bridging feature on the RAP and on all the MAPs in that sector.

In a mesh environment, with VLAN support for Ethernet bridging, the secondary Ethernet interfaces on MAPs are assigned a VLAN individually from the controller. Wired and wireless backhaul links operate as trunks with all VLANs allowed. Non-Ethernet bridged traffic, as well as untagged Ethernet bridged traffic travels along the mesh using the native VLAN of the APs in the mesh. It is similar for all the traffic to and from the wireless clients that the APs are servicing. The VLAN-tagged packets are tunneled through AWPP over wireless backhaul links.

Note Ensure Ethernet bridging is enabled for every parent mesh AP along the data path to the controller.

Ethernet bridging should be enabled for these scenarios:

- Use mesh nodes as bridges.
- Connect Ethernet devices, such as a video camera on a MAP using its Ethernet port.

VLAN tagging for MAP Ethernet clients

Primary interfaces refer to mesh AP backhauls, and secondary interfaces refer to other AP interfaces.

Ethernet VLAN tagging segments application traffic within a mesh and forwards it to a wired LAN (access mode) or another wireless mesh network (trunk mode).

Configure Ethernet bridging (GUI)

Enable Ethernet bridging on a mesh profile so that network traffic can be transparently passed between Ethernet segments.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Click **Add**.

Step 3 In **General** tab, enter the **Name** of the mesh profile.

Step 4 In the **Advanced** tab, check the **VLAN Transparent** check box to enable VLAN transparency.

Step 5 In **Advanced** tab, check the **Ethernet Bridging** check box.

Step 6 Click **Apply to Device**.

Ethernet bridging is now enabled for the selected mesh profile.

Configure Ethernet bridging (CLI)

Configure Ethernet bridging on mesh access points (APs) to allow Ethernet devices to connect through AP ports.

The Ethernet ports on MAPs are disabled by default. To enable them, configure Ethernet bridging on the Root AP and the relevant MAPs.

You can enable Ethernet bridging to:

- Use the mesh nodes as bridges.
- Connect Ethernet devices, such as a video camera, on a MAP using the MAP's Ethernet port.

Before you begin

- Ensure that you configure these commands under the mesh profile configuration for Ethernet bridging to be enabled:
  - **ethernet-bridging**: Enables the Ethernet Bridging feature on an AP.
  - **no ethernet-vlan-transparent**: Makes the wireless mesh bridge VLAN aware. VLAN filtering is allowed with this AP command: **[no] mesh ethernet** { **0** | **1** | **2** | **3** } **mode trunk vlan allowed** .

Note If you want all VLANs bridged (the bridge acts like a piece of wire), enable VLAN transparency to allow all VLANs to pass. To avoid unnecessary traffic flooding the network, filter VLANs on the wired side when using VLAN transparent mode.

- Configure the switch port that connects to the root AP as a trunk port so Ethernet bridging works.

- For Bridge mode APs, use the **ap name** *name-of-rap* **mesh vlan-trunking native** *vlan-id* command to configure a trunk VLAN on the corresponding RAP. You must configure this command to enable the Ethernet Bridging feature on the AP.
- For FlexConnect+Bridge APs, configure the native VLAN ID under the corresponding flex profile.

e

Procedure

Step 1 Enable privileged EXEC mode.

Example:

```
Device> enable
```

Enter your password, if prompted.

Step 2 Configure the Ethernet port of the AP and set the mode.

Example:

```
Device# ap name ap-name mesh ethernet {0 | 1 | 2 | 3} mode access vlan-id
```

Step 3 Set the native VLAN for the trunk port.

Example:

```
Device# ap name ap-name mesh ethernet {0 | 1 | 2 | 3} mode trunk vlan native 21
```

Step 4 Configure the allowed VLANs for the trunk port.

Example:

```
Device# ap name ap1 mesh ethernet  { 0 | 1 | 2 | 3 } mode trunk vlan allowed vlan-id
```

This command permits VLAN filtering on an Ethernet port of any Mesh or Root Access Point. It is active only when VLAN transparency is disabled in the mesh profile.

Ethernet bridging is enabled on the AP, allowing devices to communicate through configured VLANs.

```
Device> enable
Device# ap name ap1 mesh ethernet 1 mode access 21
Device# ap name ap1 mesh ethernet 1 mode trunk vlan native 21
Device# ap name ap1 mesh ethernet 1 mode trunk vlan allowed 21
```

Mesh daisy chaining

A mesh daisy chain is a wireless networking topology that

- connects mesh APs in series to relay data
- enables both serial backhaul communication and network extension for client access, and
- supports flexible deployment by allowing MAPs to connect in different modes and power configurations.

Mesh APs can daisy chain when operating as Mesh APs. In a daisy chain configuration, MAPs function as either serial backhaul links—using different channels for uplink and downlink to increase backhaul bandwidth—or as extensions of universal network access. Extending universal access allows a local mode or FlexConnect mode Mesh AP to connect to the Ethernet port of a MAP, expanding network reach for client devices.

Wired daisy-chained APs require specific cabling based on power source:

- If an AP uses DC power, connect an Ethernet cable from the LAN port of the Primary AP directly to the PoE-in port of the Subordinate AP.

Restrictions for mesh Ethernet daisy chaining

Review and meet these requirements before you configure mesh Ethernet daisy chaining:

- This feature is applicable to the Cisco Industrial Wireless 3702 AP and Cisco Catalyst 9124 Series APs.
- This feature is applicable to APs operating in Bridge mode and Flex+Bridge mode only.
- In Flex+Bridge mode, if local switching WLAN is enabled, the work group bridge (WGB) multiple VLAN is not supported.
- For Ethernet daisy chain topology, connect a power injector as the power supply for the AP. Do not connect the Cisco Industrial Wireless 3702 PoE out port to the PoE in port of another Cisco Industrial Wireless 3702 AP.
- The network convergence time increases as the number of APs in the chain increases.
- Any EWC-capable AP that is part of daisy chaining and has been assigned the RAP role must operate in CAPWAP mode (ap-type capwap).

Prerequisites for mesh Ethernet daisy chaining

Before you deploy mesh Ethernet daisy chaining, complete several configuration steps and verify specific settings on your APs. These prerequisites include designating AP roles, enabling relevant features, configuring VLAN support, and using the proper cabling to ensure optimal system performance and compatibility.

- Ensure that you have configured the AP role as root AP.
- Ensure that you have enabled Ethernet bridging and Strict Wired Uplink on the corresponding AP.
- Ensure that you have disabled VLAN transparency.
- To enable VLAN support on each root AP operating in bridge mode, use the **ap name** *name-of-rap* **mesh vlan-trunking [native]** *vlan-id* command. This command configures a trunk VLAN on the corresponding RAP.
- To enable VLAN support on each root AP, for Flex+Bridge APs, you must configure the native VLAN ID under the corresponding Flex profile.
- Ensure that you use 4-pair cables that support 1000 Mbps. This feature does not work properly with 2-pair cables that support 100 Mbps.

Configure mesh Ethernet daisy chaining (CLI)

This section provides information about how to configure the Mesh Ethernet Daisy Chaining feature on a mesh AP.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify the AP profile.

Example:

```
Device(config)# ap profile default-ap-profile
```

Step 3 Configure persistent SSID broadcast and ensure strict wired uplink. RAP will not switch to wireless backhaul when you configure this command.

Example:

```
Device(config-ap-profile)# ssid broadcast persistent
```

Mesh Ethernet daisy chaining is successfully enabled on the mesh AP. The SSID broadcast is persistent and the RAP uses a strict wired uplink.

Multicast over mesh Ethernet bridging network

A mesh multicast mode is a traffic management setting for bridging-enabled APs that

- determine how multicast and broadcast packets are forwarded across the mesh Ethernet network
- manage only non-CAPWAP multicast traffic, and
- help optimize bandwidth by reducing unnecessary multicast transmissions.

Mesh multicast modes

Mesh multicast modes determine how bridging-enabled APs such as MAP and RAP send multicast packets among Ethernet LANs within a mesh network. Mesh multicast modes manage only non-CAPWAP multicast traffic. CAPWAP multicast traffic is governed by a different mechanism.

Different mesh multicast modes are available to manage multicast and broadcast packets on all MAPs. When enabled, these modes reduce unnecessary multicast transmissions within the mesh network and conserve backhaul bandwidth.

The mesh multicast modes are:

- Regular mode: Regular mode for multicast is not supported on Cisco Catalyst 9124 Series Outdoor Access Points on EWC.

- In-only mode: When a MAP receives multicast packets from the Ethernet, it forwards them to the corresponding RAP's Ethernet network. No additional forwarding occurs. This setting ensures that the RAP does not send non-CAPWAP multicasts back to the MAP Ethernet networks within the mesh network (their point of origin). The system filters out MAP to MAP multicasts so these do not occur.
- In-out mode: The RAP and MAP multicast in different ways.
  - If a MAP receives multicast packets over Ethernet, it sends them to the RAP. The MAP does not send these packets to other MAPs over Ethernet; the system filters MAP-to-MAP packets from the multicast stream.
  - If a RAP receives multicast packets over Ethernet, it sends them to all the MAPs and their respective Ethernet networks. When in-out mode operates, partition your network to ensure a multicast sent by one RAP is not received by another RAP on the same Ethernet segment and then sent back into the network.

Configuring Multicast Modes Over Mesh (GUI)

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Click **Add**.
The **Add Mesh Profile** window is displayed.

Step 3 In the **Add Mesh Profile** window, click the **General** tab.

Step 4 Enter a profile name.

Step 5 Choose one of the following **Multicast Modes**, from the drop-down list:

a) **Regular**: In this mode, data is multicast across the entire mesh network and all its segments by bridging-enabled RAP and MAP.

b) **In**: In this mode, the multicast packets received from the Ethernet by a MAP are forwarded to the corresponding RAP's Ethernet network.

c) **In-Out**: In this mode, both RAP and MAP multicast but in a different manner.

Step 6 Click **Apply to Device**.

Configure multicast modes over mesh

Enable multicast forwarding behavior so that your wireless mesh network operates efficiently.

- If multicast packets are received at a MAP over Ethernet, the MAP sends them to the RAP. The MAP does not send them to other MAPs; it filters out MAP-to-MAP packets from the multicast.
- If multicast packets are received at a RAP over Ethernet, they are sent to all the MAPs and their respective Ethernet networks.
- The *in-out* mode is the default mode. To prevent a multicast sent by one RAP from being received by another RAP on the same Ethernet segment and then sent back into the network, properly partition your network when the *in-out* mode is in operation.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Configure mesh multicast mode.

Example:

```
Device(config-wireless-mesh-profile)# multicast {in-only | in-out | regular}
```

You have set the mesh profile to the multicast mode you want. This setting controls how multicast packets are routed in the network.

```
Device# configure terminal
Device(config)# wireless profile mesh mesh-multicast
Device(config-wireless-mesh-profile)# multicast regular
```

Radio Resource Management on mesh

Radio resource management (RRM) features are wireless network management functions that

- enable real-time RF management of the wireless network
- monitor lightweight APs for traffic load, interference, noise, and coverage, and
- operate automatically through embedded controller software.

The RRM measurement in the mesh AP backhaul is enabled based on these conditions:

- Mesh AP has the Root AP role.
- Root AP has joined using Ethernet link.
- Root AP does not serve any child AP.

Configuring RRM on Mesh Backhaul (GUI)

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Global Config**.

Step 2 In the **Backhaul** section, check the **RRM** check box to enable radio resource management on mesh.

Step 3 Click **Apply**.

Configure RRM on mesh backhaul (CLI)

RRM measurement in the mesh AP backhaul is enabled if your access point meets these conditions:

- Mesh AP has the Root AP role.
- The Root AP has joined the network using an Ethernet link.
- Root AP does not serve any child AP.



Note When RRM is enabled on the mesh backhaul, only RAPs joined via Ethernet and without child MAPs report RRM noise information.

Complete the steps to enable RRM in the mesh backhaul:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure RRM on the mesh backhaul.

Example:

```
Device(config)# wireless mesh backhaul rrm
```

RRM is enabled on the mesh backhaul for APs.

```
Device# configure terminal
Device(config)# wireless mesh backhaul rrm
```

Mesh leaf node

A mesh leaf node is a type of mesh access point (MAP) that

- operates only as a child node within a wireless mesh network
- is typically assigned to MAPs with lower performance, and
- cannot serve as a parent MAP, ensuring wireless backhaul performance is not degraded.

Leaf nodes maintain stable network throughput by preventing low-performance devices from acting as wireless backhaul links for other MAPs.

Configure the mesh leaf node (GUI)

Configure a mesh leaf node so that it blocks child connections to enforce network segmentation.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 Click the AP.

Step 3 In the **Mesh** tab, check the **Block Child** check box.

Step 4 Click **Update & Apply to Device**.

Your mesh leaf node now blocks child connections.

Configure mesh leaf node (CLI)

Set an AP as a mesh leaf node. Other mesh APs cannot select this AP as a parent MAP.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Configure the AP to operate only as a leaf node. Other MAPs cannot select this AP as a parent MAP.

Example:

```
Device# ap name ap-name mesh block-child
```

Use the **no** form of this command to change it to a regular AP.

The AP operates solely as a mesh leaf node and cannot be selected as a parent MAP.

```
Device> enable
Device# ap name ap1 mesh block-child
```

FlexConnect + bridge mode

A FlexConnect bridge mode is a wireless network configuration that

- enables FlexConnect capabilities on mesh (bridge mode) APs,

- allows mesh APs to inherit VLANs from the root AP, and
- supports VLAN trunking and native VLAN ID configuration per AP.

FlexConnect + bridge mode enables FlexConnect capabilities on mesh (bridge mode) APs. Mesh APs inherit VLANs from the root AP to which they are connected.

Any EWC-capable AP in FlexConnect mode connected to a MAP should be in CAPWAP mode (AP-type CAPWAP).

You can enable or disable VLAN trunking and configure a native VLAN ID on each AP for any of these modes:

- FlexConnect
- FlexConnect + bridge (FlexConnect + mesh)

Backhaul client access

Backhaul client access is a wireless networking feature that

- allows wireless clients to associate with mesh APs using the backhaul radio
- supports both 2.4 GHz and 5 GHz backhaul radios, and
- permits the backhaul radio to carry both client traffic and backhaul traffic simultaneously.

When backhaul client access is disabled, only backhaul traffic is sent over the backhaul radio, and client association is performed only over the access radio.

Note Backhaul client access is disabled by default. After you enable backhaul client access, all MAPs except the subordinate AP and its child APs in a daisy-chained deployment reboot.

Configure backhaul client access (GUI)

Enable backhaul client access for mesh device profiles.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Choose a profile.

Step 3 In **General** tab, check the **Backhaul Client Access** check box.

Step 4 Click **Update & Apply to Device**.

The system updates the profile and enables backhaul client access for devices that use the selected mesh profile.

Configure backhaul client access (CLI)

Enable backhaul client access on a mesh profile. This allows client devices to connect to the APs through the mesh backhaul. The result is increased network flexibility and coverage.

Note Backhaul client access is disabled by default. After you enable it, all MAPs reboot, except for the subordinate AP and its child APs in a daisy-chained deployment.

Complete these steps to enable backhaul client access on a mesh profile:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Configure backhaul with client access AP.

Example:

```
Device(config-wireless-mesh-profile)# client-access
```

You have enabled backhaul client access on the selected mesh profile.

```
Device# configure terminal
Device(config)# wireless profile mesh profile-name
Device(config-wireless-mesh-profile)# client-access
```

Background scanning and MAP fast ancestor find mode

Cisco mesh access points (MAPs) perform the following functions:

- Interconnects over wireless links in a tree topology,
- Uses Adaptive Wireless Path Protocol (AWPP) to create and maintain their topology, and
- Supports additional features: Background Scanning and MAP Fast Ancestor Finding.

When a MAP comes up, it tries to look for another MAP (parent) to join and reach the gateway through a RAP. The same happens when a MAP loses connectivity with its existing parent. This procedure is known as mesh tree convergence.

Background scanning and MAP Fast Ancestor Finding feature

The Background scanning feature:

- Updates MAPs about neighboring channels and helps find new parents swiftly by scanning all available channels.
- Minimizes the time spent during scan-and-seek phases when a MAP loses its current parent.
- Does not speed up the authentication process to the new parent.

A child MAP maintains its uplink with its parent by using the AWPP adjacency request/response messages, which act as keepalive signals. If consecutive response messages are lost, the parent is considered lost, and the child MAP searches for a new parent. A MAP maintains a list of neighbors on the current ON channel. If the AP loses its current parent, it roams to the next best potential neighbor. If no other neighbors are found, the AP scans or seeks across all the channels or subset channels to find a parent. This process is time-consuming.

The MAP Fast Ancestor Finding feature enables a method to reduce the need for sending or receiving beacons during network formation, while starting or deploying a new mesh network.

Configure AP fast ancestor find mode (GUI)

Enable a child MAP to synchronize with any neighbor parent MAP across all channels.

Use the GUI to configure the MAP Fast Ancestor Find feature within a mesh profile.

Follow these steps to configure AP fast ancestor find mode through the GUI:

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Click **Add**.
The **Add Mesh Profile** page is displayed.

Step 3 In the **Add Mesh Profile** page, click the **General** tab.

Step 4 In the **Name** field, enter the mesh profile name.

Step 5 In the **Description** field, enter a description for the mesh profile.

Step 6 Check the **MAP Fast Ancestor Find** check box to enable a MAP (child) to synchronize with any neighbor MAP (parent) across all channels.

Step 7 Click **Apply to Device** to save the configuration.

The MAP Fast Ancestor Find feature is enabled for the specified mesh profile.

Configure background scanning and MAP fast ancestor find mode (Task)

Configure background scanning and MAP fast ancestor find mode using the CLI within a mesh profile for detailed configuration options.

Follow these steps to configure background scanning and MAP fast ancestor find mode through the CLI:

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device# wireless profile mesh default-mesh-profile
```

Step 3 Enable background scanning in mesh deployments.

Example:

```
Device(config-wireless-mesh-profile)# background-scanning
```

Note
In Cisco Catalyst 9124 Series Access Points, a dedicated RF ASIC radio is used for background scanning.

Step 4 Enable fast ancestor find mode.

Example:

```
Device(config-wireless-mesh-profile)# map-fast-ancestor-find
```

Background scanning and MAP fast ancestor find mode are enabled for the specified mesh profile.

Example

```
Device# configure terminal
Device# wireless profile mesh default-mesh-profile
Device(config-wireless-mesh-profile)# background-scanning
Device(config-wireless-mesh-profile)# map-fast-ancestor-find
```

Configure dot11ax rates on mesh backhaul per AP (GUI)

This task enables you to configure specific dot11ax (Wi-Fi 6) rates for mesh backhaul connections on individual APs.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.
The **All Access Points** section, which lists all the configured APs in the network, is displayed with their corresponding details.

Step 2 Select the mesh AP that has been configured.
The **Edit AP** page is displayed.

Step 3 Choose the **Mesh** tab.

Step 4 In the **General** section, under the **Backhaul** section, the default **Backhaul Radio Type** , **Backhaul Slot ID** , and **Rate Types** field details are displayed. Note that the values for **Backhaul Radio Type** and **Backhaul Slot ID** can be changed only for a root AP.

Step 5 From the **Rate Types** drop-down list, choose the backhaul rate type.

Based on the choice, enter the details for the corresponding fields that are displayed.The backhaul interface varies between auto and the 802.11a/b/g/n/ac/ax rates, depending on the AP. The Cisco Catalyst 9124AX Outdoor AP is the only AP that supports 11ax backhaul rates on the mesh backhaul.

Step 6 In the **Backhaul MCS Index** field, enter the Modulation Coding Scheme (MCS) rate, that can be transmitted between the APs. The valid range is from 0 to 11, on both bands.

Step 7 In the **Spatial Stream** field, enter the number of spatial streams that are supported. The maximum number of spatial streams supported on a single radio in a 5 GHz radio band is 8, while 2.4 GHz radio band supports 4 spatial streams.

Step 8 Click **Update and Apply to Device**.

After you complete the steps, the selected mesh access point operates using the configured dot11ax rates for its backhaul link.

Configuring Dot11ax Rates on Mesh Backhaul in Mesh Profile (GUI)

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Click **Add**.
The **Add Mesh Profile** window is displayed.

Step 3 In the **Add Mesh Profile** window, click the **General** tab.

Step 4 In the **Name** field, enter the mesh profile name.

Step 5 Click the **Advanced** tab.

Step 6 In the **5 GHz Band Backhaul** section and the **2.4 GHz Band Backhaul** section, choose the **dot11ax** backhaul rate type from **Rate Types** the drop-down list.

Note
Cisco Catalyst 9124AXI/D Series outdoor Access Point is the only AP to support 11ax backhaul rates on the mesh backhaul.

Step 7 In the **Dot11ax MCS index** field, specify the MCS rate at which data can be transmitted between the APs. The value range is between 0 to 11, on both the radio bands.

Step 8 In the **Spatial Stream** field, enter a value. The maximum number of spatial streams supported on a single radio in a 5-GHz radio band is 8, while 2.4- GHz radio band supports 4 spatial streams.

Step 9 Click **Update and Apply to Device**.

Configure data rate per AP (CLI)

Configure data transmission rates for each AP on mesh backhaul for the 2.4 GHz and 5 GHz bands using the command-line interface.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Configure the 802.11ax mesh backhaul rates for the 2.4 GHz and 5 GHz bands.

Example:

```
Device# ap name ap-name mesh backhaul rate dot11ax mcs <0-11> ss <1-8>
```

The AP uses the configured backhaul data rates for 2.4 GHz and 5 GHz bands.

```
Device> enable
Device# ap name ap-name mesh backhaul rate dot11ax mcs 5 ss 4
```

Configure data rate using mesh profile (CLI)

Set specific data rates for 2.4 GHz and 5 GHz backhaul communication in mesh profiles to optimize wireless mesh network performance.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Configure the backhaul transmission rate for the 2.4 GHz band and the 5 GHz band. For the 2.4 GHz band, set the 802.11ax spatial stream value from 1 to 4. For the 5 GHz band, set the spatial stream value from 1 to 8.

Example:

```
Device(config-wireless-mesh-profile)# backhaul rate dot11 {24ghz | 5ghz} dot11ax mcs <0-11>
 spatial-stream <1-8>
```

The mesh profile is updated with the configured data rate for the specified frequency band and spatial streams.

```
Device# configure terminal
Device(config)# wireless profile mesh profile-name
Device(config-wireless-mesh-profile)# backhaul rate dot11 5ghz dot11ax mcs 5 spatial-stream
 6
```

Specify the backhaul slot for the root AP (GUI)

Configure the backhaul slot for a root access point to optimize wireless mesh connectivity and ensure reliable network communication.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Click **Add**.

Step 3 In the **General** tab, enter the **Name** of the mesh profile.

Step 4 In the **Advanced** tab, select the rate types for **5 GHz Band Backhaul** and **2.4 GHz Band Backhaul** from the **Rate Types** drop-down list.

Step 5 Click **Apply to Device**.

The system updates the root access point with the specified backhaul slot settings. It uses the selected rate types for 5 GHz and 2.4 GHz band backhaul connections.

Specify the backhaul slot for the root AP (CLI)

Assign a specific radio slot (2.4 GHz or 5 GHz) to the mesh backhaul of your root access point to optimize wireless connectivity and network performance.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Specify the mesh backhaul radio slot for your root AP.

Example:

```
Device# ap name ap-name mesh backhaul radio dot11 {24ghz | 5ghz} [slot slot-id]
```

Assign a radio slot (2.4 GHz or 5 GHz) to the mesh backhaul of your root access point to improve wireless connectivity and network performance.

```
Device> enable
Device# ap name rap1 mesh backhaul radio dot11 24ghz slot 2
```

Configure wireless backhaul data rate (CLI)

Configure the data transmission rate for wireless backhaul connections between APs using CLI commands to optimize wireless network performance, coverage, and spectrum use.

Use backhaul to create a wireless connection between APs. Depending on the AP, the backhaul interface can be 802.11bg, 802.11a, 802.11n, or 802.11ac. Selecting a rate lets you use the available RF spectrum effectively.

Data rates can also affect the RF coverage and network performance. Lower data rates, for example, 6 Mbps, can extend farther from the AP than higher data rates, for example, 1300 Mbps. As a result, the data rate affects cell coverage, and consequently, the number of APs required.

Note You can configure backhaul data rate, preferably, through the mesh profile. In certain cases, where a specific data rate is needed, use the command to configure the data rate per AP.

Follow this procedure to configure wireless backhaul data rate in privileged EXEC mode or in mesh profile configuration mode.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Configure backhaul transmission rate.

Example:

```
Device# ap name ap-name mesh backhaul rate {auto | dot11abg | dot11ac | dot11n}
```

Step 3 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 4 Configure backhaul transmission rate.

Example:

```
Device(config-wireless-mesh-profile)# backhaul rate dot11  { 24ghz | 5ghz} dot11n RATE_6M
```

Note
Ensure the rate you configure on the AP (step 2) matches the rate you configure on the mesh profile (step 4).

After you configure the wireless backhaul data rate, your APs will balance coverage area and performance for your deployment.

```
Device> enable
Device# ap name ap1 mesh backhaul rate auto
Device(config)# wireless profile mesh mesh1
Device(config-wireless-mesh-profile)# backhaul rate dot11 5ghz dot11n mcs 31
```

Use a link test on mesh backhaul (GUI)

Network administrators can validate wireless mesh backhaul connectivity and signal strength with this task. Running a link test enables proactive identification of performance issues, ensures reliable mesh network operation, and helps troubleshoot weak connections.

Procedure

Step 1 Choose **Monitoring** > **Wireless** > **AP Statistics** > **General**.

Step 2 Select the Access Point.

Step 3 Choose **Mesh** > **Neighbor** > **Linktest**.

Step 4 Select the desired values from the **Date Rates**, **Packets to be sent (per second)**, **Packet Size (bytes)**, and **Test Duration (seconds)** drop-down lists.

Step 5 Click **Start**.

You can see the detailed link test results for the selected mesh backhaul connection.

Use a link test on mesh backhaul

To initiate a link test between neighbor mesh APs, complete these steps.

Note Use the **test mesh linktest mac-address** *neighbor-ap-mac* **rate** *data-rate* **fps** *frames-per-second* **frame-size** *frame-size* command to perform link test from an AP.

Procedure

Step 1 Enters privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Set the link test parameters.

Example:

```
Device# ap name ap-name mesh linktest H.H.H data-rate packet-per-sec packet-size test-duration
```

- *H.H.H*: Specify the destination AP MAC address.
- *data-rate*: Specify the data rates in Mbps. The values are 1, 2, 5, 6, 9, 11, 12, 18, 24, 36, 48, 54, 108, or m0 through m15.
- *packet-per-sec*: Specify the packets to be sent per second. The range is from 1 to 25,000.
- *packet-size*: Specify the packet size in bytes. The range is from 1 to 1,500.
- *test-duration*: Specify the test duration in seconds. The range is from 10 to 300.

The system displays test results, including throughput, loss, and latency metrics, to verify link quality between access points.

```
Device> enable
Device# ap name ap1 mesh linktest F866.F267.7DFB 24 234 1200 200
```

Mesh call admission control

A mesh call admission control is a quality of service mechanism that

- continuously monitors bandwidth available to mesh access points
- regulates voice call admissions to maintain acceptable call quality, and
- rejects calls when bandwidth or resource limits are reached.

Call Admission Control (CAC) enables a mesh AP to maintain controlled quality of service (QoS) on the controller. This management helps maintain voice quality on the mesh network. Bandwidth-based, or static, CAC enables the client to specify how much bandwidth or shared medium time is required to accept a new call. Each AP determines whether it can accommodate a call by checking the available bandwidth and comparing it to the bandwidth required for the call. If there is not enough bandwidth available to maintain the maximum allowed number of calls with acceptable quality, the mesh AP rejects the call.

Mesh CAC is not supported in these scenarios.

- APs in a Mesh tree assigned with different site tags.
- APs in a Mesh tree assigned with the default site tag.

Configure mesh CAC (CLI)

Enable mesh CAC to manage call admission and ensure quality over wireless mesh links.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enable mesh CAC mode.

Example:

```
Device(config)# wireless mesh cac
```

Mesh CAC is activated. Only the supported number of concurrent calls can occur over mesh links, which preserves call quality.

Mesh network recovery mechanisms

A mesh network recovery mechanism is a network self-healing feature that

- rapidly detects uplink gateway reachability failures in mesh APs
- automatically triggers alternate uplink selection to maintain connectivity, and
- uses ICMP pings to default gateways to verify uplink status after failover events or controller disconnections.

In all 802.11ac Wave 2 APs, detecting uplink gateway failures quickly speeds up mesh network recovery. Mesh APs use ICMP ping to the default gateway, either IPv4 or IPv6, to check uplink gateway reachability.

Reachability checks for mesh APs work

A mesh AP triggers the reachability check in two scenarios:

- After a new uplink is selected and before the mesh AP joins the controller

  After a new uplink is selected, the mesh AP has a 45-second window to reach the gateway (through static IP or DHCP) through the selected uplink. If the mesh AP does not reach the gateway within 45 seconds, the system blocks the current uplink and starts selecting a new uplink. If the AP joins the controller during this window, it stops the reachability check. The system does not perform gateway reachability checks during normal operations.

- As soon as the mesh AP times out its connection with the controller

  When the mesh AP times out its connection with the controller and fails to reach the gateway within 5 seconds, the system marks the current uplink as blocked and starts the uplink selection process.

Fast teardown for a mesh deployment

A fast teardown is a mesh deployment feature that

- enables rapid detection of root AP uplink failures
- helps restore or reconfigure network service when the uplink is lost, and
- applies to mesh deployments with unreliable uplinks, such as wireless microwave links.

Fast teardown for mesh APs is not supported on Cisco Industrial Wireless (IW) 3702 Access Points.

Enable wireless mesh profile (CLI)

To enable and configure a wireless mesh profile to support mesh networking functionality on your device.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Enable the fast teardown of mesh network and configure the parameters of the feature.

Example:

```
Device(config-wireless-profile-mesh)# fast-teardown
```

The wireless mesh profile is enabled and configured with the fast teardown feature.

```
Device# configure terminal
Device(config)# wireless profile mesh mesh1
Device(config-wireless-profile-mesh)# fast-teardown
```

Associate wireless mesh to an AP profile (CLI)

Associate a mesh profile with an AP profile to enable mesh capabilities on compatible APs through CLI configuration.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure the AP profile to enter AP profile configuration mode.

Example:

```
Device(config)# ap profile default-ap-profile
```

Step 3 In AP profile configuration mode, configure the mesh profile.

Example:

```
Device(config-ap-profile)# mesh-profile mesh-profile-name
```

The AP profile now uses the specified mesh profile. All APs using this profile inherit mesh configuration parameters.

```
Device# configure terminal
Device(config)# ap profile default-ap-profile
Device(config-ap-profile)# mesh-profile test1
```

Configure fast teardown for a mesh AP profile (GUI)

Use this procedure to configure mesh AP profiles for rapid detection of uplink failures and improve mesh network resiliency.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Click **Add**.

Step 3 In the **Add Mesh Profile** window, click **Advanced**.

Step 4 Select a security mode, an authentication method, and an authorization method.

Step 5 Enable **Ethernet bridging** if it is required.

Step 6 Enter the bridge group name. Then enable Strict Match BGN.

Step 7 Select a band backhaul transmission rate for your radio.

Step 8 Perform these actions in the **Fast Roaming** section:

- Check the **Fast Teardown** check box to detect the root AP uplink failure faster in a mesh deployment and to address fast teardown of the mesh network when an uplink failure occurs.
- In the **Number of Retries** field, enter the number of retries allowed until gateway is considered unreachable. The valid range is from 1 to 10.

- In the **Interval value** field, enter the retry value. The valid range is from 1 to 10 seconds.
- In the **Latency Threshold** field, enter the threshold for a round-trip latency between the AP and the controller. The valid range is from 1 and 500 milliseconds.
- In the **Latency Exceeded Threshold** field, enter the latency interval in which at least one ping must succeed in less than the specified time. The valid range is from 1 to 30 seconds.
- In the **Uplink Recovery Interval** field, enter the time during which root AP uplink must be stable in order to accept the child connections. The valid range is from 1 and 3600 seconds.

Step 9 Click **Apply to Device**.

Your mesh AP profile now supports fast teardown. This configuration enables the system to detect uplink failures more quickly, helping your devices recover rapidly.

Configure fast teardown for a mesh AP profile (CLI)

Enable and configure fast teardown for a mesh AP profile to reduce network restoration time and increase network reliability.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile and enter the mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Enable the fast teardown of mesh network and configure the feature's parameter.

Example:

```
Device(config-wireless-mesh-profile)# fast-teardown
```

Step 4 Enable the fast teardown feature.

Example:

```
Device(config-wireless-mesh-profile-fast-teardown)# enabled
```

Step 5 (Optional) Configure the retry interval.

Example:

```
Device(config-wireless-mesh-profile-fast-teardown)# interval duration
```

The valid range is from 1 to 10 seconds.

Step 6 (Optional) Set the latency interval so that at least one ping succeeds within your chosen threshold time.

Example:

```
Device(config-wireless-mesh-profile-fast-teardown)# latency-exceeded-threshold duration
```

The valid range is from 1 to 30 seconds.

Step 7 (Optional) Specify the latency threshold.

Example:

```
Device(config-wireless-mesh-profile-fast-teardown)# latency-threshold threshold-range
```

The valid range is from 1 to 500 milliseconds.

Step 8 (Optional) Specify the number of retries until the gateway is considered unreachable.

Example:

```
Device(config-wireless-mesh-profile-fast-teardown)# retries retry-limit
```

The valid range is from 1 to 10.

Step 9 (Optional) Specify the time during which root access point uplink has to be stable to accept child connections.

Example:

```
Device(config-wireless-mesh-profile-fast-teardown)# uplink-recovery-intervals recovery
interval
```

The valid range is from 1 to 3600 seconds.

You have configured the mesh AP profile with fast teardown enabled and applied custom parameters. This configuration improves your network's responsiveness to disruptions.

```
Device# configure terminal
Device(config)# wireless profile mesh mesh1
Device(config-wireless-mesh-profile)# fast-teardown
Device(config-wireless-mesh-profile-fast-teardown)# enabled
Device(config-wireless-mesh-profile-fast-teardown)# interval 5
Device(config-wireless-mesh-profile-fast-teardown)# latency-exceeded-threshold 20
Device(config-wireless-mesh-profile-fast-teardown)# latency-threshold 20
Device(config-wireless-mesh-profile-fast-teardown)# retries 1
Device(config-wireless-mesh-profile-fast-teardown)# uplink-recovery-intervals 1
```

Verify fast teardown with default mesh profile

To verify the fast teardown with the default mesh profile, use this command:

```
Device# show wireless profile mesh detailed default-mesh-profile
Mesh Profile Name            default-mesh-profile
------------------------------------------------
Fast Teardown                        : ENABLED
Number of Retries                    : 4
Interval in sec                      : 1
Latency Threshold in msec            : 10
Latency Exceeded Threshold in sec    : 8
Uplink Recovery Interval in sec      : 60
```

Configure subset channel synchronization

Enable synchronization of mesh subset channels to ensure efficient convergence of RAPs and MAPs.

The controller sends all channels used by RAPs to MAPs for future seeking and convergence. The controller keeps a list of subset channels for each Bridge Group Name (BGN) and shares this list across all controllers in a mobility group.

The subset channel list includes channels where RAPs within a Bridge Group Name (BGN) operate. This list is distributed to all mesh access points (MAPs) within controllers and across controllers. Maintaining a subset channel list helps Mesh APs converge faster. You can select the convergence method in the mesh profile. The system sends the subset channel list to MAPs if the convergence method is non-standard.

Follow these steps to configure subset channel synchronization for a mobility group.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure subset channel synchronization for a mobility group.

Example:

```
Device(config)# wireless mesh subset-channel-sync mac
```

The mobility group synchronizes subset channels, which enables mesh APs to converge faster.

```
Device# configure terminal
Device(config)# wireless mesh subset-channel-sync mac
```

Select a preferred parent (GUI)

Direct a mesh-capable AP to use a designated parent for uplink within the wireless topology.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points**.

Step 2 Click the AP.

Step 3 In the **Mesh** tab, enter the **Preferred Parent MAC**.

Step 4 Click **Update & Apply to Device**.

The AP uses the specified preferred parent MAC address for uplink, optimizing connectivity in the mesh network.

Select a preferred parent (CLI)

To configure a preferred parent for a MAP, complete these steps.

You can override the AWPP-defined parent selection and assign a specific preferred parent to a mesh AP using this mechanism.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Configure mesh parameters for the AP and set the mesh-preferred parent MAC address.

Example:

```
Device# ap name ap-name mesh parent preferred mac-address
```

Note
Ensure that you use the radio MAC address of the preferred parent.

For Cisco Wave 1 APs, specify the MAC address of the actual mesh neighbor as the preferred parent. Use the base radio MAC address that ends with the letter "f". For example, if the base radio MAC address is 00:24:13:0f:92:00, then you must specify 00:24:13:0f:92:0f as the preferred parent.

```
Device# ap name ap1 mesh parent preferred 00:24:13:0f:92:0f
```

For Cisco Wave 2 APs, specify the MAC address for the preferred parent by adding "0x11" to the last two characters of the base radio MAC address. For example, if the base radio MAC address is 00:24:13:0f:92:00, then you must specify 00:24:13:0f:92:11 as the preferred parent.

```
Device# ap name ap1 mesh parent preferred 00:24:13:0f:92:11
```

The mesh AP is configured to use the specified MAC address as its preferred parent.

```
Device> enable
Device# ap name ap1 mesh parent preferred 00:0d:ed:dd:25:8F
```

Change the role of an AP (GUI)

Change the operational role of an AP to support different network topologies.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Access Points** .

Step 2 Click the **Access Point** .

Step 3 In the **Mesh** tab, choose **Root** or **Mesh** from the **Role** drop-down list.

Step 4 Click **Update & Apply to Device** .

The AP automatically restarts to apply the new role configuration.

Change the role of an AP (CLI)

Change your Cisco access point (AP) role between mesh AP (MAP) and root AP (RAP) using command-line interface (CLI) commands.

To change the AP from MAP to RAP or the reverse, follow this procedure. By default, your AP joins the controller in the mesh AP role.

Procedure

Step 1 Enter privileged EXEC mode.

Example:

```
Device> enable
```

Step 2 Change the role of the Cisco bridge mode AP. The AP reboots after the role change.

Example:

```
Device# ap name ap-name role {mesh-ap | root-ap}
```

The specified AP reboots and operates in its new role. After rebooting, it connects and functions in your wireless mesh network.

```
Device> enable
Device# ap name ap1 role root-ap
```

Configure battery state for mesh AP (GUI)

Configure the battery state on a mesh AP using the web interface.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **Mesh** > **Profiles**.

Step 2 Select a profile.

Step 3 On the **General** tab, check the **Battery State for an AP** check box.

Step 4 Click **Update & Apply to Device**.

After you configure the profile, the profile displays the battery state for the selected mesh AP.

Configure battery state for mesh AP (CLI)

Some outdoor APs come with the option of battery backup. The AP also includes a POE-out port that powers a video surveillance camera. The integrated battery provides temporary backup power during external power interruptions.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a mesh profile, and enter mesh profile configuration mode.

Example:

```
Device(config)# wireless profile mesh profile-name
```

Step 3 Configure the battery state for an AP.

Example:

```
Device(config-wireless-mesh-profile)# battery-state
```

You have configured the battery state for the mesh AP, so backup power is now available when required.

```
Device# configure terminal
Device(config)# wireless profile mesh mesh-profile-name
Device(config-wireless-mesh-profile)# battery-state
```

Verifying Mesh Configuration in Embedded Wireless Controller

Verify mesh configuration

Use these **show** commands to verify the various aspects of mesh configuration:

- **show wireless mesh stats** *ap-name*
- **show wireless mesh security-stats** {*all* | *ap-name*}
- **show wireless mesh queue-stats** {*all* | *ap-name*}
- **show wireless mesh per-stats summary** {*all* | *ap-name*}
- **show wireless mesh neighbor summary** {*all* | *ap-name*}
- **show wireless mesh neighbor detail** *ap-name*

- **show wireless mesh ap summary**
- **show wireless mesh ap tree**
- **show wireless mesh ap backhaul**
- **show wireless mesh config**
- **show wireless mesh convergence detail** *bridge-group-name*
- **show wireless mesh convergence subset-channels**
- **show wireless mesh neighbor**
- **show wireless profile mesh detailed** *mesh-profile-name*
- **show wireless stats mesh security**
- **show wireless stats mesh queue**
- **show wireless stats mesh packet error**
- **show wireless mesh ap summary**
- **show ap name** *ap-name* **mesh backhaul**
- **show ap name** *ap-name* **mesh neighbor detail**
- **show ap name** *ap-name* **mesh path**
- **show ap name** *ap-name* **mesh stats packet error**
- **show ap name** *ap-name* **mesh stats queue**
- **show ap name** *ap-name* **mesh stats security**
- **show ap name** *ap-name* **mesh stats**
- **show ap name** *ap-name* **mesh bhrate**
- **show ap name** *ap-name* **config ethernet**
- **show ap name** *ap-name* **cablemodem**
- **show ap name** *ap-name* **environment**
- **show ap name** *ap-name* **gps location**
- **show ap name** *ap-name* **environment**
- **show ap name** *ap-name* **mesh linktest data** *dest-mac*
- **show ap environment**
- **show ap gps location**

For details about these commands, see the Cisco Catalyst 9800 Series Wireless Controller Command Reference document.

MAC authorization

Use this **show** command to verify the MAC authorization configuration:

```
Device# show run aaa
aaa authentication dot1x CENTRAL_LOCAL local
aaa authorization credential-download CENTRAL_AUTHOR local
username 002cc8de4f31 mac
username 00425a0a53b1 mac

ewlc_eft#sh wireless profile mesh detailed madhu-mesh-profile

Mesh Profile Name             : abc-mesh-profile
-------------------------------------------------
Description                   :
Bridge Group Name             : bgn-abbc
Strict match BGN              : ENABLED
Amsdu                         : ENABLED
...
Battery State                 : ENABLED
Authorization Method          : CENTRAL_AUTHOR
Authentication Method         : CENTRAL_LOCAL
Backhaul tx rate(802.11bg)    : auto
Backhaul tx rate(802.11a)     : 802.11n mcs15
```

PSK provisioning

Use this **show** command to verify PSK provisioning configuration:

```
Device# show wireless mesh config
Mesh Config
  Backhaul RRM                                  : ENABLED
  Mesh CAC                                      : DISABLED
  Outdoor Ext. UNII B Domain channels(for BH)   : ENABLED
  Mesh Ethernet Bridging STP BPDU Allowed       : ENABLED
  Rap Channel Sync                              : ENABLED

Mesh Alarm Criteria
  Max Hop Count                                 :  4
  Recommended Max Children for MAP              : 10
  Recommended Max Children for RAP              : 20
  Low Link SNR                                  : 12
  High Link SNR                                 : 60
  Max Association Number                        : 10
  Parent Change Number                          :  3

Mesh PSK Config
  PSK Provisioning                              : ENABLED
  Default PSK                                   : ENABLED
  PSK In-use key number                         : 1
  Provisioned PSKs(Maximum 5)

  Index    Description
  ------   ------------
  1         key1
```

Bridge group name

Use this **show** command to verify the bridge group name configuration:

```
Device# show wireless profile mesh detailed abc-mesh-profile
Mesh Profile Name             : abc-mesh-profile
-------------------------------------------------
Description                   :
Bridge Group Name             : bgn-abc
Strict match BGN              : ENABLED
Amsdu                         : ENABLED
```

```
Background Scan               : ENABLED
Channel Change Notification   : DISABLED
Backhaul client access        : ENABLED
Ethernet Bridging             : ENABLED
Ethernet Vlan Transparent     : DISABLED
Full Sector DFS               : ENABLED
IDS                           : ENABLED
Multicast Mode                : In-Out
Range in feet                 : 12000
Security Mode                 : EAP
Convergence Method            : Fast
LSC only Authentication       : DISABLED
Battery State                 : ENABLED
Authorization Method          : CENTRAL_AUTHOR
Authentication Method         : CENTRAL_LOCAL
Backhaul tx rate(802.11bg)    : auto
Backhaul tx rate(802.11a)     : 802.11n mcs15
```

Backhaul client access

Use this **show** command to verify the backhaul client access configuration:

```
Device# show wireless profile mesh detailed abc-mesh-profile
Mesh Profile Name             : abc-mesh-profile
-------------------------------------------------
Description                   :
Bridge Group Name             : bgn-abc
Strict match BGN              : ENABLED
Amsdu                         : ENABLED
Background Scan               : ENABLED
Channel Change Notification   : DISABLED
Backhaul client access        : ENABLED
Ethernet Bridging             : ENABLED
Ethernet Vlan Transparent     : DISABLED
...
Backhaul tx rate(802.11bg)    : auto
Backhaul tx rate(802.11a)     : 802.11n mcs15
```

Wireless backhaul data rate

Use this **show** command to verify the wireless backhaul data rate configuration:

```
Device# show wireless profile mesh detailed abc-mesh-profile
Mesh Profile Name             : abc-mesh-profile
-------------------------------------------------
Description                   :
Bridge Group Name             : bgn-abc
Strict match BGN              : ENABLED
...
Authorization Method          : CENTRAL_AUTHOR
Authentication Method         : CENTRAL_LOCAL
Backhaul tx rate(802.11bg)    : auto
Backhaul tx rate(802.11a)     : 802.11n mcs15
```

Dynamic frequency selection

Use this **show** command to verify the dynamic frequency selection configuration:

```
Device# show wireless profile mesh detailed abc-mesh-profile
Mesh Profile Name             : abc-mesh-profile
-------------------------------------------------
Description                   :
Bridge Group Name             : bgn-abc
```

```
Strict match BGN              : ENABLED
Amsdu                         : ENABLED
Background Scan               : ENABLED
Channel Change Notification   : DISABLED
Backhaul client access        : ENABLED
Ethernet Bridging             : ENABLED
Ethernet Vlan Transparent     : DISABLED
Full Sector DFS               : ENABLED
...
Backhaul tx rate(802.11a)     : 802.11n mcs15
```

Intrusion detection system

Use this **show** command to verify the wireless backhaul data rate configuration:

```
Device# show wireless profile mesh detailed abc-mesh-profile
Mesh Profile Name             : abc-mesh-profile
-------------------------------------------------
Description                   :
Bridge Group Name             : bgn-abc
Strict match BGN              : ENABLED
Amsdu                         : ENABLED
Background Scan               : ENABLED
Channel Change Notification   : DISABLED
Backhaul client access        : ENABLED
Ethernet Bridging             : ENABLED
Ethernet Vlan Transparent     : DISABLED
Full Sector DFS               : ENABLED
IDS                           : ENABLED
Multicast Mode                : In-Out
...
Backhaul tx rate(802.11a)     : 802.11n mcs15
```

Ethernet bridging

Use this **show** command to verify ethernet bridging configuration:

```
Device# show wireless profile mesh detailed abc-mesh-profile
Mesh Profile Name             : abc-mesh-profile
-------------------------------------------------
Description                   :
Bridge Group Name             : bgn-abc
Strict match BGN              : ENABLED
Amsdu                         : ENABLED
Background Scan               : ENABLED
Channel Change Notification   : DISABLED
Backhaul client access        : ENABLED
Ethernet Bridging             : ENABLED
Ethernet Vlan Transparent     : DISABLED
Full Sector DFS               : ENABLED
IDS                           : ENABLED
Multicast Mode                : In-Out
...
Backhaul tx rate(802.11a)     : 802.11n mcs15
```

Multicast over mesh

Use this **show** command to verify multicast over Mesh configuration:

```
Device# show wireless profile mesh detailed abc-mesh-profile
Mesh Profile Name             : abc-mesh-profile
-------------------------------------------------
Description                   :
```

```
Bridge Group Name             : bgn-abc
Strict match BGN              : ENABLED
Amsdu                         : ENABLED
Background Scan               : ENABLED
Channel Change Notification   : DISABLED
Backhaul client access        : ENABLED
Ethernet Bridging             : ENABLED
Ethernet Vlan Transparent     : DISABLED
Full Sector DFS               : ENABLED
IDS                           : ENABLED
Multicast Mode                : In-Out
...
Backhaul tx rate(802.11a)     : 802.11n mcs15
```

RRM on mesh backhaul

Use this **show** command to verify RRM on Mesh backhaul configuration:

```
Device# show wireless mesh config
Mesh Config
  Backhaul RRM                                  : ENABLED
  Mesh CAC                                      : DISABLED
  Outdoor Ext. UNII B Domain channels(for BH)   : ENABLED
  Mesh Ethernet Bridging STP BPDU Allowed       : ENABLED
  Rap Channel Sync                              : ENABLED

Mesh Alarm Criteria
  Max Hop Count                                 :  4
  Recommended Max Children for MAP              : 10
  Recommended Max Children for RAP              : 20
  Low Link SNR                                  : 12
  High Link SNR                                 : 60
  Max Association Number                        : 10
  Parent Change Number                          :  3

Mesh PSK Config
  PSK Provisioning                              : ENABLED
  Default PSK                                   : ENABLED
  PSK In-use key number                         : 1
  Provisioned PSKs(Maximum 5)

  Index    Description
  ------   ------------
  1         key1
```

Preferred parent selection

Use this **show** command to verify preferred parent configuration:

```
Device# show wireless mesh ap tree
=====================================================================
AP Name [Hop Ctr,Link SNR,BG Name,Channel,Pref Parent,Chan Util,Clients]
=====================================================================

[Sector 1]
-----------
1542-RAP [0, 0, bgn-madhu, (165), 0000.0000.0000, 1%, 0]
   |-MAP-2700 [1, 67, bgn-madhu, (165), 7070.8b7a.6fb8, 0%, 0]

Number of Bridge APs : 2
Number of RAPs : 1
Number of MAPs : 1
```

```
(*)  Wait for 3 minutes to update or Ethernet Connected Mesh AP.
(**) Not in this Controller
```

AP role change

Use this **show** command to verify AP role change configuration:

```
Device# show wireless mesh ap summary
AP Name                          AP Model BVI MAC        BGN        AP Role
-------                          -------- -------        ---        -------
1542-RAP                         1542D    002c.c8de.1338 bgn-abc  Root AP
MAP-2700                         2702I    500f.8095.01e4 bgn-abc  Mesh AP

Number of Bridge APs         :   2
Number of RAPs               :   1
Number of MAPs               :   1
Number of Flex+Bridge APs    :   0
Number of Flex+Bridge RAPs   :   0
Number of Flex+Bridge MAPs   :   0
```

Mesh leaf node

Use this **show** command to verify mesh leaf node configuration:

```
Device# show ap name MAP-2700 config general
Cisco AP Name   : MAP-2700
=================================================

Cisco AP Identifier                             : 7070.8bbc.d3e0
Country Code                                    : Multiple Countries : IN,US,IO,J4
Regulatory Domain Allowed by Country            : 802.11bg:-AEJPQU   802.11a:-ABDJNPQU
AP Country Code                                 : IN  - India
AP Regulatory Domain
  Slot 0                                        : -A
  Slot 1                                        : -D
MAC Address                                     : 500f.8095.01e4
...
AP Mode                                         : Bridge
Mesh profile name                               : abc-mesh-profile
AP Role                                         : Mesh AP
Backhaul radio type                             : 802.11a
Backhaul slot id                                : 1
Backhaul tx rate                                : auto
Ethernet Bridging                               : Enabled
Daisy Chaining                                  : Disabled
Strict Daisy Rap                                : Disabled
Bridge Group Name                               : bgn-abc
Strict-Matching BGN                             : Enabled
Preferred Parent Address                        : 7070.8b7a.6fb8
Block child state                               : Disabled
PSK Key Timestamp                               : Not Configured
...
FIPS status                                     : Disabled
WLANCC status                                   : Disabled
GAS rate limit Admin status                     : Disabled
WPA3 Capability                                 : Disabled
EWC-AP Capability                                : Disabled
AWIPS Capability                                : Disabled
Proxy Hostname                                  : Not Configured
Proxy Port                                      : Not Configured
Proxy NO_PROXY list                             : Not Configured
GRPC server status                              : Disabled
```

Subset channel synchronization

Use this **show** command to verify the subset channel synchronization configuration:

```
Device# show wireless mesh config
Mesh Config
  Backhaul RRM                                  : ENABLED
  Mesh CAC                                      : DISABLED
  Outdoor Ext. UNII B Domain channels(for BH)   : ENABLED
  Mesh Ethernet Bridging STP BPDU Allowed       : ENABLED
  Rap Channel Sync                              : ENABLED

Mesh Alarm Criteria
  Max Hop Count                                 :  4
  Recommended Max Children for MAP              : 10
  Recommended Max Children for RAP              : 20
  Low Link SNR                                  : 12
  High Link SNR                                 : 60
  Max Association Number                        : 10
  Parent Change Number                          :  3

Mesh PSK Config
  PSK Provisioning                              : ENABLED
  Default PSK                                   : ENABLED
  PSK In-use key number                         : 1
  Provisioned PSKs(Maximum 5)

  Index    Description
  ------   ------------
  1         key1
```

Provisioning LSC for bridge-mode and mesh APs

Use this **show** command to verify the provisioning LSC for Bridge-Mode and Mesh AP configuration:

```
Device# show wireless profile mesh detailed default-mesh-profile
Mesh Profile Name             : default-mesh-profile
-------------------------------------------------
Description                   : default mesh profile
Bridge Group Name             : bgn-abc
Strict match BGN              : DISABLED
Amsdu                         : ENABLED
Background Scan               : ENABLED
Channel Change Notification   : ENABLED
Backhaul client access        : ENABLED
Ethernet Bridging             : DISABLED
Ethernet Vlan Transparent     : ENABLED
Full Sector DFS               : ENABLED
IDS                           : DISABLED
Multicast Mode                : In-Out
Range in feet                 : 12000
Security Mode                 : EAP
Convergence Method            : Fast
LSC only Authentication       : DISABLED
Battery State                 : ENABLED
Authorization Method          : default
Authentication Method         : default
Backhaul tx rate(802.11bg)    : auto
Backhaul tx rate(802.11a)     : auto
```

Specify backhaul slot for root AP

Use this **show** command to verify the backhaul slot for the Root AP configuration:

```
Device# show ap name 1542-RAP mesh backhaul
MAC Address : 380e.4d85.5e60
  Current Backhaul Slot: 1
  Radio Type: 0
  Radio Subband: All
  Mesh Radio Role: DOWNLINK
  Administrative State: Enabled
  Operation State: Up
  Current Tx Power Level:
  Current Channel: (165)
  Antenna Type: N/A
  Internal Antenna Gain (in .5 dBm units): 18
```

Use a link test on mesh backhaul

Use this **show** command to verify the use of link test on mesh backhaul configuration:

```
Device# show ap name 1542-RAP mesh linktest data 7070.8bbc.d3ef
380e.4d85.5e60 ==> 7070.8bbc.d3ef

Started at : 05/11/2020 20:56:28
Status: In progress

Configuration:
==============
Data rate:  Mbps
Packets per sec: : 234
Packet Size: : 1200
Duration: : 200
```

Mesh CAC

Use this **show** command to verify mesh CAC configuration:

```
Device# show wireless mesh config
Mesh Config
  Backhaul RRM                                  : ENABLED
  Mesh CAC                                      : DISABLED
  Outdoor Ext. UNII B Domain channels(for BH)   : ENABLED
  Mesh Ethernet Bridging STP BPDU Allowed       : ENABLED
  Rap Channel Sync                              : ENABLED

Mesh Alarm Criteria
  Max Hop Count                                 :  4
  Recommended Max Children for MAP              : 10
  Recommended Max Children for RAP              : 20
  Low Link SNR                                  : 12
  High Link SNR                                 : 60
  Max Association Number                        : 10
  Parent Change Number                          :  3

Mesh PSK Config
  PSK Provisioning                              : ENABLED
  Default PSK                                   : ENABLED
  PSK In-use key number                         : 1
  Provisioned PSKs(Maximum 5)

  Index    Description
  ------   ------------
  1         key1
```

Verify mesh convergence

This example shows the output from the **show wireless profile mesh detailed** command, which displays the mesh convergence method.

```
Device# show wireless profile mesh detailed default-mesh-profile

Mesh Profile Name             : default-mesh-profile
-------------------------------------------------
Description                 : default mesh profile
Convergence Method          : Fast
```

This example shows the output from **show wireless mesh convergence subset-channels** command, which displays the subset channels for the selected bridge group name.

```
Device# show wireless mesh convergence subset-channels

Bridge group name                Channel
----------------------------------------
Default                          132
```

Verify mesh backhaul

Use the **show ap name mesh backhaul** command to view details of the mesh backhaul at 2.4 GHz.

```
Device# show ap name test-ap mesh backhaul

MAC Address : xxxx.xxxx.xxxx
Current Backhaul Slot: 0
Radio Type: 0
Radio Subband: All
Mesh Radio Role: DOWNLINK
Administrative State: Enabled
Operation State: Up
Current Tx Power Level:
Current Channel: (11)
Antenna Type: N/A
Internal Antenna Gain (in .5 dBm units): 0
```

Use the **show wireless mesh ap backhaul** command to view the mesh backhaul details.

```
Device# show wireless mesh ap backhaul

MAC Address : xxxx.xxxx.0x11
Current Backhaul Slot: 1
Radio Type: Main
Radio Subband: All
Mesh Radio Role: Downlink
Administrative State: Enabled
Operation State: Up
Current Tx Power Level: 6
Current Channel: (100)*
Antenna Type: N/A
Internal Antenna Gain (in .5 dBm units): 10
```

Use the **show ap summary** command to view the radio MAC address and the corresponding AP name.

```
Device# show ap summary
Number of APs: 1
AP Name    Slots  AP Model         Ethernet       MAC Radio MAC  Location         Country
IP Address   State
-----------------------------------------------------------------------------------------------------------
```

```
AP-Cisco-1  2     AIR-APXXXXX-E-K9 xxxx.xxxx.xxd4 xxxx.xxxx.0x11 default location  DE
10.11.70.170 Registered
```

Verify mesh Ethernet daisy chaining

Use the **show ap config general** command to find out if a Persistent SSID is configured for an AP.

```
Device# show ap 3702-RAP config general

Persistent SSID Broadcast                   Enabled/Disabled
```

Use the **show wireless mesh persistent-ssid-broadcast summary** command to view the Persistent SSID broadcast status for all bridge root APs

```
Device# show wireless mesh persistent-ssid-broadcast summary

 AP Name     AP Model BVI MAC        BGN        AP Role              Persistent SSID state
-------     -------- -------        ---        -------              ---------------------
3702-RAP     3702     5c71.0d07.db50 ap_name    Root AP               Enabled
1560-RAP    1562E    380e.4dbf.c6b0 ap_name    Root AP              Disabled
```

Verify dot11ax rates on mesh backhaul

To verify the 802.11ax rates on mesh backhaul in the mesh profile, use this command:

```
Device# show wireless profile mesh detailed default-mesh-profile
Mesh Profile Name             : default-mesh-profile
-------------------------------------------------
Description                   : default mesh profile
.
.
Backhaul tx rate(802.11bg)    : 802.11ax mcs7 ss1
Backhaul tx rate(802.11a)     : 802.11ax mcs9 ss2
```

To verify the 802.11ax rates on mesh backhaul in the general configuration of an AP, use this command:

```
Device# show ap config general
Cisco AP Identifier            : 5c71.0d17.49e0
.
.
Backhaul slot id               : 1
Backhaul tx rate               : 802.11ax mcs7 ss1
```

Verify background scanning and MAP fast ancestor find

To verify whether the Background Scanning and MAP Fast Ancestor Find features are enabled, run the **show wireless profile mesh detailed** command.

To verify the background scan, use this command:

```
Device# show wireless profile mesh detailed Mesh_Profile | i Background Scan
Background Scan               : ENABLED
```

To verify MAP Fast Ancestor Find, use this command:

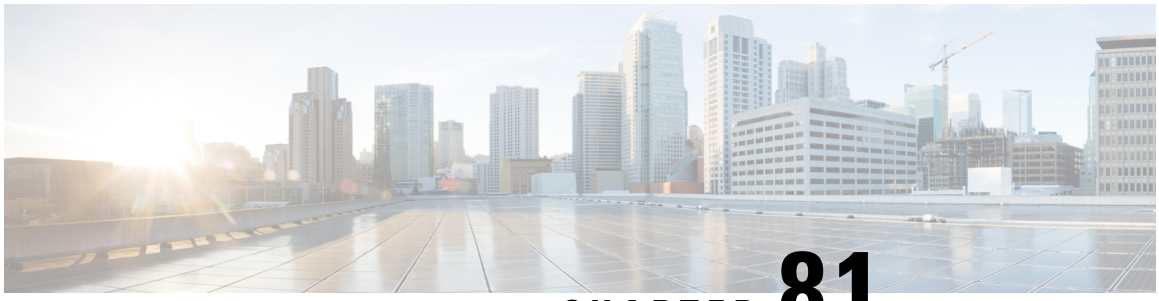
```
Device# show wireless profile mesh detailed Mesh_Profile | i MAP fast ancestor find
MAP fast ancestor find        : ENABLED
```



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WLAN

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CHAPTER 81

WLANs

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Information About WLANs

This feature enables you to control WLANs for lightweight access points. Each WLAN has a separate WLAN ID, a separate profile name, and a WLAN SSID. All access points can advertise up to 16 WLANs. However, you can create up to 4096 WLANs and then selectively advertise these WLANs (using profiles and tags) to different APs for better manageability.

You can configure WLANs with different SSIDs or with the same SSID. An SSID identifies the specific wireless network that you want the controller to access.

Band Selection

The 2.4-GHz band is often congested. Clients using the 2.4-GHz band often experience interference from Bluetooth devices, microwave ovens, cordless phones, and other access points. The 802.11b/g limit of three nonoverlapping channels also causes co-channel interference.

Off-Channel Scanning Deferral

A lightweight access point, in normal operational conditions, periodically goes off-channel and scans another channel. This is in order to perform RRM operations such as the following:

- Transmitting and receiving Neighbor Discovery Protocol (NDP) packets with other APs.
- Detecting rogue APs and clients.
- Measuring noise and interference.

During the off-channel period, which normally is about 70 milliseconds, the AP is unable to transmit or receive data on its serving channel. Therefore, there is a slight impact on its performance and some client transmissions might be dropped.

While the AP is sending and receiving important data, it is possible to configure off-channel scanning deferral so that the AP does not go off-channel and its normal operation is not impacted. You can configure off-channel scanning deferral on a per-WLAN basis, per WMM UP class basis, with a specified time threshold in milliseconds. If the AP sends or receives, on a particular WLAN, a data frame marked with the given UP class within the specified threshold, the AP defers its next RRM off-channel scan. For example, by default, off-channel scanning deferral is enabled for UP classes 4, 5, and 6, with a time threshold of 100 milliseconds. Therefore, when RRM is about to perform an off-channel scan, a data frame marked with UP 4, 5, or 6 is received within the last 100 milliseconds, RRM defers going off-channel. The AP radio does not go off-channel when a voice call sending and receiving audio samples are marked as UP class 6 for every active 20 milliseconds.

Off-channel scanning deferral does come with a tradeoff. Off-channel scanning can impact throughput by 2 percent or more, depending on the configuration, traffic patterns, and so on. Throughput can be slightly improved if you enable off-channel scanning deferral for all traffic classes and increase the time threshold. However, by not going off-channel, RRM can fail to identify AP neighbors and rogues, resulting in negative impact to security, DCA, TPC, and 802.11k messages.

DTIM Period

In the 802.11 networks, lightweight access points broadcast a beacon at regular intervals, which coincides with the Delivery Traffic Indication Map (DTIM). After the access point broadcasts the beacon, it transmits any buffered broadcast and multicast frames based on the value set for the DTIM period. This feature allows power-saving clients to wake up at the appropriate time if they are expecting broadcast or multicast data.

Typically, the DTIM value is set to 1 (to transmit broadcast and multicast frames after every beacon) or 2 (to transmit broadcast and multicast frames after every other beacon). For instance, if the beacon period of the 802.11 network is 100 ms and the DTIM value is set to 1, the access point transmits buffered broadcast and multicast frames for 10 times every second. If the beacon period is 100 ms and the DTIM value is set to 2, the access point transmits buffered broadcast and multicast frames for 5 times every second. Either of these settings are suitable for applications, including Voice Over IP (VoIP), that expect frequent broadcast and multicast frames.

However, the DTIM value can be set as high as 255 (to transmit broadcast and multicast frames after every 255th beacon). The only recommended DTIM values are 1 and 2; higher DTIM values will likely cause communications problems.



Note A beacon period, which is specified in milliseconds on the device, is converted internally by the software to 802.11 Time Units (TUs), where 1 TU = 1.024 milliseconds. Depending on the AP model, the actual beacon period may vary slightly; for example, a beacon period of 100 ms may in practice equate to 104.448 ms.

Session Timeouts

You can configure a WLAN with a session timeout. The session timeout is the maximum time for a client session to remain active before requiring reauthorization.

If a WLAN is configured with Layer 2 security, for example WPA2-PSK, and a Layer 3 authentication is also configured, the WLAN session timeout value is overridden with the 802.1X reauthentication timeout value. If APF reauthentication timeout value is greater than 65535, the WLAN session timeout is by default set to 65535; else, the configured 802.1X reauthentication timeout value is applied as the WLAN session timeout.

This section contains the following subsections:

Cisco Client Extensions

The Cisco Client Extensions (CCX) software is licensed to manufacturers and vendors of third-party client devices. The CCX code resident on these clients enables them to communicate wirelessly with Cisco access points and to support Cisco features that other client devices do not, including those features that are related to increased security, enhanced performance, fast roaming, and power management.

- The software supports CCX versions 1 through 5, which enables devices and their access points to communicate wirelessly with third-party client devices that support CCX. CCX support is enabled automatically for every WLAN on the device and cannot be disabled. However, you can configure Aironet information elements (IEs).
- If Aironet IE support is enabled, the access point sends an Aironet IE 0x85 (which contains the access point name, load, number of associated clients, and so on) in the beacon and probe responses of this WLAN, and the device sends Aironet IEs 0x85 and 0x95 (which contains the management IP address of the device and the IP address of the access point) in the reassociation response if it receives Aironet IE 0x85 in the reassociation request.

Peer-to-Peer Blocking

Peer-to-peer blocking is applied to individual WLANs, and each client inherits the peer-to-peer blocking setting of the WLAN to which it is associated. Peer-to-Peer enables you to have more control over how traffic is directed. For example, you can choose to have traffic bridged locally within the device, dropped by the device, or forwarded to the upstream VLAN.

Peer-to-peer blocking is supported for clients that are associated with local and central switching WLANs.



Note Peer-to-peer blocking feature is VLAN-based. WLANs using the same VLAN has an impact, if Peer-to-peer blocking feature is enabled.

Diagnostic Channel

You can choose a diagnostic channel to troubleshoot why the client is having communication problems with a WLAN. You can test the client and access points to identify the difficulties that the client is experiencing and allow corrective measures to be taken to make the client operational on the network. You can use the device GUI or CLI to enable the diagnostic channel, and you can use the device **diag-channel** CLI to run the diagnostic tests.



Note We recommend that you enable the diagnostic channel feature only for non-anchored SSIDs that use the management interface. CCX Diagnostic feature has been tested only with clients having Cisco ADU card

Prerequisites for WLANs

- You can associate up to 16 WLANs with each policy tag.
- We recommend that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that devices properly route VLAN traffic.

Restrictions for WLANs

- Do not configure PSK as this configuration is not supported and impacts client join flow.
- Ensure that TKIP or AES ciphers are enabled with WPA1 configuration, else ISSU may break during upgrade process.
- When you change the WLAN profile name, then FlexConnect APs (using AP-specific VLAN mapping) will become WLAN-specific. If FlexConnect Groups are configured, the VLAN mapping will become Group-specific.
- Do not enable IEEE 802.1X Fast Transition on Flex Local Authentication enabled WLAN, as client association is not supported with Fast Transition 802.1X key management.
- Peer-to-peer blocking does not apply to multicast traffic.
- In FlexConnect, peer-to-peer blocking configuration cannot be applied only to a particular FlexConnect AP or a subset of APs. It is applied to all the FlexConnect APs that broadcast the SSID.
- The WLAN name and SSID can have up to 32 characters.
- WLAN and SSID names support only the following ASCII characters:
  - Numerals: 48 through 57 hex (0 to 9)
  - Alphabets (uppercase): 65 through 90 hex (A to Z)
  - Alphabets (lowercase): 97 through 122 hex (a to z)
  - ASCII space: 20 hex
  - Printable special characters: 21 through 2F, 3A through 40, and 5B through 60 hex, that is: ! " # $ % & ' ( ) * + , - . / : ; < = > ? @ [\ ] ^ _ ` { | } ~
- WLAN name cannot be a keyword; for example, if you try to create a WLAN with the name as 's' by entering the **wlan s** command, it results in shutting down all WLANs because 's' is used as a keyword for shutdown.
- You cannot map a WLAN to VLAN 0. Similarly, you cannot map a WLAN to VLANs 1002 to 1006.
- Dual stack clients with a static-IPv4 address is not supported.
- In a dual-stack with IPv4 and IPv6 configured in the Cisco 9800 controller, if an AP tries to join controller with IPv6 tunnel before its IPv4 tunnel gets cleaned, you would see a traceback and AP join will fail.
- When creating a WLAN with the same SSID, you must create a unique profile name for each WLAN.

- When multiple WLANs with the same SSID get assigned to the same AP radio, you must have a unique Layer 2 security policy so that clients can safely select between them.
- If the newly configured SSID is on a 5-GHz DFS channel, beaconing does not start immediately.
- RADIUS server overwrite is not configured on a per WLAN basis, but rather on a per AAA server group basis.
- Downloadable ACL (DACL) is supported only on the central switching mode. It is not supported for Flex Local switching or on the Cisco Embedded Wireless Controller.
- Wi-Fi 6E APs support up to 8 WLANs. If more than 8 WLANs are already configured under the policy tag and a new 6-GHz WLAN is configured, CAPWAP disconnect is required for a Wi-Fi 6E AP. Otherwise, the newly configured 6-GHz WLAN is not pushed to applicable Wi-Fi 6E APs.

Note After AP reconnects, the controller will re-evaluate the first eight 6-GHz applicable WLANs for Wi-Fi 6E AP. This limitation is irrelevant from the 17.15 release onwards, where the controller supports 16 WLANs on 6-GHz radio.

Caution Some clients might not be able to connect to WLANs properly if they detect the same SSID with multiple security policies. Use this WLAN feature with care.

How to Configure WLANs

Creating WLANs (GUI)

Procedure

Step 1 In the **Configuration** > **Tags & Profiles** > **WLANs** page, click **Add**.

The **Add WLAN** window is displayed.

Step 2 Under the **General** tab and **Profile Name** field, enter the name of the WLAN. The name can be ASCII characters from 32 to 126, without leading and trailing spaces.

Step 3 Click **Save & Apply to Device**.

Creating WLANs (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name wlan-id* [*ssid*] **Example:** `Device(config)# wlan mywlan 34 mywlan-ssid`	Specifies the WLAN name and ID: • For the *profile-name*, enter the profile name. The range is from 1 to 32 alphanumeric characters. • For the *wlan-id*, enter the WLAN ID. The range is from 1 to 512. • For the *ssid*, enter the Service Set Identifier (SSID) for this WLAN. If the SSID is not specified, the WLAN profile name is set as the SSID. **Note** • You can create SSID using GUI or CLI. However, we recommend that you use CLI to create SSID. • By default, the WLAN is disabled.
Step 3	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Deleting WLANs (GUI)

Procedure

Step 1 In the **Configuration** > **Tags & Profiles** > **WLANs** page, check the checkbox adjacent to the WLAN you want to delete.

To delete multiple WLANs, select multiple WLANs checkboxes.

Step 2 Click **Delete**.

Step 3 Click **Yes** on the confirmation window to delete the WLAN.

Deleting WLANs

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**no wlan** *wlan-name wlan-id ssid* **Example:** `Device(config)# no wlan test2`	Deletes the WLAN. The arguments are as follows: • The *wlan-name* is the WLAN profile name. • The *wlan-id* is the WLAN ID. • The *ssid* is the WLAN SSID name configured for the WLAN.
Step 3	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Searching WLANs (CLI)

To verify the list of all WLANs configured on the controller, use the following show command:

```
Device# show wlan summary
Number of WLANs: 4

WLAN Profile Name                     SSID                           VLAN Status
-------------------------------------------------------------------------------
1    test1                             test1-ssid                     137  UP
3    test2                             test2-ssid                     136  UP
2    test3                             test3-ssid                     1    UP
45   test4                             test4-ssid                     1    DOWN
```

To use wild cards and search for WLANs, use the following `show` command:

```
Device# show wlan summary | include test-wlan-ssid
1    test-wlan                      test-wlan-ssid                   137   UP
```

Enabling WLANs (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 On the **WLANs** page, click the WLAN name.

Step 3 In the **Edit WLAN** window, toggle the **Status** button to **ENABLED**.

Step 4 Click **Update & Apply to Device**.

Enabling WLANs (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name* **Example:** `Device(config)# wlan test4`	Enters WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.
Step 3	**no shutdown** **Example:** `Device(config-wlan)# no shutdown`	Enables the WLAN.
Step 4	**end** **Example:** `Device(config-wlan)# end`	Returns to privileged EXEC mode.

Disabling WLANs (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 In the **WLANs** window, click the WLAN name.

Step 3 In the **Edit WLAN** window, set the **Status** toggle button as **DISABLED**.

Step 4 Click **Update & Apply to Device**.

Disabling WLANs (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name* **Example:** `Device(config)# wlan test4`	Enters WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.
Step 3	**shutdown** **Example:** `Device(config-wlan)# shutdown`	Disables the WLAN.
Step 4	**end** **Example:** `Device(config-wlan)# end`	Returns to privileged EXEC mode.
Step 5	**show wlan summary** **Example:** `Device# show wlan summary`	Displays the list of all WLANs configured on the device. You can search for the WLAN in the output.

Configuring General WLAN Properties (CLI)

You can configure the following properties:

- Media stream
- Broadcast SSID
- Radio

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**wlan** *profile-name* **Example:** `Device(config)# wlan test4`	Enters WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.
Step 3	**shutdown** **Example:** `Device(config-wlan)# shutdown`	Disables the WLAN.
Step 4	**broadcast-ssid** **Example:** `Device(config-wlan)# broadcast-ssid`	Broadcasts the SSID for this WLAN.
Step 5	**dot11bg 11g** **Example:** `Device(config-wlan)# dot11bg 11g`	Configures the WLAN radio policy for dot11 radios.
Step 6	**media-stream multicast-direct** **Example:** `Device(config-wlan)# media-stream multicast-direct`	Enables multicast VLANs on this WLAN.
Step 7	**no shutdown** **Example:** `Device(config-wlan)# no shutdown`	Enables the WLAN.
Step 8	**end** **Example:** `Device(config-wlan)# end`	Returns to privileged EXEC mode.

Configuring Advanced WLAN Properties (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name* **Example:** `Device(config)# wlan test4`	Enters WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.

	Command or Action	Purpose
Step 3	**chd** **Example:** `Device(config-wlan)# chd`	Enables coverage hole detection for this WLAN.
Step 4	**ccx aironet-iesupport** **Example:** `Device(config-wlan)# ccx aironet-iesupport`	Enables support for Aironet IEs for this WLAN.
Step 5	**client association limit** {*clients-per-wlan* | **ap** *clients-per-ap-per-wlan* | **radio***clients-per-ap-radio--per-wlan*} **Example:** `Device(config-wlan)# client association limit ap 400`	Sets the maximum number of clients, clients per AP, or clients per AP radio that can be configured on a WLAN.
Step 6	**ip access-group web** *acl-name* **Example:** `Device(config-wlan)# ip access-group web test-acl-name`	Configures the IPv4 WLAN web ACL. The variable *acl-name* specifies the user-defined IPv4 ACL name.
Step 7	**peer-blocking** [**drop** | **forward-upstream**] **Example:** `Device(config-wlan)# peer-blocking drop`	Configures peer to peer blocking parameters. The keywords are as follows: • **drop**—Enables peer-to-peer blocking on the drop action. • **forward-upstream**—No action is taken and forwards packets to the upstream.
Step 8	**channel-scan** {**defer-priority** {**0-7**} | **defer-time** {**0 - 6000**}} **Example:** `Device(config-wlan)# channel-scan defer-priority 6`	Sets the channel scan defer priority and defer time. The arguments are as follows: • **defer-priority**—Specifies the priority markings for packets that can defer off-channel scanning. The range is from 0 to 7. The default is 3. • **defer-time**—Deferral time in milliseconds. The range is from 0 to 6000. The default is 100.
Step 9	**end** **Example:** `Device(config-wlan)# end`	Returns to privileged EXEC mode.

Configuring Advanced WLAN Properties (GUI)

Before you begin

Ensure that you have configured an AP Join Profile prior to configuring the primary and backup controllers.

Procedure

Step 1 Choose **Configuration** > **Wireless** > **WLANs** > **Wireless Networks**.

Step 2 In the **Wireless Networks** window, click **Add**.

Step 3 Under the **Advanced** tab, check the **Coverage Hole Detection** check box.

Step 4 Check the **Aironet IE** check box to enable Aironet IE on the WLAN.

Step 5 Check the **Diagnostic Channel** check box to enable diagnostic channel on the WLAN.

Step 6 From the **P2P Blocking Action** drop-down list, choose the required value.

Step 7 Set the **Multicast Buffer** toggle button as enabled or diabled.

Step 8 Check the **Media Stream Multicast-Direct** check box to enable the feature.

Step 9 In the **Max Client Connections** section, specify the maximum number of client connections for the following:

- In the **Per WLAN** field, enter a value. The valid range is between 0 and 10000.
- In the **Per AP Per WLAN** field, enter a value. The valid range is between 0 and 400.
- In the **Per AP Radio Per WLAN** field, enter a value. The valid range is between 0 and 200.

Step 10 In the **11v BSS Transition Support** section, perform the following configuration tasks:

a) Check the BSS Transition check box to enable 802.11v BSS Transition support.
b) In the **Disassociation Imminent** field, enter a value. The valid range is between 0 and 3000.
c) In the **Optimized Roaming Disassociation Timer** field, enter a value. The valid range is between 0 and 40.
d) Select the check box to enable the following:

- BSS Max Idle Service
- BSS Max Idle Protected
- Disassociation Imminent Service
- Directed Multicast Service
- Universal Admin
- Load Balance
- Band Select
- IP Source Guard

Step 11 From the **WMM Policy** drop-down list, choose the policy as Allowed, Disabled, or Required. By default, the WMM policy is Allowed.

Step 12 In the **Off Channel Scanning Defer** section, choose the appropriate **Defer Priority** values and then specify the required Scan Defer Time value in milliseconds.

Step 13 In the **Assisted Roaming (11k)** section, choose the appropriate status for the following:

- Prediction Optimization
- Neighbor List
- Dual-Band Neighbor List

Step 14 In the **DTIM Period (in beacon intervals)** section, specify a value for 802.11a/n and 802.11b/g/n radios. The valid range is from 1 to 255.

Step 15 Click **Save & Apply to Device**.

Verifying WLAN Properties (CLI)

To verify the WLAN properties based on the WLAN ID, use the following `show` command:

```
Device# show wlan id wlan-id
```

To verify the WLAN properties based on the WLAN name, use the following `show` command:

```
Device# show wlan name wlan-name
```

To verify the WLAN properties of all the configured WLANs, use the following `show` command:

```
Device# show wlan all
```

To verify the summary of all WLANs, use the following `show` command:

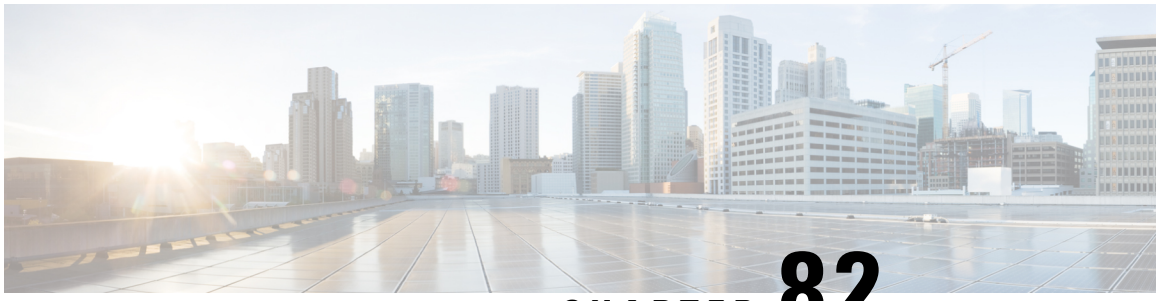
```
Device# show wlan summary
```

To verify the running configuration of a WLAN based on the WLAN name, use the following `show` command:

```
Device# show running-config wlan wlan-name
```

To verify the running configuration of all WLANs, use the following `show` command:

```
Device# show running-config wlan
```



CHAPTER 82

Network Access Server Identifier

This chapter explains how to configure and apply NAS-ID attributes for wireless RADIUS authentication using GUI and CLI, map AAA policies to tags or WLANs, and verify NAS-ID settings for accurate policy selection.

- Network Access Server Identifier (NAS-ID), on page 863

Network Access Server Identifier (NAS-ID)

A network access server identifier (NAS-ID) is a RADIUS attribute that

- identifies the source device, WLAN profile, VLAN interface, or AP group initiating a RADIUS access request
- enables the RADIUS server to apply appropriate authentication and policy selection, and
- supports customized policy enforcement based on user groups or device types.

The NAS-ID is sent to the RADIUS server by the embedded wireless controller through an authentication request to classify users to different groups. This enables the RADIUS server to send a customized authentication response.

Starting with Cisco IOS XE Cupertino 17.7.1, a new string named custom-string (custom string) is available.

Note The acct-session-id is sent with the RADIUS access request only if accounting is enabled on the policy profile.

If you configure a NAS-ID for a WLAN profile, it overrides the NAS-ID that is configured for the VLAN interface.

These options can be configured for a NAS ID:

- sys-name (System Name)
- sys-ip (System IP Address) and sys-mac (System MAC Address)
- ap-ip (AP's IP address) and ap-name (AP's Name)
- ap-mac (AP's MAC Address)
- ap-eth-mac (AP's Ethernet MAC Address)

- ap-policy-tag (AP's policy tag name)
- ap-site-tag (AP's site tag name)
- ssid (SSID Name) and ap-location (AP's Location)
- custom-string (custom string)

Create a NAS ID policy (GUI)

Configure a NAS ID policy that defines how network access server identifiers are applied within your wireless AAA policy using the GUI.

Creating a NAS ID policy ensures correct identification and handling of wireless authentication requests. This is typically performed when setting up or modifying wireless AAA policies.

Procedure

Step 1 Choose **Configuration** > **Security** > **Wireless AAA Policy**.

Step 2 On the **Wireless AAA Policy** page, click the name of the **Policy** or click **Add** to create a new one.

Step 3 In the **Add/Edit Wireless AAA Policy** window that is displayed, enter the name of the policy in the **Policy Name** field.

Step 4 Select from one of the NAS ID options from the **Option 1** drop-down list.

Step 5 Select from one of the NAS ID options from the **Option 2** drop-down list.

Step 6 Select from one of the NAS ID options from the **Option 3** drop-down list.

Step 7 Save the configuration.

Create a NAS ID policy (CLI)

Create and configure a NAS ID policy for wireless RADIUS authentication and accounting using commands.

Follow the procedure given below to create NAS ID policy:

Before you begin

- A NAS ID can combine up to a maximum of three options.
- The maximum length of the NAS ID attribute is 253. Before adding a new attribute, the system checks the attribute buffer. If there is not enough space, the system ignores the new attribute.
- By default, a wireless aaa policy (default-aaa-policy) is created with the default configuration (sys-name). You can update this policy with various NAS ID options. However, the default-aaa-policy cannot be deleted.
- If you do not configure a NAS ID, the system uses the default sys-name as the NAS ID for all wireless-specific RADIUS packets (authentication and accounting) from the embedded wireless controller.
- Starting with Cisco IOS XE Cupertino 17.7.1, you can configure a custom NAS ID string using combinations of option1, option2, and option3 (**nas-id option3custom-string***custom-string*) for RADIUS packets.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a new AAA policy.

Example:

```
Device(config)# wireless aaa policy policy-name
```

Step 3 Configure NAS ID for option1.

Example:

```
Device(config-aaa-policy)# nas-id option1 sys-name
```

Step 4 Configure NAS ID for option2.

Example:

```
Device(config-aaa-policy)# nas-id option2 sys-ip
```

Step 5 Configure NAS ID for option3.

Example:

```
Device(config-aaa-policy)# nas-id option3 sys-mac
```

Attach a policy to a tag (GUI)

Map a policy to a tag for consistent network device configuration using the GUI.

Attach a predefined policy to a tag to apply specific settings or profiles across selected devices.
Before you begin

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 Click **Add** and enter a name for the new policy, for example, test1, in the **General** tab.

Step 3 Click the **Advanced** tab, and under **AAA Policy**, from the **Policy Name** drop-down list, select the policy name that you had created in the **General** tab.

Step 4 Click **Apply to Device**.

Step 5 Choose **Configuration** > **Tags & Profiles** > **Tags** > **Policy**.

Step 6 Click **Add** to view the **Add Policy Tag** window.

Step 7 Enter a name and description for the policy tag.

Step 8 Click **Add** to map WLAN profile and policy profile.

Step 9 Choose the **WLAN Profile** to map with the appropriate **Policy Profile**, and click the tick icon. Click **Save & Apply to Device**.

Attach a policy to a tag (CLI)

Configure and attach a NAS ID policy to a wireless policy tag using commands.

Follow the procedure given below to attach a NAS ID policy to a tag:

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a WLAN policy profile.

Example:

```
Device(config)# wireless profile policy policy-name
```

Step 3 Configure a AAA policy profile.

Example:

```
Device(config-wireless-policy)# aaa-policy aaa-policy-name
```

Step 4 Return to the global configuration mode.

Example:

```
Device(config-wireless-policy)# exit
```

Step 5 Configure a wireless policy tag.

Example:

```
Device(config)# wireless tag policy policy-tag
```

Step 6 Map a WLAN profile to a policy profile.

Example:

```
Device(config)# wlan wlan1 policy policy-name
```

Note
You can also use the **ap-tag** option to configure a NAS ID for an AP group. This NAS ID overrides the NAS ID configured for a WLAN profile or VLAN interface.

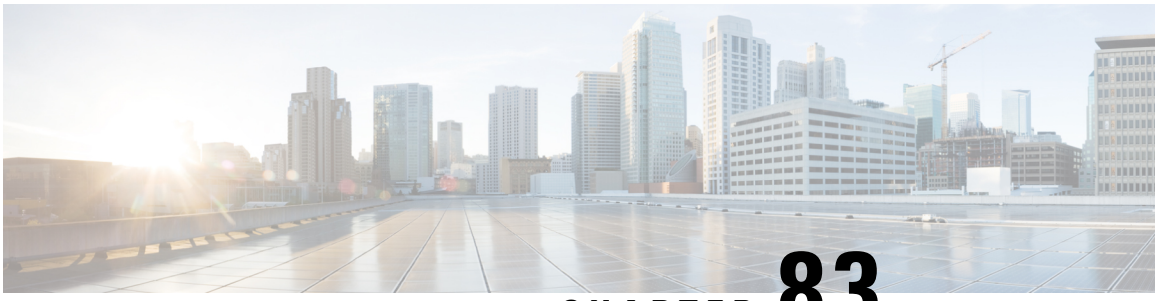
Verify the NAS ID configuration

Use this **show** command to verify the NAS ID configuration:

```
Device# show wireless profile policy detailed test1

Policy Profile Name           : test1
Description                   :
Status                        : ENABLED
VLAN                          : 1
Client count                  : 0

:
:
AAA Policy Params
  AAA Override                : DISABLED
  NAC                         : DISABLED
  AAA Policy name             : test
```



CHAPTER 83

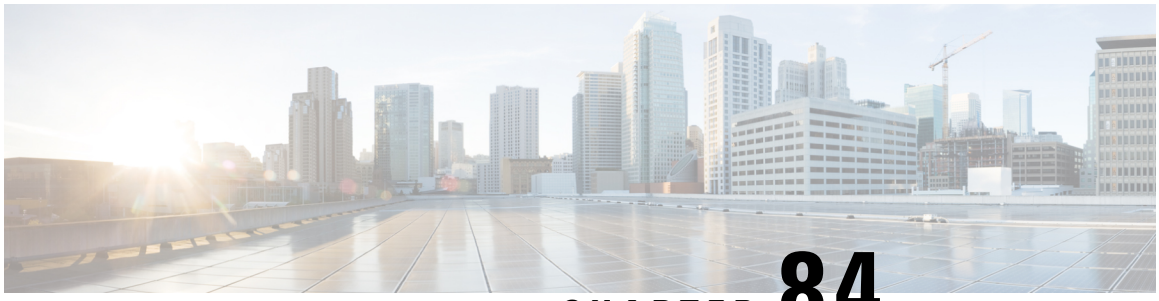
DHCP for WLANs

• DHCP for WLANs, on page 869

DHCP for WLANs

DHCP packets sent by the wireless clients are released in their respective VLANs as broadcast by the AP and relies on the fact that the network gateway of that VLAN forwards the requests to the DHCP server.

Note Internal DHCP server is not supported in EWC.



CHAPTER 84

WLAN Security

- Information About AAA Override, on page 871
- Prerequisites for Layer 2 Security, on page 871
- How to Configure WLAN Security, on page 872

Information About AAA Override

The AAA Override option of a WLAN enables you to configure the WLAN for identity networking. It enables you to apply VLAN tagging, Quality of Service (QoS), and Access Control Lists (ACLs) to individual clients based on the returned RADIUS attributes from the AAA server.

Prerequisites for Layer 2 Security

WLANs with the same SSID must have unique Layer 2 security policies so that clients can make a WLAN selection based on the information advertised in beacon and probe responses. The available Layer 2 security policies are as follows:

- None (open WLAN)
- WPA+WPA2

Note

- Although WPA and WPA2 cannot be used by multiple WLANs with the same SSID, you can configure two WLANs with the same SSID with WPA/TKIP with PSK and Wi-Fi Protected Access (WPA)/Temporal Key Integrity Protocol (TKIP) with 802.1X, or with WPA/TKIP with 802.1X or WPA/AES with 802.1X.
- A WLAN configured with TKIP support will not be enabled on an RM3000AC module.

- Static WEP (not supported on Wave 2 APs)

How to Configure WLAN Security

Configuring Static WEP Layer 2 Security Parameters (CLI)

Before you begin

You must have administrator privileges.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring WPA + WPA2 Layer 2 Security Parameters (CLI)

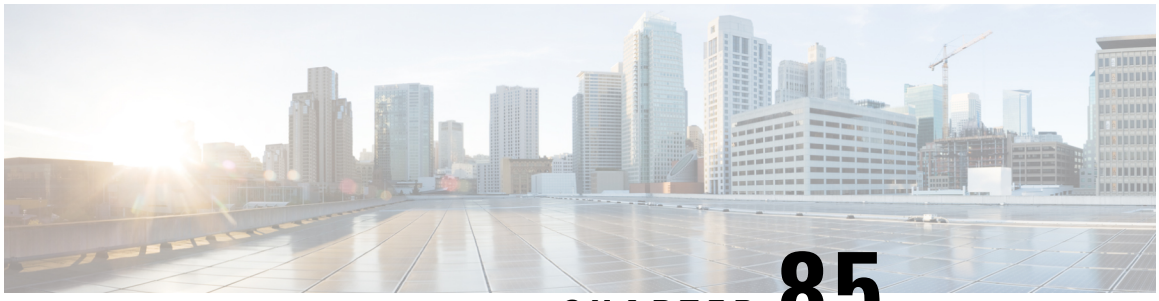
Before you begin

You must have administrator privileges.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**security wpa** **Example:** `Device(config-wlan)# security wpa`	
Step 3	**security wpa wpa1** **Example:** `Device(config-wlan)# security wpa wpa1`	Enables .
Step 4	**security wpa wpa1 ciphers** [**aes** | **tkip**] **Example:**	Specifies the WPA1 cipher. Choose one of the following encryption types:

	Command or Action	Purpose
	`Device(config-wlan)# security wpa wpa1 ciphers aes`	• **aes**—Specifies WPA/AES support. • **tkip**—Specifies WPA/TKIP support.
Step 5	**security wpa wpa2** **Example:** `Device(config-wlan)# security wpa wpa2`	Enables WPA2.
Step 6	**security wpa wpa2 ciphers aes** **Example:** `Device(config-wlan)# security wpa wpa2` **Example:**	Configure WPA2 cipher.



CHAPTER 85

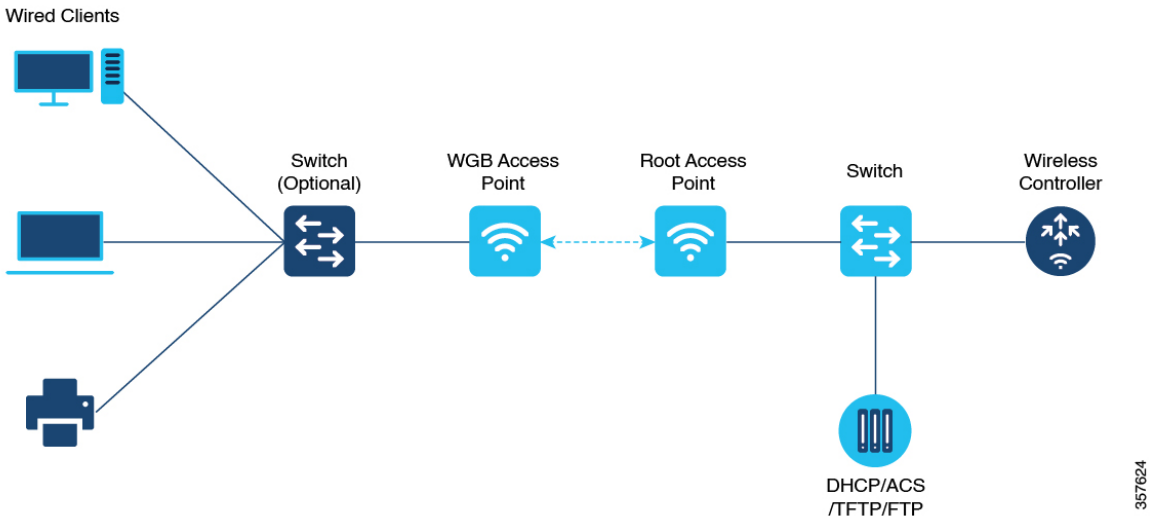
Workgroup Bridges

- Cisco Workgroup Bridges, on page 875
- Configuring Workgroup Bridge on a WLAN, on page 877
- Verifying the Status of Workgroup Bridges, on page 878
- Information About Simplifying WGB Configuration, on page 878
- Configuring Multiple WGBs (CLI), on page 879
- Verifying WGB Configuration, on page 880

Cisco Workgroup Bridges

A workgroup bridge (WGB) is an Access Point (AP) mode to provide wireless connectivity to wired clients that are connected to the Ethernet port of the WGB AP. A WGB connects a wired network over a single wireless segment by learning the MAC addresses of its wired clients on the Ethernet interface and reporting them to the WLC through infrastructure AP using Internet Access Point Protocol (IAPP) messaging. The WGB establishes a single wireless connection to the root AP, which in turn, treats the WGB as a wireless client.

Figure 12: Example of a WGB



The mode supported in WGB for Embedded Wireless Controller is:

- Flex Mode: Central authentication and local switching.

Note Cenral authentication is supported on Wave 1 and Wave 2 APs, whereas local switching is supported only on Wave 2 APs.

The following features are supported for use with a WGB:

Table 51: WGB Feature Matrix

Feature	Cisco Wave 1 APs	Cisco Wave 2
802.11r	Supported	Supported
QOS	Supported	Supported
UWGB mode	Supported	Supported on Wave 2 APs
IGMP Snooping or Multicast	Supported	Supported
802.11w	Supported	Supported
PI support (without SNMP)	Supported	Not supported
IPv6	Supported	Supported
VLAN	Supported	Supported
802.11i (WPAv2)	Supported	Supported
Broadcast tagging/replicate	Supported	Supported
Unified VLAN client	Implicitly supported (No CLI required)	Supported
WGB client	Supported	Supported
802.1x – PEAP, EAP-FAST, EAP-TLS	Supported	Supported
NTP	Supported	Supported
Wired client support on all LAN ports	Supported in Wired-0 and Wired-1 interfaces	Supported in all Wired-0, 1 and LAN ports 1, 2, and 3

Table 52: Supported Access Points and Requirements

Access Points	Requirements
Cisco Aironet 2700, 3700, and 1572 Series	Requires autonomous image.

Access Points	Requirements
Cisco Aironet 2800, 3800, 4800, 1562, and Cisco Catalyst 9105, 9115, IW6300 and ESW6300 Series	CAPWAP image starting from Cisco AireOS 8.8 release.

- MAC filtering is not supported for wired clients.
- Idle timeout is not supported for both WGB and wired clients.
- Session timeout is not applicable for wired clients.
- Web authentication is not supported.
- WGB supports only up to 20 clients.
- If you want to use a chain of certificates, copy all the CA certificates to a file and install it under a trust point on the WGB, else server certificate validation may fail.
- Wired clients connected to the WGB are not authenticated for security. Instead, the WGB is authenticated against the access point to which it associates. Therefore, we recommend that you physically secure the wired side of the WGB.
- Wired clients connected to a WGB inherit the WGB's QoS and AAA override attributes.
- To enable the WGB to communicate with the root AP, create a WLAN and make sure that Aironet IE is enabled under the Advanced settings.

Configuring Workgroup Bridge on a WLAN

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name* **Example:** `Device(config)# wlan wlan-profile`	Enters WLAN configuration submode. The *wlan-profile* is the profile name of the configured WLAN.
Step 3	**ccx aironet-iesupport** **Example:** `Device(config-wlan)# ccx aironet-iesupport`	Enables support for Aironet IEs for this WLAN.
Step 4	**no shutdown** **Example:** `Device(config-wireless-policy)# no shutdown`	Restarts the WLAN.

Verifying the Status of Workgroup Bridges

- To verify the number of WGBs, use the following command:

  show wireless wgb summary

  The following is a sample output:

```
Device#show wireless wgb summary
Number of WGBs: 1
MAC Address    AP Name                          WLAN State              Clients
-------------------------------------------------------------------------------
7070.8b7a.7030 Ed2-JFW-AP1                      1    Run                1
```

- To verify WGB details, use the following command:

  show wireless wgb mac-address *MAC-address* **detail**

  The following is a sample output:

```
Device#show wireless wgb mac-address 7XXX.8XXa.7XXX detail

Work Group Bridge

MAC Address        : 7XXX.8XXa.7XXX
AP Name            : Ed2-JFW-AP1
WLAN ID            : 1
State              : Run

Number of Clients: 1

MAC Address
------------
d8XX.97XX.bXXX
```

- To view the client details on the controller, use the following command:

  show wireless client mac-address *MAC-address* **detail**

  The following is a sample output:

```
Device#show wireless client mac-address 7XXX.8bXX.70XX detail

Workgroup Bridge
Wired Client count : 1
```

- The following is a sample output:

```
Device#show wireless client mac-address d8XX.97XX.b0XX detail
Workgroup Bridge Client
WGB MAC Address : 7XXX.8bXX.70XX
```

Information About Simplifying WGB Configuration

From Cisco IOS XE Cupertino 17.8.1, it is possible to configure WGB in multiple Cisco access points (APs) simultaneously. By importing a running configuration, you can deploy multiple WGBs in a network and make them operational quicker. When new Cisco APs are added to the network, you can transfer an existing or

working configuration to the new Cisco APs to make them operational. This enhancement eliminates the need to configure multiple Cisco APs using CLIs, after logging into them.

A network administrator can onboard Cisco APs using either of the following methods:

- Upload the working configuration from an existing Cisco AP to a server and download it to the newly deployed Cisco APs.
- Send a sample configuration to all the Cisco APs in the deployment.

This feature is supported only on the following Cisco APs:

- Cisco Aironet 1562 Access Points
- Cisco Aironet 2800 Access Points
- Cisco Aironet 3800 Access Points
- Cisco Catalyst 9105 Access Points
- Cisco Catalyst 9115 Access Points
- Cisco Catalyst 9120 Access Points
- Cisco Catalyst IW6300 Series Heavy Duty Access Points

For latest support information on various features in Cisco Wave 2 and 802.11ax (Wi-Fi 6) Access Points in Cisco IOS XE releases, see the Feature Matrix for Wave 2 and 802.11ax (Wi-Fi 6) Access Points document.

Configuring Multiple WGBs (CLI)

Perform the following procedure on the APs in WGB mode.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enters privileged EXEC mode.
Step 2	**copy configuration upload**{**sftp:**| **tftp:**} *ip-address* [*directory*] [*file-name*] **Example:** `Device# copy configuration upload sftp: 10.10.10.1 C:sample.txt`	Creates upload configuration file and uploads to the SFTP or TFTP server using the specified path.
Step 3	**copy configuration download**{**sftp:**| **tftp:**} *ip-address* [*directory*] [*file-name*] **Example:** `Device# copy configuration download sftp: 10.10.10.1 C:sample.txt`	Downloads the configuration file and replaces the old configuration in the AP and reboots the WGB. When the device restarts, new configuration is applied.

	Command or Action	Purpose
Step 4	**show wgb dot11 association** **Example:** `Device# show wgb dot11 association`	Lists the WGB uplink information.
Step 5	**show version** **Example:** `Device# show version`	Displays the AP software information.

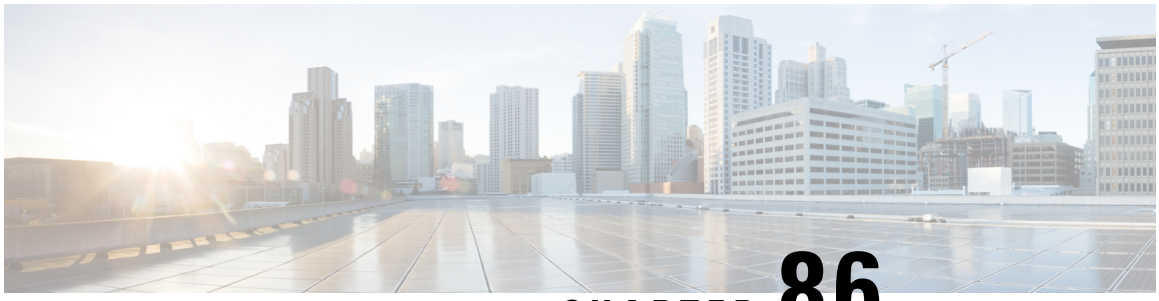
Verifying WGB Configuration

After completing the configuration download and reboot of the AP, the WGB rejoins the network. Use the **show logging** command to list and verify the download events that are captured in the debug logs:

```
Device# show logging

Jan 13 18:19:17 kernel: [*01/13/2022 18:19:17.4880] WGB - Applying download config...
Jan 13 18:19:18 download_config: configure clock timezone UTC
Jan 13 18:19:18 download_config: configure dot1x credential dot1x_profile username wifiuser
 password U2FsdGVkX1+8PWmAOnFO8BXyk5EAphMy2PmhPPhWV0w=
Jan 13 18:19:18 download_config: configure eap-profile eap_profile method PEAP
Jan 13 18:19:18 download_config: configure eap-profile eap_profile dot1x-credential
dot1x_profile
Jan 13 18:19:18 chpasswd: password for user changed
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7260] chpasswd: password for user changed
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7610]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7610]  Management user configuration saved
successfully
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7610]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7650] Warning!!! Attach SSID profile with the
 radio to use the new changes.
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7650]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7650]  Dot1x credential configuration has
been saved successfully
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7650]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7740] Warning!!! Attach SSID profile with the
 radio to use the new changes.
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7740]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7740]  EAP profile configuration has been
saved successfully
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7740]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7790] Warning!!! Attach SSID profile with the
 radio to use the new changes.
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7790]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7790]  EAP profile configuration has been
saved successfully
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7790]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7830] Warning!!! Attach SSID profile with the
 radio to use the new changes.
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7830]
Jan 13 18:19:18 download_config: configure ssid-profile psk ssid alpha_psk authentication
psk U2FsdGVkX18meBfFFeiC4sgkEmbGPNH/ul1dne6h/m8= key-management wpa2
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7930] Warning!!! Attach SSID profile with the
 radio to use the new changes.
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7930]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7930]  EAP profile configuration has been
saved successfully
```

```
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.7930]
Jan 13 18:19:18 download_config: configure ssid-profile open ssid alpha_open authentication
 open
Jan 13 18:19:18 download_config: configure ssid-profile openax ssid alpha_open_ax
authentication open
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.8650]  SSID-Profile dot1xpeap has been saved
 successfully
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.8650]
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.9270]  SSID-Profile psk has been saved
successfully
Jan 13 18:19:18 kernel: [*01/13/2022 18:19:18.9270]
Jan 13 18:19:19 kernel: [*01/13/2022 18:19:19.0380]  SSID-Profile open has been saved
successfully
Jan 13 18:19:19 kernel: [*01/13/2022 18:19:19.0380]
Jan 13 18:19:19 kernel: [*01/13/2022 18:19:19.0380]  SSID-Profile openax has been saved
successfully
Jan 13 18:19:19 kernel: [*01/13/2022 18:19:19.0380]
Jan 13 18:19:22 download_config: configure wgb broadcast tagging disable
Jan 13 18:19:22 download_config: configure wgb packet retries 64 drop
Jan 13 18:19:22 kernel: [*01/13/2022 18:19:22.9710] Broadcast tagging 0 successfully
Jan 13 18:19:22 kernel: [*01/13/2022 18:19:22.9710]
Jan 13 18:19:23 download_config: configure dot11Radio 1 mode wgb ssid-profile open
Jan 13 18:19:23 download_config: configure dot11Radio 1 enable
Jan 13 18:19:23 download_config: configure ap address ipv6 disable
```



CHAPTER 86

Device Analytics

- Device Analytics, on page 883
- Adaptive 802.11r, on page 886

Device Analytics

Information About Device Analytics

The Device Analytics feature enhances the enterprise Wi-Fi experience for client devices to ensure seamless connectivity. This feature provides a set of data analytics tools for analyzing wireless client device behavior. With device profiling enabled on the controller, information is exchanged between the client device and the controller and AP. This data is encrypted using AES-256-CBC to ensure device security.

Note

- From 17.1.1 release onwards, this feature is applicable to Samsung devices.

Note From Cisco IOS XE Dublin 17.12.1, MacBook Analytics is supported on the controller when the MacBook device sends 11k action frames along with the model information.

Note Apple clients such as iPhones and iPads use 802.11k action frames to send device information to the controller. When they fail to send 802.11k action frames, the controller will not perform device classification based on the 802.11 protocol. Hence, this falls back to legacy device classification which is based on HTTP and DHCP protocols.

Restrictions for Device Analytics

- This feature is applicable only for Cisco device ecosystem partners.
- This feature is supported only on the 802.11ax and Wave 2 APs.

- This feature is supported using central authentication in either local mode or FlexConnect mode.

Configuring Device Analytics (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 On the **WLANs** page, click the name of the WLAN.

Step 3 In the **Edit WLAN** window, click the **Advanced** tab.

Step 4 In the **Device Analytics** section, select the **Advertise Support** check box.

Step 5 (Optional) In the **Device Analytics** section, select the **Share Data with Client** check box.

Step 6 Click **Update & Apply to Device**.

Configuring Device Analytics (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *wlan-name wlan-id SSID-name* **Example:** `Device(config)# wlan device_analytics 1 device_analytics`	Enters the WLAN configuration sub-mode. • *wlan-name*—Enter the profile name. The range is from 1 to 32 alphanumeric characters. • *wlan-id*—Enter the WLAN ID. The range is from 1 to 512. • *SSID-name*—Enter the Service Set Identifier (SSID) for this WLAN. If the SSID is not specified, the WLAN profile name is set as the SSID. **Note** If you have already configured WLAN, enter **wlan** *wlan-name* command.

	Command or Action	Purpose
Step 3	**client association limit** {*clients-per-wlan* | **ap***clients-per-ap-per-wlan* | **radio** *clients-per-ap-radio-per-wlan*} **Example:** `Device(config)# client association limit 1 1`	Sets the maximum number of clients, clients per AP, or clients per AP radio that can be configured on a WLAN.
Step 4	**[no] device-analytics** **Example:** `Device(config)# device-analytics`	This is enabled by default. Enables or disables device analytics. WLANs advertise analytics capability in beacons & probe responses.
Step 5	**[no] device-analytics** [**export**] **Example:** `Device(config)# device-analytics export`	When **export** option is set, the information from Cisco devices are shared with compatible clients (such as, Samsung devices). Here, information from Cisco devices refer to the Cisco controller details, AP version, and model number. This configuration is disabled by default.
Step 6	**no shutdown** **Example:** `Device(config)# no shutdown`	Enables the WLAN.
Step 7	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

Verifying Device Analytics Configuration

To view the status of device analytics export, use the following command:

```
Device# show wlan 1 test-wlan

WLAN Profile Name     : test-wlan
================================================
Identifier                       : 1
Description                      :
Network Name (SSID)              : test-open-ssid
Status                           : Enabled
Broadcast SSID                   : Enabled
Advertise-Apname                 : Disabled
Universal AP Admin               : Disabled

Device Analytics
    Advertise Support            : Enabled
    Share Data with Client       : Disabled
```

To view client device information, use the following command:

```
Device# show device classifier mac-address 0040.96ae.xxx detail
```

```
Client Mac: 0040.96ae.xxxx
Device Type: Samsung Galaxy S10e(Phone)
Confidence Level: 40
Device Name: android-dhcp-9
Software Version(Carrier Code): SD7(TMB)
Device OS: Android 9
Device Vendor: android-dhcp-9
Country: US
```

To view the last disconnect reason, use the following command:

```
Device# show device classifier mac-address 0040.96ae.xxxx detail

Client MAC Address : 0040.96ae.xxxx
Client IPv4 Address : 12.1.0.52
Client IPv6 Addresses : fe80::631b:5b4f:f9b6:53cc
Client Username: N/A
AP MAC Address : 7069.5a51.53c0
AP Name: AP4C77.6D9E.61B2
AP slot : 1
Client State : Associated

Assisted Roaming Neighbor List
Nearby AP Statistics:
EoGRE : No/Simple client
Last Disconnect Reason : User initiated disconnection - Device was powered off or Wi-Fi
turned off
```

Adaptive 802.11r

Information About Adaptive 802.11r

The Cisco device ecosystem partner now supports 11r functionality on an adaptive 802.11r SSID. Samsung is one of the partners.



Note The Adaptive 802.11r is enabled by default. This means that when you create a WLAN, the adaptive 802.11r is configured by default.

Client device information such as its model number, supported operating system is shared with the controller and AP while the device receives information such as controller and AP type, software release, etc. Also, this enables 802.11r-compatible devices to benefit from adaptive 802.11r on Cisco networks. This ecosystem comes handy especially for troubleshooting device disconnection from the AP as the controller receives information such as the disconnect reason code from the client device.

Note Devices without 11r support cannot join an SSID where 11r is enabled.

To use the 11r functionality on devices, you need to create a separate SSID with 11r enabled and another with 11r disabled to support the non-11r devices in the network.

Adaptive dot11r is supported by Apple iPad, Apple iPhone, and Samsung S10 devices. However; some software update creates a MIC mismatch error in these devices. But these errors are transient and clients will successfully be able to associate to the SSID in subsequent results.

Configuring Adaptive 802.11r (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 On the **WLANs** page, click the name of the WLAN.

Step 3 In the **Edit WLAN** window, click the **Security** > **Layer2** tab.

Step 4 In the **WPA Parameters** section and **Fast Transition** drop-down list, choose **Adaptive Enabled**.

Step 5 Click **Update & Apply to Device**.

Verifying Adaptive 802.11r

To view the details, use the following command:

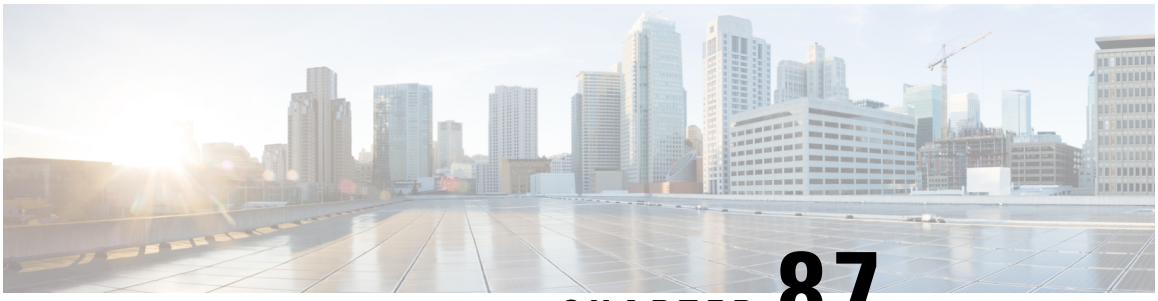
```
Device# show running-config all
wlan test-psk 2 test-psk
 security ft adaptive
"adaptive" is  optional
```

Note The following command is used to enable or disable adaptive 11r:

[no] security ft adaptive

The following command is used to enable or disable 802.11r:

[no] security ft



CHAPTER 87

Device Classifier Dynamic XML Support

- Feature History for Device Classifier Dynamic XML Support, on page 889
- Information About Device Classifier Dynamic XML Support, on page 890
- Enabling Device Classifier (CLI), on page 893
- Updating Dynamic XML File, on page 893
- Verifying TLV Values, on page 894
- Clearing Old Classification Cache, on page 894

Feature History for Device Classifier Dynamic XML Support

This table provides release and related information about the feature explained in this section.

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 53: Feature History for Device Classifier Dynamic XML Support

Release	Feature	Feature Information
Cisco IOS XE Dublin 17.10.1	Device Classifier Dynamic XML Support	You can do the following: • Add rules, checks, and profile name to an XML file. • Upload the XML file to the device file system. This feature enables better device classification without upgrading the device to a new release. **Note** Device classifier dynamic XML support is applicable for the following: • Devices that are not classified previously: The classification takes effect from the latest file without any reboot. • Devices that are already classified: The clients have to rejoin for the classification to take effect. • Client previously classified with higher protocol values such as DHCP + HTTP: If the same client wants to be classified with only DHCP, use the **clear wireless client device cache** command.

Information About Device Classifier Dynamic XML Support

The current device classifier uses static XML file wherein you define checks, rules, and profiles based on MAC, DHCP, and HTTP TLVs in wireless devices. The static XML file is converted to a text file and integrated with the image. When you enable the device classified functionality using **device classifier** command, the contents in the text file is read and populated into the device classifier structures.

Note The subsequent device classification is based on the populated device classifier structures.

Presently, if you find any unclassified devices in a controller, the static XML file is updated with the new rules, checks, and profiles to get the devices classified. You will need to wait till the subsequent release as the static XML file is integrated with the image and cannot be changed from the controller.

Workflow: To Classify Unclassified Devices with Dynamic XML File

1. The dynamic XML filename must be **dc_user_profiles.xml**.

Note Files with any other name are not read and parsed even if they have the correct schema.

2. Copy the sample dynamic XML file to your system using the following command:

   copy {flash:} {ftp: | tftp:}

3. Provide a new version for the dynamic XML file:

   <Version>1.1</Version>

4. Edit the dynamic XML file with the new rules, checks, and profiles as defined in the schema after examining the TLV values of the unclassified devices.

Note To check the TLV values, use the following command:

show wireless client mac-address *mac* **detail**

5. Copy the dynamic XML file to the device flash using the following command:

   copy {ftp: | tftp:} {flash:}

Once the file is copied to the device file system, the newly connected clients are classified according to the new profiles defined in the dynamic XML file. You need to reconnect the already unclassified devices to send the DHCP and HTTP TLVs, and then classify them according to the new profiles. The already classified devices remain as classified until they are reconnected.

Dynamic XML File

The device classifier dynamic XML support enhancement addresses this problem for device classifier dynamic XML file.

With the introduction of dynamic XML support, you are provided with a new dynamic device classifier XML file support.



Note The filename will be **dc_user_profiles.xml** and you can update the dynamic XML file with the new rules, checks, and profiles based on the devices connected and according to the provided schema.You can then copy this XML file to the device file system to enable better device classification without the need to upgrade the device to a new release.

The static XML file support is still available. If a device is connected, its TLVs are checked with the dynamic XML user profiles first and if it matches it is classified as per that profile. If you search for non-static XML profiles and if it matches it is classified as per that profile.

Note The sample dynamic XML file is available in the device at ***flash:dc_profile_dir/.***. You can consider the following sample dynamic XML file schema and copy this to your system using **copy {flash:} {ftp: | tftp:}** command, and append or replace the content with your own profiles, rules, and checks:

```
<?xml version="1.0" encoding="UTF-8"?>
<DeviceList>
             <CopyRight>Copyright (c) 2021-2022 by Cisco Systems, Inc. All rights
reserved.</CopyRight>
             <Version>1.0</Version>
             <Device>
                   <DeviceType>Sample_Profile_1</DeviceType>
                   <RuleName>Sample_Rule_1</RuleName>
                   <RuleOperator>OR</RuleOperator>
                   <RuleCertaintyMetric>20</RuleCertaintyMetric>
                   <Check>
                              <Protocol>DHCP</Protocol>
                              <TLV-Type>12</TLV-Type>
                              <TLV-Value-Type>String</TLV-Value-Type>
                              <TLV-Value>test</TLV-Value>
                   </Check>
                   <Check>
                              <Protocol>HTTP</Protocol>
                              <TLV-Type>3</TLV-Type>
                              <TLV-Value-Type>Integer</TLV-Value-Type>
                              <TLV-Value>23</TLV-Value>
                    </Check>
             </Device>
             <Device>
                  <DeviceType>Sample_Profile_2</DeviceType>
                  <RuleName>Sample_Rule_2</RuleName>
                  <RuleOperator>AND</RuleOperator>
                  <RuleCertaintyMetric>30</RuleCertaintyMetric>
                  <Check>
                         <Protocol>DHCP</Protocol>
                        <TLV-Type>12</TLV-Type>
                        <TLV-Value-Type></TLV-Value-Type>
                        <TLV-Value>test</TLV-Value>
                  </Check>
                  <Check>
                         <Protocol>MAC</Protocol>
                         <TLV-Value-Type>String</TLV-Value-Type>
                         <TLV-Value>Cisco</TLV-Value>
                   </Check>
</Device>
</DeviceList>
```

Each time you copy a new dynamic XML file, the older user profiles are erased completely and newer profiles are populated. After copying the dynamic XML files, only the newly connected clients are classified based on the new dynamic file whereas the already classified devices still remain as classified with older profiles until they are reconnected.

MAC OUI-Based Profiles

The Organizational Unique Identifier (OUI) of a MAC address is part of the MAC address that identifies the vendor of the network adapter. The OUI is the first three bytes of the six-byte field and administered by the IEEE.

To define MAC-based profiles in the dynamic XML file, see https://standards-oui.ieee.org/.

For example, if the Client MAC address is **7035.094d.000**, then OUI is **0x703509**. You can find the corresponding entry in the https://standards-oui.ieee.org/ as follows:

```
70-35-09   (hex)  Cisco Systems, Inc
703509     (base 16)    Cisco Systems, Inc
      80 West Tasman Drive
      San Jose  CA  94568
      US
```

Enabling Device Classifier (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**device classifier** **Example:** `Device(config)# device classifier`	Enables the classification of attached devices.
Step 3	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.

Updating Dynamic XML File

To classify a device, add the following lines in the dynamic XML file:

```
<DeviceList>
           <CopyRight>Copyright (c) 2021-2022 by Cisco Systems, Inc. All rights
reserved.</CopyRight>
           <Version>1.1</Version>
           <Device>
                  <DeviceType>Device-test”</DeviceType>
                <RuleName>Rule-Test</RuleName>
               <RuleOperator>AND</RuleOperator>
               <RuleCertaintyMetric>20</RuleCertaintyMetric>
               <Check>
                       <Protocol>DHCP</Protocol>
                       <TLV-Type>12</TLV-Type>
                      <TLV-Value-Type>String</TLV-Value-Type>
                      <TLV-Value>test</TLV-Value>
                </Check>
          </Device>

.............................
</DeviceList>
```

Verifying TLV Values

To verify the TLV values, use the following command:

```
Device# show  wireless  client  mac-address 7035.094d.0001 detail
Client MAC Address : 7035.094d.0001

.....

Nearby AP Statistics:

EoGRE : Pending Classification

Device Classification Information:

  Device Type         : Un-Classified Device

  Device Name      : Unknown Device

  Protocol Map     : 0x000009  (OUI, DHCP)

  Device Protocol  : DHCP                      -→ <Protocol>DHCP</Protocol>

    Type             : 12   14                          --> <TLV-Type>12</TLV-Type>

    Data             : 0e

    00000000  00 0c 00 0a 74 65 73 74  2d 30 30 30 30 31         |....test-00001  |
    ---><TLV-Value>test</TLV-Value>

    Type             : 60   8

    Data             : 08

    00000000  00 3c 00 04 74 65 73 74                           |.<..test        |

    Type             : 55   11

    Data             : 0b

    00000000  00 37 00 07 01 1c 02 03  0f 06 0c                 |.7.........     |

Max Client Protocol Capability: Wi-Fi6 (802.11ax)
```

Clearing Old Classification Cache

If an already classified client uses any of the three type-length-values (TLVs) [OUI, DHCP, or HTTP] and if the combination value is lower, the existing value is ignored. To avoid such a scenario, use the following command:

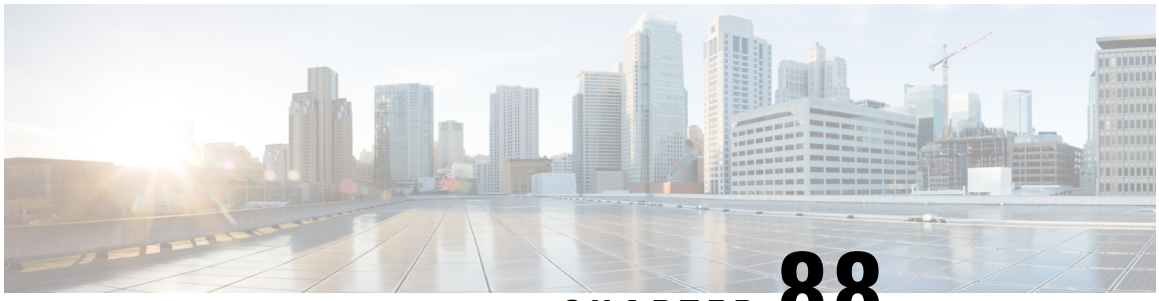
```
Device# clear wireless client device cache
```



Note The priority of the TLVs is as follows:

- OUI
- DHCP
- HTTP

After executing the clear command, you must rejoin the client to get it classified as per the latest XML file.



CHAPTER 88

Peer-to-Peer Client Support

- Information About Peer-to-Peer Client Support, on page 897
- Configure Peer-to-Peer Client Support, on page 897

Information About Peer-to-Peer Client Support

Peer-to-peer client support can be applied to individual WLANs, with each client inheriting the peer-to-peer blocking setting of the WLAN to which it is associated. The peer-to-Peer Client Support feature provides a granular control over how traffic is directed. For example, you can choose to have traffic bridged locally within a device, dropped by a device, or forwarded to the upstream VLAN.

Peer-to-peer blocking is supported for clients that are associated with local and central switching WLANs.

Restrictions

- Peer-to-peer blocking does not apply to multicast traffic.
- Peer-to-peer blocking is not enabled by default.
- In FlexConnect, peer-to-peer blocking configuration cannot be applied only to a particular FlexConnect AP or a subset of APs. It is applied to all the FlexConnect APs that broadcast the SSID.
- FlexConnect central switching clients supports peer-to-peer upstream-forward. However, this is not supported in the FlexConnect local switching. This is treated as peer-to-peer drop and client packets are dropped.

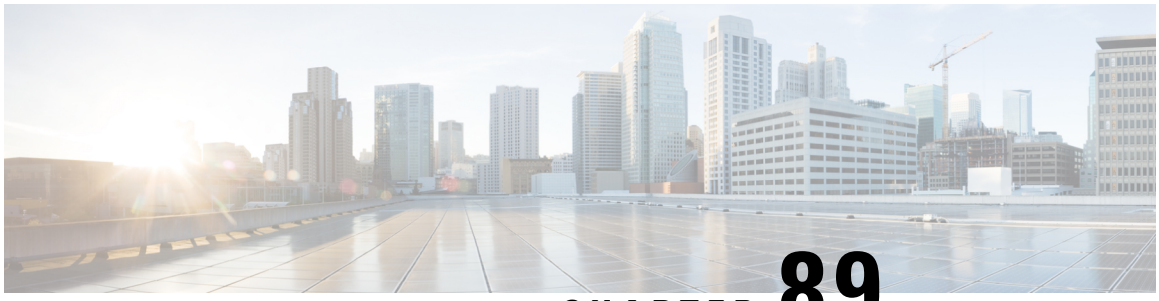
  FlexConnect central switching clients supports peer-to-peer blocking for clients associated with different APs. However, for FlexConnect local switching, this solution targets only clients connected to the same AP. FlexConnect ACLs can be used as a workaround for this limitation.

Configure Peer-to-Peer Client Support

Follow the procedure given below to configure Peer-to-Peer Client Support:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name* **Example:** `Device(config)# wlan wlan1`	Enters WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.
Step 3	**peer-blocking** [**drop** | **forward-upstream**] **Example:** `Device(config-wlan)# peer-blocking drop`	Configures peer to peer blocking parameters. The keywords are as follows: • **drop**—Enables peer-to-peer blocking on the drop action. • **forward-upstream**—No action is taken and forwards packets to the upstream.
Step 4	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode.
Step 5	**show wlan id** *wlan-id* **Example:** `Device# show wlan id 12`	Displays the details of the selected WLAN.



CHAPTER 89

802.11r BSS Fast Transition

- Information About 802.11r Fast Transition, on page 899
- Restrictions for 802.11r Fast Transition, on page 900
- Monitoring 802.11r Fast Transition (CLI), on page 901
- Configuring 802.11r BSS Fast Transition on a Dot1x Security Enabled WLAN (CLI), on page 902
- Configuring 802.11r Fast Transition in an Open WLAN (CLI), on page 903
- Configuring 802.11r Fast Transition on a PSK Security–Enabled WLAN (CLI), on page 904
- Disabling 802.11r Fast Transition (GUI), on page 905
- Disable 802.11r Fast Transition (CLI), on page 906

Information About 802.11r Fast Transition

802.11r, which is the IEEE standard for fast roaming, introduces a new concept of roaming where the initial handshake with a new AP is done even before the corresponding client roams to the target access point. This concept is called Fast Transition. The initial handshake allows a client and the access points to do the Pairwise Transient Key (PTK) calculation in advance. These PTK keys are applied to the client and the access points after the client responds to the reassociation request or responds to the exchange with new target AP.

The FT key hierarchy is designed to allow clients to make fast BSS transitions between APs without requiring reauthentication at every AP. WLAN configuration contains a new Authenticated Key Management (AKM) type called FT (Fast Transition).

Client Roaming

For a client to move from its current AP to a target AP using the FT protocols, message exchanges are performed using one of the following methods:

- Over-the-Air—The client communicates directly with the target AP using IEEE 802.11 authentication with the FT authentication algorithm.
- Over-the-Distribution System (DS)—The client communicates with the target AP through the current AP. The communication between the client and the target AP is carried in FT action frames between the client and the current AP and is then sent through the device.

Figure 13: Message Exchanges when Over–the–Air Client Roaming is Configured

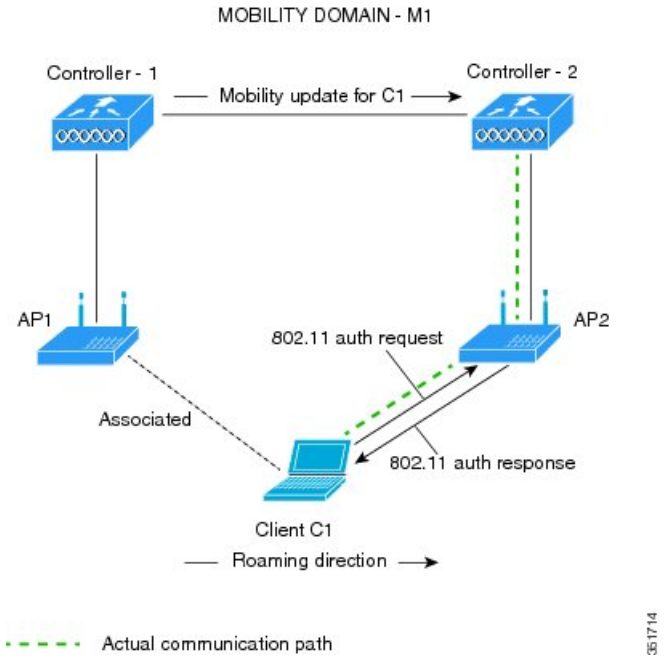
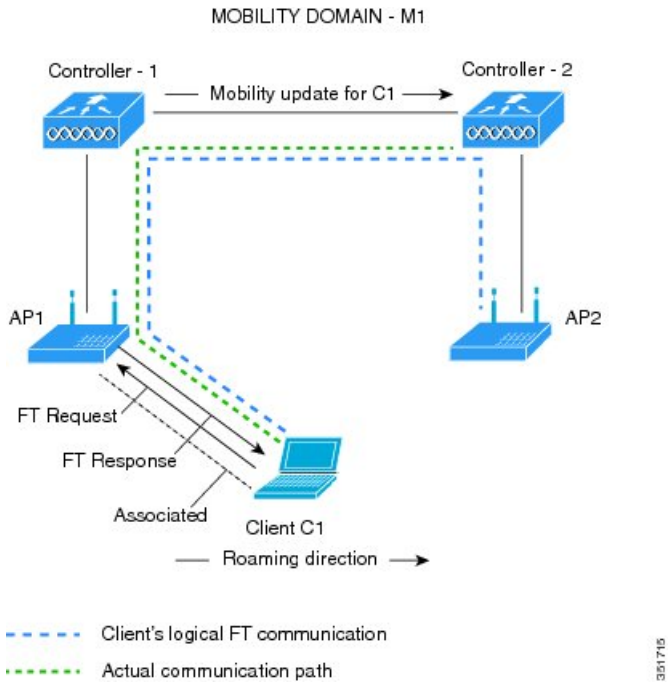


Figure 14: Message Exchanges when Over–the–DS Client Roaming is Configured



Restrictions for 802.11r Fast Transition

- EAP LEAP method is not supported.

- Traffic Specification (TSPEC) is not supported for 802.11r fast roaming. Therefore, RIC IE handling is not supported.
- If WAN link latency exists, fast roaming is also delayed. Voice or data maximum latency should be verified. The Cisco WLC handles 802.11r Fast Transition authentication requests during roaming for both Over-the-Air and Over-the-DS methods.
- Legacy clients cannot associate with a WLAN that has 802.11r enabled if the driver of the supplicant that is responsible for parsing the Robust Security Network Information Exchange (RSN IE) is old and not aware of the additional AKM suites in the IE. Due to this limitation, clients cannot send association requests to WLANs. These clients, however, can still associate with non-802.11r WLANs. Clients that are 802.11r-capable can associate as 802.11i clients on WLANs that have both 802.11i and 802.11r Authentication Key Management Suites enabled.

  The workaround is to enable or upgrade the driver of the legacy clients to work with the new 802.11r AKMs, after which the legacy clients can successfully associate with 802.11r-enabled WLANs.

  Another workaround is to have two SSIDs with the same name, but with different security settings (FT and non-FT).
- Fast Transition resource–request protocol is not supported because clients do not support this protocol. Also, the resource–request protocol is an optional protocol.
- To avoid any Denial of Service (DoS) attack, each Cisco WLC allows a maximum of three Fast Transition handshakes with different APs.
- Non-802.11r–capable devices will not be able to associate with FT-enabled WLAN.
- We recommend 802.11r FT Over-the-Air roaming for FlexConnect deployments.

Monitoring 802.11r Fast Transition (CLI)

The following command can be used to monitor 802.11r Fast Transition:

Command	Description
show wlan name *wlan-name*	Displays a summary of the configured parameters on the WLAN.

Command	Description
show wireless client mac-address *mac-address*	Displays the summary of the 802.11r authentication key management configuration on a client. . . . . . . Client Capabilities CF Pollable : Not implemented CF Poll Request : Not implemented Short Preamble : Not implemented PBCC : Not implemented Channel Agility : Not implemented Listen Interval : 15 Fast BSS Transition : Implemented Fast BSS Transition Details : Client Statistics: Number of Bytes Received : 9019 Number of Bytes Sent : 3765 Number of Packets Received : 130 Number of Packets Sent : 36 Number of EAP Id Request Msg Timeouts : 0 Number of EAP Request Msg Timeouts : 0 Number of EAP Key Msg Timeouts : 0 Number of Data Retries : 1 Number of RTS Retries : 0 Number of Duplicate Received Packets : 1 Number of Decrypt Failed Packets : 0 Number of Mic Failured Packets : 0 Number of Mic Missing Packets : 0 Number of Policy Errors : 0 Radio Signal Strength Indicator : -48 dBm Signal to Noise Ratio : 40 dB . . . . . .

Configuring 802.11r BSS Fast Transition on a Dot1x Security Enabled WLAN (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name* **Example:** `Device# wlan test4`	Enters WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.

	Command or Action	Purpose
Step 3	**client vlan** *vlan-name* **Example:** `Device(config-wlan)# client vlan 0120`	Associates the client VLAN to this WLAN.
Step 4	**security dot1x authentication-list default** **Example:** `Device(config-wlan)# security dot1x authentication-list default`	Enables security authentication list for dot1x security. The configuration is similar for all dot1x security WLANs.
Step 5	**security ft** **Example:** `Device(config-wlan)# security ft`	Enables 802.11r Fast Transition on the WLAN.
Step 6	**security wpa akm ft dot1x** **Example:** `Device(config-wlan)# security wpa akm ft dot1x`	Enables 802.1x security on the WLAN.
Step 7	**no shutdown** **Example:** `Device(config-wlan)# no shutdown`	Enables the WLAN.
Step 8	**end** **Example:** `Device(config-wlan)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-z** to exit global configuration mode

Configuring 802.11r Fast Transition in an Open WLAN (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name* **Example:** `Device# wlan test4`	Enters WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.
Step 3	**client vlan** *vlan-id* **Example:** `Device(config-wlan)# client vlan 0120`	Associates the client VLAN to the WLAN.

	Command or Action	Purpose
Step 4	**no security wpa** **Example:** `Device(config-wlan)# no security wpa`	Disables WPA security.
Step 5	**no security wpa akm dot1x** **Example:** `Device(config-wlan)# no security wpa akm dot1x`	Disables security AKM for dot1x.
Step 6	**no security wpa wpa2** **Example:** `Device(config-wlan)# no security wpa wpa2`	Disables WPA2 security.
Step 7	**no wpa wpa2 ciphers aes** **Example:** `Device(config-wlan)# no security wpa wpa2 ciphers aes`	Disables WPA2 ciphers for AES.
Step 8	**security ft** **Example:** `Device(config-wlan)# security ft`	Specifies the 802.11r Fast Transition parameters.
Step 9	**no shutdown** **Example:** `Device(config-wlan)# shutdown`	Shuts down the WLAN.
Step 10	**end** **Example:** `Device(config-wlan)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-z** to exit global configuration mode

Configuring 802.11r Fast Transition on a PSK Security–Enabled WLAN (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**wlan** *profile-name* **Example:** `Device# wlan test4`	Enters WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.
Step 3	**client vlan** *vlan-name* **Example:** `Device(config-wlan)# client vlan 0120`	Associates the client VLAN to this WLAN.
Step 4	**no security wpa akm dot1x** **Example:** `Device(config-wlan)# no security wpa akm dot1x`	Disables security AKM for dot1x.
Step 5	**security wpa akm ft psk** **Example:** `Device(config-wlan)# security wpa akm ft psk`	Configures Fast Transition PSK support.
Step 6	**security wpa akm psk set-key** {**ascii** {**0** | **8**} | **hex** {**0** | **8**}} **Example:** `Device(config-wlan)# security wpa akm psk set-key ascii 0 test`	Configures PSK AKM shared key.
Step 7	**security ft** **Example:** `Device(config-wlan)# security ft`	Configures 802.11r Fast Transition.
Step 8	**no shutdown** **Example:** `Device(config-wlan)# no shutdown`	Enables the WLAN.
Step 9	**end** **Example:** `Device(config-wlan)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-z** to exit global configuration mode

Disabling 802.11r Fast Transition (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 On the **WLANs** page, click the WLAN name.

Step 3 In the **Edit WLAN** window, click the **Security** > **Layer2** tab.

Step 4 From the **Fast Transition** drop-down list, choose **Disabled**. Note that you cannot enable or disable Fast Transition, if you have configured an SSID with Open Authentication.

Step 5 Click **Update & Apply to Device**.

Disable 802.11r Fast Transition (CLI)

Prevent fast transitions in 802.11r-enabled WLANs using commands.

Procedure

Step 1 Enter the global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Enter the WLAN configuration submode.

Example:

```
Device(config)# profile-name wlan test4
```

Step 3 Disable the FT AKMs that are enabled before disabling FT.

Example:

```
Device(config-wlan)# no security wpa akm ft dot1x
```

The available FT AKMs are: SAE-FT, SAE-EXT-FT and 802.1x-FT.

Step 4 Disable 802.11r Fast Transition on the WLAN.

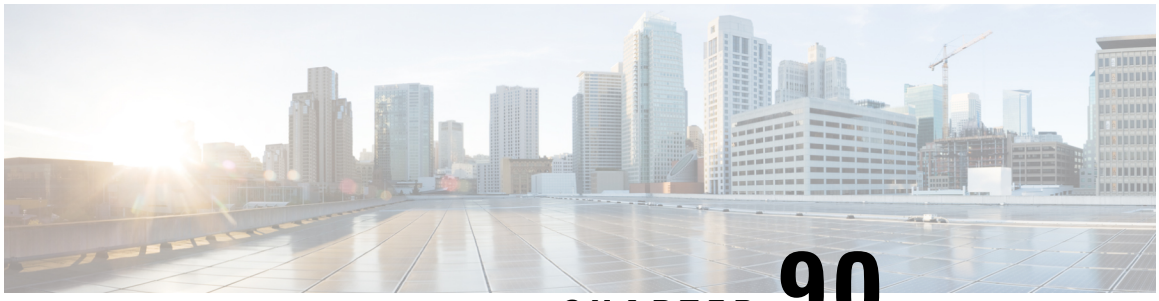
Example:

```
Device(config-wlan)# no security ft { adaptive | over-the-ds | reassociation-timeout
timeout-in-seconds }
```

Step 5 Return to privileged EXEC mode.

Example:

```
Device(config)# end
```



CHAPTER 90

Assisted Roaming

- 802.11k Neighbor List and Assisted Roaming, on page 907
- Restrictions for Assisted Roaming, on page 908
- How to Configure Assisted Roaming, on page 908
- Verifying Assisted Roaming, on page 909
- Configuration Examples for Assisted Roaming, on page 909

802.11k Neighbor List and Assisted Roaming

The 802.11k standard allows an AP to inform 802.11k-capable clients of neighboring BSSIDs (APs in the same SSID). This can help the client to optimize its scanning and roaming behavior. Additionally, the Assisted Roaming Prediction Optimization feature can be used with non-802.11k clients, to discourage them from roaming to suboptimal APs.

Note We recommend not configuring two SSIDs with the same name in the controller, which may cause roaming issues.

Prediction Based Roaming - Assisted Roaming for Non-802.11k Clients

You can optimize roaming for non-802.11k clients by generating a prediction neighbor list for each client without sending an 802.11k neighbor list request. When prediction based roaming enables a WLAN, after each successful client association/re-association, the same neighbor list optimization applies on the non-802.11k client to generate and store the neighbor list in the mobile station software data structure. Clients at different locations have different lists because the client probes are seen with different RSSI values by the different neighbors as the clients usually probe before any association or re-association. This list is created with the most updated probe data and predicts the next AP that the client is likely to roam to.

The wireless infrastructure discourages clients from roaming to those less desirable neighbors by denying association if the association request to an AP does not match the entries on the stored prediction neighbor list.

- Denial count: Maximum number of times a client is refused association.
- Prediction threshold: Minimum number of entries required in the prediction list for the assisted roaming feature to activate.

For more information, see https://www.cisco.com/c/en/us/td/docs/wireless/controller/8-5/Enterprise-Mobility-8-5-Design-Guide/Enterprise_Mobility_8-5_Deployment_Guide/Chapter-11.html#pgfId-1140097.

Restrictions for Assisted Roaming

- This feature is supported only on 802.11n capable indoor access points. For a single band configuration, a maximum of 6 neighbors are visible in a neighbor list. For dual band configuration, a maximum of 12 neighbors are visible.
- You can configure assisted roaming only using the device CLI.

How to Configure Assisted Roaming

Configuring Assisted Roaming (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless assisted-roaming floor-bias** *dBm* **Example:** `Device(config)# wireless assisted-roaming floor-bias 20`	Configures neighbor floor label bias. The valid range is from 5 to 25 dBm, and the default value is 15 dBm.
Step 3	**wlan** *wlan-id* **Example:** `Device(config)# wlan wlan1`	Enters the WLAN configuration submode. The *wlan-name* is the profile name of the configured WLAN.
Step 4	**assisted-roaming neighbor-list** **Example:** `Device(wlan)# assisted-roaming neighbor-list`	Configures an 802.11k neighbor list for a WLAN. By default, assisted roaming is enabled on the neighbor list when you create a WLAN. The **no** form of the command disables assisted roaming neighbor list.
Step 5	**assisted-roaming dual-list** **Example:** `Device(wlan)# assisted-roaming dual-list`	Configures a dual-band 802.11k dual list for a WLAN. By default, assisted roaming is enabled on the dual list when you create a WLAN. The **no** form of the command disables assisted roaming dual list.

	Command or Action	Purpose
Step 6	**assisted-roaming prediction** **Example:** `Device(wlan)# assisted-roaming prediction`	Configures assisted roaming prediction list feature for a WLAN. By default, the assisted roaming prediction list is disabled. **Note** A warning message is displayed and load balancing is disabled for the WLAN if load balancing is already enabled for the WLAN.
Step 7	**wireless assisted-roaming prediction-minimum** *count* **Example:** `Device# wireless assisted-roaming prediction-minimum`	Configures the minimum number of predicted APs required for the prediction list feature to be activated. The default value is 3. **Note** If the number of the AP in the prediction assigned to the client is less than the number that you specify, the assisted roaming feature will not apply on this roam.
Step 8	**wireless assisted-roaming denial-maximum** *count* **Example:** `Device# wireless assisted-roaming denial-maximum 8`	Configures the maximum number of times a client can be denied association if the association request is sent to an AP does not match any AP on the prediction. The valid range is from 1 to 10, and the default value is 5.
Step 9	**end** **Example:** `Device(config)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Verifying Assisted Roaming

The following command can be used to verify assisted roaming configured on a WLAN:

Command	Description
show wlan id *wlan-id*	Displays the WLAN parameters on the WLAN.

Configuration Examples for Assisted Roaming

This example shows how to configure the neighbor floor label bias:

```
Device# configure terminal
Device(config)# wireless assisted-roaming floor-bias 10
Device(config)# end
Device# show wlan id 23
```

This example shows how to disable neighbor list on a specific WLAN:

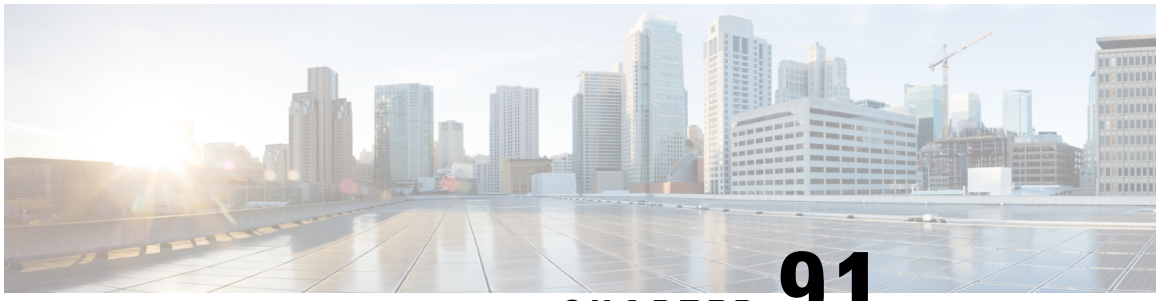
```
Device# configure terminal
Device(config)# wlan test1
Device(config (wlan)# no assisted-roaming neighbor-list
Device(config)(wlan)# end
Device# show wlan id 23
```

This example shows how to configure the prediction list on a specific WLAN:

```
Device# configure terminal
Device(config)# wlan test1
Device(config)(wlan)# assisted-roaming prediction
Device(config)(wlan)# end
Device# show wlan id 23
```

This example shows how to configure the prediction list based on assisted roaming prediction threshold and maximum denial count on a specific WLAN:

```
Device# configure terminal
Device(config)# wireless assisted-roaming prediction-minimum 4
Device(config)# wireless assisted-roaming denial-maximum 4
Device(config)(wlan)# end
Device# show wlan id 23
```



CHAPTER 91

802.11v

- Information About 802.11v, on page 911
- Prerequisites for Configuring 802.11v, on page 912
- Restrictions for 802.11v, on page 912
- Enabling 802.11v BSS Transition Management, on page 912
- Configuring 802.11v BSS Transition Management (GUI), on page 913
- Configuring 802.11v BSS Transition Management (CLI), on page 913

Information About 802.11v

The embedded wireless controller supports 802.11v amendment for wireless networks, which describes numerous enhancements to wireless network management.

One such enhancement is Network assisted Power Savings which helps clients to improve the battery life by enabling them to sleep longer. As an example, mobile devices typically use a certain amount of idle period to ensure that they remain connected to access points and therefore consume more power when performing the following tasks while in a wireless network.

Another enhancement is Network assisted Roaming which enables the WLAN to send requests to associated clients, advising the clients as to better APs to associate to. This is useful for both load balancing and in directing poorly connected clients.

Enabling 802.11v Network Assisted Power Savings

Wireless devices consume battery to maintain their connection to the clients, in several ways:

- By waking up at regular intervals to listen to the access point beacons containing a DTIM, which indicates buffered broadcast or multicast traffic that the access point delivers to the clients.
- By sending null frames to the access points, in the form of keepalive messages– to maintain connection with access points.
- Devices also periodically listen to beacons (even in the absence of DTIM fields) to synchronize their clock to that of the corresponding access point.

All these processes consume battery and this consumption particularly impacts devices (such as Apple), because these devices use a conservative session timeout estimation, and therefore, wake up often to send keepalive messages. The 802.11 standard, without 802.11v, does not include any mechanism for the controller or the access points to communicate to wireless clients about the session timeout for the local client.

To save the power of clients due to the mentioned tasks in wireless network, the following features in the 802.11v standard are used:

- Directed Multicast Service
- Base Station Subsystem (BSS) Max Idle Period

Directed Multicast Service

Using Directed Multicast Service (DMS), the client requests the access point to transmit the required multicast packet as unicast frames. This allows the client to receive the multicast packets it has ignored while in sleep mode and also ensures Layer 2 reliability. Furthermore, the unicast frame is transmitted to the client at a potentially higher wireless link rate which enables the client to receive the packet quickly by enabling the radio for a shorter duration, thus also saving battery power. Since the wireless client also does not have to wake up at each DTIM interval in order to receive multicast traffic, longer sleeping intervals are allowed.

BSS Max Idle Period

The BSS Max Idle period is the timeframe during which an access point (AP) does not disassociate a client due to nonreceipt of frames from the connected client. This helps ensure that the client device does not send keepalive messages frequently. The idle period timer value is transmitted using the association and reassociation response frame from the access point to the client. The idle time value indicates the maximum time that a client can remain idle without transmitting any frame to an access point. As a result, the clients remain in sleep mode for a longer duration without transmitting the keepalive messages often. This in turn contributes to saving battery power.

Prerequisites for Configuring 802.11v

- Applies for Apple clients like Apple iPad, iPhone, and so on, that run on Apple iOS version 7 or later.
- Supports local mode; also supports FlexConnect access points in central authentication modes only.

Restrictions for 802.11v

Client needs to support 802.11v BSS Transition.

Enabling 802.11v BSS Transition Management

802.11v BSS Transition is applied in the following three scenarios:

- Solicited request—Client can send an 802.11v Basic Service Set (BSS) Transition Management Query before roaming for a better option of AP to reassociate with.
- Unsolicited Load Balancing request—If an AP is heavily loaded, it sends out an 802.11v BSS Transition Management Request to an associated client.
- Unsolicited Optimized Roaming request—If a client's RSSI and rate do not meet the requirements, the corresponding AP sends out an 802.11v BSS Transition Management Request to this client.

Note 802.11v BSS Transition Management Request is a suggestion (or advice) given to a client, which the client can choose to follow or ignore. To force the task of disassociating a client, turn on the disassociation-imminent function. This disassociates the client after a period if the client is not reassociated to another AP.

Configuring 802.11v BSS Transition Management (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Click **Add** to create WLANs.

The **Add WLAN** page is displayed.

Step 3 In the **Advanced** tab and **11v BSS Transition Support** section, select the **BSS Transition** check box to enable BSS transition per WLAN.

Step 4 Enable the **Dual Neighbor List** check box to include the neighbors of other radio slots of the same AP in the BSS transition response.

Note
This is applicable only for 2.4 GHz and 5 GHz radio slots.

Step 5 Enable the **BSS Max Idle Service** check box to help clients and APs efficiently decide how long to remain associated when no traffic is being transmitted. The device uses this information to preserve device battery life.

Step 6 Enable the **BSS Max Idle Protected** check box to enable the AP to accept only authenticated frames (encrypted with Robust Security Network (RSN) information) from the client to reset the BSS Max Idle period counter. Without protected mode, any data or management frame (encrypted or unencrypted) sent by the client will reset the idle timer for the client.

Step 7 Enable the **Directed Multicast Service** check box to request the AP to send a multicast stream as unicast, to any DMS capable client on this WLAN.

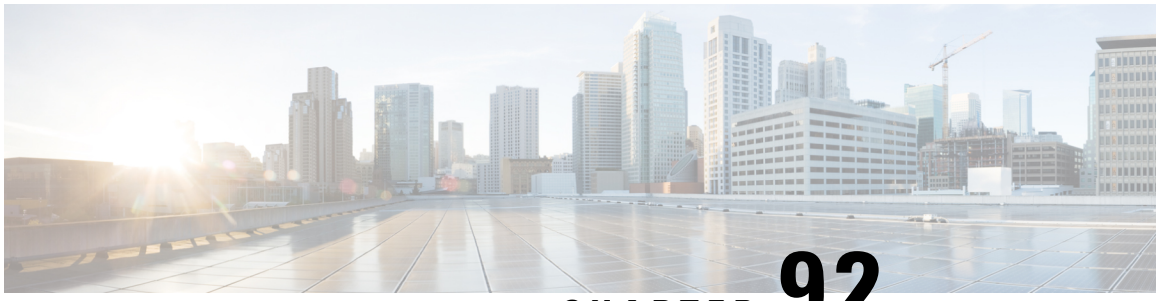
Step 8 Click **Save & Apply to Device**.

Configuring 802.11v BSS Transition Management (CLI)

802.11v BSS Transtion is applied in the following three scenarios:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters the global configuration mode.
Step 2	**wlan** *profile-name* **Example:** `Device(config)# wlan test-wlan`	Configures WLAN profile and enters the WLAN profile configuration mode.
Step 3	**shut** **Example:** `Device(config-wlan)# shut`	Shutdown the WLAN profile.
Step 4	**bss-transition** **Example:** `Device(config-wlan)# bss-transition`	Configure BSS transition per WLAN.
Step 5	**bss-transition disassociation-imminent** **Example:** `Device(config-wlan)# bss-transition disassociation-imminent`	Configure BSS transition disassociation Imminent per WLAN.
Step 6	**no shutdown** **Example:** `Device(config-wlan)# no shutdown`	Enables the WLAN profile.
Step 7	**end** **Example:** `Device(config-wlan)# end`	Return to privilege EXEC mode. Alternatively, you can press **CTRL + Z** to exit global configuration mode.



CHAPTER 92

802.11w

- Protected management frames with 802.11w, on page 915

Protected management frames with 802.11w

A protected management frame is a wireless security feature that

- uses the 802.11w protocol to safeguard management frames
- prevents spoofing and forgery of authentication, de-authentication, association, and disassociation frames, and
- enhances the overall security of Wi-Fi networks by protecting key network management actions from attack.

While data frames can be encrypted, management frames were traditionally sent in the clear, making them vulnerable to interception and forgery. The 802.11w standard addresses this vulnerability by requiring cryptographic protection for certain management frames between client and access point.

An attacker attempting to disconnect a legitimate client by sending forged disassociation frames will fail on networks supporting protected management frames, as only cryptographically validated frames are accepted.

Types of management frames protected by 802.11w

The 802.11w protocol protects certain management frames by using the Protected Management Frames (PMF) service. These frames are classified as robust management frames and include:

- Disassociation frames
- De-authentication frames
- Robust Action frames

Robust Action frames protected by 802.11w include:

- Spectrum Management
- Quality of Service (QoS)
- Direct Link Setup (DLS)

- Block acknowledgement
- Radio Measurement
- Fast Basic Service Set (BSS) Transition
- Security Association (SA) Query
- Protected Dual of Public Action
- Vendor-specific Protected

Frames not included in this list are not protected by 802.11w.

Protections offered by 802.11w

When 802.11w is implemented, these protections are provided:

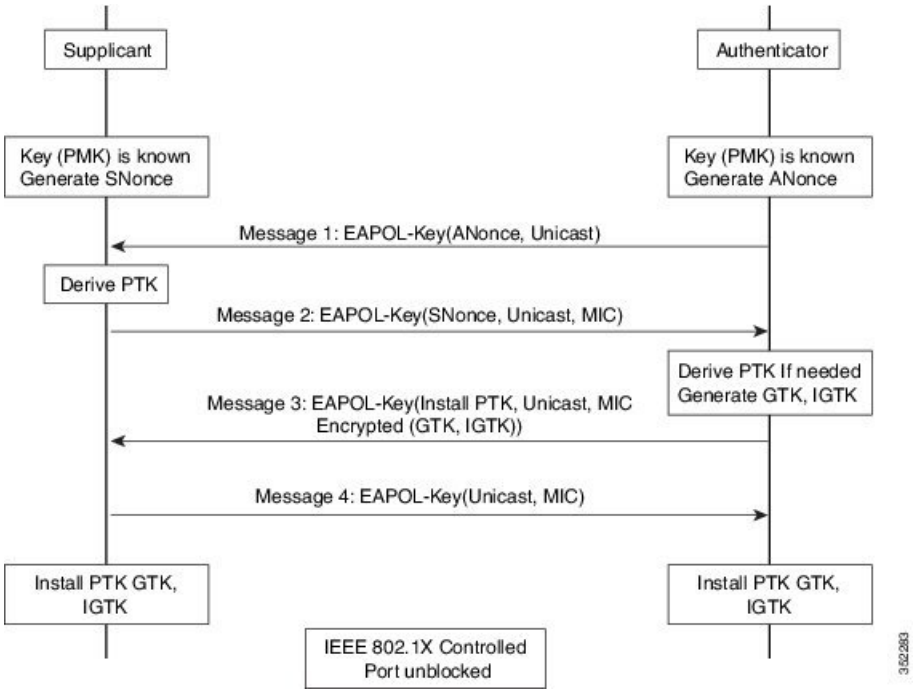
- **Client protection:** The AP adds cryptographic protection to de-authentication and dissociation frames, preventing spoofing in DOS attacks.
- **Infrastructure protection**: Security Association (SA) teardown protection is implemented using Association Comeback Time and SA-Query procedures to prevent spoofed association requests from disconnecting connected clients.

Integrity Group Temporal Key (IGTK)

An integrity group temporal key (IGTK) is a wireless security mechanism that

- protects broadcast and multicast robust management frames.
- uses random values assigned by the authenticator station (such as a wireless LAN controller), and
- secures MAC management protocol data units (MMPDUs) in 802.11w networks.

Figure 15: IGTK exchange in four-way handshake



802.11w introduced IGTKs to enhance the security of management frames in wireless networks.

How IGTK is used in 802.11w management frame protection

When you enable management frame protection, the AP encrypts the group temporal key (GTK) and IGTK values in an Extensible Authentication Protocol over LAN-Key (EAPoL-Key) frame. The AP includes this frame in the third message of the four-way handshake.

- IGTK is exchanged during the four-way handshake process.
- If the AP changes the GTK later, it sends the new GTK and the new IGTK to your client device using the Group Key Handshake

Imagine a wireless network as a secured meeting room, with announcements broadcast to everyone inside. The IGTK acts like a special group password that lets only authorized members hear these important messages. The authenticator (such as a wireless LAN controller) is like the meeting organizer, who gives each member a random, unique password at the door. When the password changes for added security, the organizer discreetly shares the new password with all members so that only legitimate participants can continue to hear future group announcements.

Broadcast or multicast integrity protocol (BIP)

A broadcast or multicast integrity protocol (BIP) is a wireless security mechanism that

- ensures data integrity of broadcast and multicast robust management frames
- provides replay protection for these frames after you establish an Integrity Group Temporal Key Security Association (IGTKSA), and

- adds a message integrity code (MIC) calculated using the shared IGTK key.

SA teardown protection

SA teardown protection is a wireless network security mechanism that

- prevents spoofed or replay attacks from disconnecting already associated clients
- uses Association Comeback Time and an SA-Query procedure to verify the authenticity of association requests, and
- ensures the AP only accepts new associations after the original security association is proven invalid.

How association comeback time and SA query procedures work

This process describes how Association Comeback Time and SA Query procedures protect wireless client sessions from replay-based association teardown attacks."

Summary

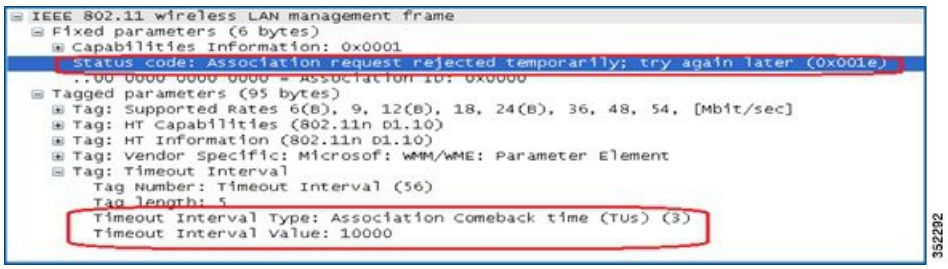
The key components involved in the process are:

- AP: implements security association (SA) teardown protection and manages association requests."
- Client device: Maintains a security association and sends and receives association and SA Query frames.
- SA Teardown Protection Mechanism: Provides the logic for handling replay and spoofed association attempts.

In this process, the AP and client device exchange association and SA Query frames. This exchange validates security associations and prevents unauthorized session teardown.

Workflow

Figure 16: Association Reject with Comeback Time



These stages describe how the Association Comeback Time and SA Query procedures operate to protect client sessions:

1. When an AP receives an Association Request from a client with an existing valid security association (SA) negotiated with 802.11w, the AP rejects the request with status code 30 ("Association request rejected temporarily; try again later") and sends an Association Comeback Time.
2. The AP does not modify the existing association during the comeback interval.

3. If no ongoing SA Query session with the client exists, the AP sends SA Query requests repeatedly until it receives a valid SA Query response or the comeback time expires.
4. Receiving a matching SA Query response or a valid protected frame indicates a valid SA. The AP may then allow a new association attempt without more SA Query cycles.

Result

This process ensures that spoofed requests cannot disconnect valid clients, protecting against replay-based association teardown attacks.

Prerequisites for 802.11w

- To configure 802.11w feature for optional and mandatory, you must have WPA and AKM configured.



Note The RNS (Robust Secure Network) IE must be enabled with an AES Cipher.

Restrictions for 802.11w

- You cannot use 802.11w with open WLANs, Wired Equivalent Privacy (WEP)-encrypted WLANs, or Temporal Key Integrity Protocol (TKIP)-encrypted WLANs.
- You can use 802.11w with Protected Management Frames (PMF) for non-Apple clients. For Apple iOS version 11 and earlier, request a fix from Apple to resolve association issues
- When clients do not use 802.11w PMF, the controller ignores disassociation frames or deauthentication frames they send. If a client uses PMF, its entry is deleted immediately when the controller receives such a frame. This process helps prevent denial-of-service attacks by malicious devices, since frames without PMF are not secure.

How to Configure 802.11w

Configure 802.11w (GUI)

To protect management traffic against spoofing and replay attacks, configure 802.11w settings after enabling WPA and AKM.

Enable protected management frames (PMF) on a WLAN to strengthen security for management communications.

Before you begin

Ensure WPA and AKM are configured on the target WLAN.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Click **Add** to create WLANs.

The **Add WLAN** page is displayed.

Step 3 In the **Security** > **Layer2** tab, navigate to the **Protected Management Frame** section.

Step 4 Choose **PMF** as *Disabled*, *Optional*, or *Required*. By default, the PMF is *disabled*.

If you choose **PMF** as *Optional* or *Required*, you can view these fields:

- **Association Comeback Timer**—Enter a value between 1 and 10 seconds to configure 802.11w association comeback time.
- **SA Query Time**—Enter a value between 100 to 500 milliseconds. This is required for clients to negotiate 802.11w PMF protection on a WLAN.

Step 5 Click **Save & Apply to Device**.

802.11w PMF is enabled with the parameters you selected. This strengthens the security of management frames on the WLAN.

Configure 802.11w (CLI)

Configuring 802.11w improves security for management frames on wireless LANs.

Enable 802.11w Protected Management Frames (PMF) on a WLAN using CLI commands.

Before you begin

- Configure WPA.
- Configure AKM (Authentication and Key Management) on the WLAN.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a WLAN and enters configuration mode.

Example:

```
Device(config)# wlan profile-name wlan-id ssid
```

Step 3 Configure 802.1x support using the **security wpa akm pmf dot1x** command.

Example:

```
Device(config-wlan)#security wpa akm pmf dot1x
```

Step 4 Configure the 802.11w association comeback time.

Example:

```
Device(config-wlan)# security pmf association-comeback comeback-interval
```

Example:

```
Device(config-wlan)# security pmf association-comeback 10
```

Step 5 Require clients to negotiate 802.11w PMF protection on a WLAN.

Example:

```
Device(config-wlan)# security pmf mandatory
```

Step 6 Configure time interval identified in milliseconds before which the SA query response is expected.

Example:

```
Device(config-wlan)# security pmf saquery-retry-time timeout
```

Example:

```
Device(config-wlan)# security pmf saquery-retry-time 100
```

If the device does not get a response, another SQ query is tried.

802.11w Protected Management Frames are enabled and mandatory on the specified WLAN, providing improved protection of management frames.

Disable 802.11w

Disabling 802.11w may be necessary for compatibility with legacy or non-compliant devices.

Prevent wireless clients from using 802.11w Protected Management Frames on a specified WLAN.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Configure a WLAN and enters configuration mode.

Example:

```
Device(config)# wlan profile-name wlan-id ssid
```

Step 3 Disable 802.1x support using the **no security wpa akm pmf dot1x** command.

Example:

```
Device(config-wlan)# no security wpa akm pmf dot1x
```

Step 4 Configure the 802.11w association comeback time.

Example:

```
Device(config-wlan)# security pmf association-comeback comeback-interval
```

```
Device(config-wlan)# security pmf association-comeback 10
```

Step 5 Disable client negotiation of 802.11w PMF protection on a WLAN.

Example:

```
Device(config-wlan)# no security pmf mandatory
```

Step 6 Disable SQ query retry.

Example:

```
Device(config-wlan)# no security pmf saquery-retry-time 100
```

802.11w PMF protection is disabled for the specified WLAN.

Monitor 802.11w

Use these commands to monitor 802.11w.

Procedure

Step 1 Display the WLAN parameters on the WLAN.

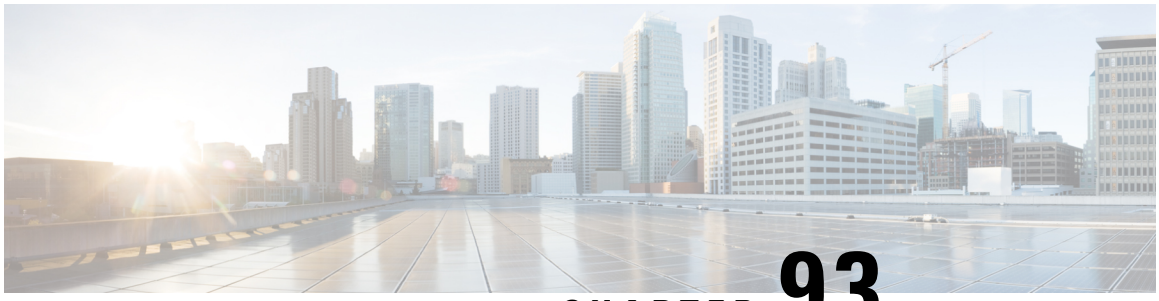
The PMF parameters are displayed.

```
Device# show wlan name wlan-name
                        . . . .
                        . . . .
                        Auth Key Management
                        802.1x                                  : Disabled
                        PSK                                     : Disabled
                        CCKM                                    : Disabled
                        FT dot1x                                : Disabled
                        FT PSK                                  : Disabled
                        FT SAE                                  : Disabled
                        Dot1x-SHA256                            : Enabled
                        PSK-SHA256                              : Disabled
                        SAE                                     : Disabled
                        OWE                                     : Disabled
                        SUITEB-1X                               : Disabled
                        SUITEB192-1X                            : Disabled
                        CCKM TSF Tolerance                              : 1000
                        FT Support                                      : Adaptive
                        FT Reassociation Timeout                : 20
                        FT Over-The-DS mode                     : Enabled
                        PMF Support                                     : Required
                        PMF Association Comeback Timeout        : 1
                        PMF SA Query Time                       : 500
                        . . . .
                        . . . .
```

Step 2 Display the summary of the 802.11w authentication key management configuration on a client.

```
Device# show wireless client mac-address mac-address detail
                        . . . .
                        . . . .
                        Policy Manager State: Run
                        NPU Fast Fast Notified : No
                        Last Policy Manager State : IP Learn Complete
                        Client Entry Create Time : 497 seconds
                        Policy Type : WPA2
                        Encryption Cipher : CCMP (AES)
                        Authentication Key Management : 802.1x-SHA256
                        Encrypted Traffic Analytics : No
                        Management Frame Protection : No
```

```
Protected Management Frame - 802.11w : Yes
EAP Type : LEAP
VLAN : 39
Multicast VLAN : 0
Access VLAN : 39
Anchor VLAN : 0
WFD capable : No
Manged WFD capable : No
. . . .
. . . .
```



CHAPTER 93

802.11ax Per WLAN

- 802.11ax mode per WLAN, on page 925

802.11ax mode per WLAN

An 802.11ax mode per WLAN is a wireless configuration feature that

- enables or disables 802.11ax functionality at the individual WLAN level rather than per radio band
- provides granular control over 11ax settings for specific SSIDs
- allows mixed 11ax and legacy client connectivity on the same access point.

Configuration evolution and behavior

Prior to Cisco IOS XE Bengaluru Release 17.4.1, the 802.11ax mode was configured per radio band. In this configuration, the 11ax mode was either enabled or disabled for all WLANs (AP) that were configured per radio, all at once. When 11ax was enabled per radio, the 11ac clients were not able to scan or connect to the SSID if the beacon had 11ax information elements. Client could not probe an access point (AP), if the beacon has 11ax IE.

Therefore, a 11ax configuration knob per AP is introduced, from Cisco IOS XE Bengaluru Release 17.5.1. This knob is introduced under the WLAN profile. By default, the 11ax knob per WLAN is now enabled on the controller.

Note For 6-GHz radio, the 802.11ax parameters are taken from the multi BSSID profile tagged to the corresponding 6-GHz RF profile of the AP. So, the WLAN dot11ax parameters are overridden by multi BSSID profile parameters in the case of 6-GHz. There are no changes for 2.4 and 5-GHz band WLANs. They continue to use the WLAN parameters for 802.11ax.

Configure 802.11ax mode per WLAN (GUI)

Enable or disable 802.11ax mode on a specific WLAN to control Wi-Fi 6 functionality.

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Click **Add**.

The **Add WLAN** window is displayed.

Step 3 Click the **Advanced** tab.

Step 4 In the **11ax** section, check the **Enable 11ax** check box to enable 802.11ax operation status on the WLAN.

Note
When 11ax is disabled, beacons will not display 11ax IE, and all the 11ax features will be operationally disabled on the WLAN.

Step 5 Click **Apply to Device**.

The 802.11ax mode is now configured or disabled on the specified WLAN according to your requirements.

Configure 802.11ax mode per WLAN (CLI)

Enable or disable 802.11ax mode on a specific WLAN to control Wi-Fi 6 functionality.

802.11ax (Wi-Fi 6) provides improved performance and efficiency. This configuration allows you to enable or disable 802.11ax mode on individual WLANs based on your network requirements.

Procedure

Step 1 Enter global configuration mode.

Example:

```
Device# configure terminal
```

Step 2 Specify the WLAN name and enter the WLAN configuration mode.

Example:

```
Device(config)# wlan wlan-profile-name
```

Step 3 Configure 802.11ax on a WLAN.

Example:

```
Device(config-wlan)# dot11ax
```

Step 4 Disable 802.11ax on the WLAN profile.

Example:

```
Device(config-wlan)# no dot11ax
```

The 802.11ax mode is now configured or disabled on the specified WLAN according to your requirements.

Verify 802.11ax mode per WLAN

This task verifies the operational status of 802.11ax parameters for a specific WLAN configuration to ensure the wireless network is operating with the expected 802.11ax features enabled.

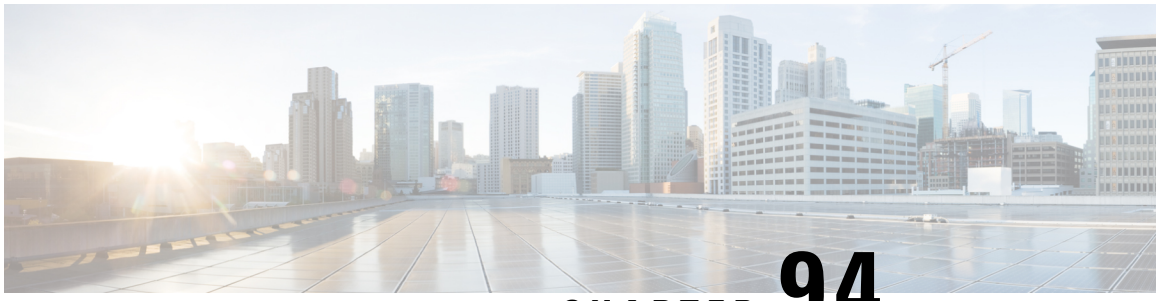
Follow these steps to verify 802.11ax mode per WLAN:

Procedure

Display the status of the 11ax parameter by running this command:

Example:

```
Device# show wlan id 6
WLAN Profile Name     : power
===============================================
Identifier                                    : 6
Description                                   :
Network Name (SSID)                           : power
Status                                        : Enabled
Broadcast SSID                                : Enabled
Advertise-Apname                              : Disabled
Universal AP Admin                            : Disabled
Max Associated Clients per WLAN               : 0
Max Associated Clients per AP per WLAN        : 0
Max Associated Clients per AP Radio per WLAN  : 200
.
.
.
802.11ac MU-MIMO                              : Enabled
802.11ax parameters
    802.11ax Operation Status                 : Enabled
    OFDMA Downlink                            : Enabled
    OFDMA Uplink                              : Enabled
    MU-MIMO Downlink                          : Enabled
    MU-MIMO Uplink                            : Enabled
    BSS Target Wake Up Time                   : Enabled
    BSS Target Wake Up Time Broadcast Support  : Enabled
.
.
.
```



CHAPTER 94

Deny Wireless Client Session Establishment Using Calendar Profiles

- Information About Denial of Wireless Client Session Establishment, on page 929
- Configuring Daily Calendar Profile, on page 930
- Configuring Weekly Calendar Profile, on page 931
- Configuring Monthly Calendar Profile, on page 932
- Mapping a Daily Calendar Profile to a Policy Profile, on page 933
- Mapping a Weekly Calendar Profile to a Policy Profile, on page 934
- Mapping a Monthly Calendar Profile to a Policy Profile, on page 935
- Verifying Calendar Profile Configuration, on page 936
- Verifying Policy Profile Configuration, on page 936

Information About Denial of Wireless Client Session Establishment

Denial of client session establishment feature allows the controller to stop client session establishment based on a particular time. This helps control the network in efficient and controlled manner without any manual intervention.

In Embedded Wireless Controller, you can deny the wireless client session based on the following recurrences:

- Daily
- Weekly
- Monthly

The Calendar Profiles created are then mapped to the policy profile. By attaching the calendar profile to a policy profile, you will be able to create different recurrences for the policy profile using different policy tag.

Note You need to create separate Calendar Profile for Daily, Weekly, and Monthly sub-categories.

The following is the workflow for denial of wireless client session establishment feature:

- Create a calendar profile.
- Apply the calendar profile to a policy profile.

Note A maximum of 100 calendar profile configuration and 5 calendar profile association to policy profile is supported.

Points to Remember

If you boot up your controller, the denial of client session establishment feature kicks in after a minute from the system boot up.

If you change the system time after the calendar profile is associated to a policy profile, you can expect a maximum of 30 second delay to adapt to the new clock timings.

Note You cannot use the **no action deny-client** command to disable action while associating the calendar profile to a policy profile.

If you want to disable the action command, you need to disassociate the calendar profile from the policy profile, and re-configure again.

Configuring Daily Calendar Profile

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile calendar-profile name** *name* **Example:** `Device(config)# wireless profile calendar-profile name daily_calendar_profile`	Configures a calendar profile. Here, *name* refers to the name of the calendar profile.
Step 3	**start** *start_time* **end** *end_time* **Example:**	Configures start and end time for the calendar profile.

	Command or Action	Purpose
	`Device(config-calendar-profile)# start 09:00:00 end 17:00:00`	Here, *start_time* is the start time for the calendar profile. You need to enter start time in **HH:MM:SS** format. *end_time* is the end time for the calendar profile. You need to enter end time in **HH:MM:SS** format.
Step 4	**recurrence daily** **Example:** `Device(config-calendar-profile)# recurrence daily`	Configures daily recurrences for a calendar profile.
Step 5	**end** **Example:** `Device(config-calendar-profile)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode. **Note** When the calendar profile kicks in, the AP power profile rules (for example, radio state and USB device state) that are defined for the Ethernet speed are not applied and continue to be as per the fixed power profile.

Configuring Weekly Calendar Profile

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile calendar-profile name** *name* **Example:** `Device(config)# wireless profile calendar-profile name weekly_calendar_profile`	Configures a calendar profile. Here, *name* refers to the name of the calendar profile.
Step 3	**start** *start_time* **end** *end_time* **Example:** `Device(config-calendar-profile)# start 18:00:00 end 19:00:00`	Configures start and end time for the calendar profile. Here,

	Command or Action	Purpose
		start_time is the start time for the calendar profile. You need to enter start time in **HH:MM:SS** format. *end_time* is the end time for the calendar profile. You need to enter end time in **HH:MM:SS** format.
Step 4	**recurrence weekly** **Example:** `Device(config-calendar-profile)# recurrence weekly`	Configures weekly recurrences for the calendar profile.

Step 5	**day** {**friday** | **monday** | **saturday** | **sunday** | **thursday** | **tuesday** | **wednesday**}
	Example:
	`Device(config-calendar-profile)# day friday`
	`Device(config-calendar-profile)# day monday`
		Configure days when the weekly calendar needs to be active.
		Note You can configure multiple days using this command.

Step 6	**end** **Example:** `Device(config-calendar-profile)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring Monthly Calendar Profile

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile calendar-profile name** *name* **Example:** `Device(config)# wireless profile calendar-profile name monthly_calendar_profile`	Configures a calendar profile. Here, *name* refers to the name of the calendar profile.
Step 3	**start** *start_time* **end** *end_time* **Example:** `Device(config-calendar-profile)# start 18:00:00 end 19:00:00`	Configures start and end time for the calendar profile. Here,

	Command or Action	Purpose
		start_time is the start time for the calendar profile. You need to enter start time in **HH:MM:SS** format. *end_time* is the end time for the calendar profile. You need to enter end time in **HH:MM:SS** format.
Step 4	**recurrence monthly** **Example:** `Device(config-calendar-profile)# recurrence monthly`	Configures monthly recurrences for the calendar profile.
Step 5	**date** *value* **Example:** `Device(config-calendar-profile)# date 25`	Configures a date for the calendar profile. **Note** If the requirement is to perform denial of service in certain timing, such as, 2,10, and 25 of every month, all three days need to be configured using the **date** command. There is no range for date. You need to configure the dates as per your requirement.
Step 6	**end** **Example:** `Device(config-calendar-profile)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Mapping a Daily Calendar Profile to a Policy Profile

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile policy** *profile-name* **Example:** `Device(config)# wireless profile policy default-policy-profile`	Creates policy profile for the WLAN. The *profile-name* is the profile name of the policy profile.
Step 3	**calender-profile name** *calendar-profile-name* **Example:**	Maps a calendar profile to a policy profile. The *calendar-profile-name* is the name of the calendar profile name created in #unique_1194.

	Command or Action	Purpose
	`Device(config-wireless-policy)# calender-profile name daily_calendar_profile`	**Note** You need to disable Policy Profile before associating a calendar profile to a policy profile. The following needs to be done: `Device(config-wireless-policy)# shutdown`
Step 4	**action deny-client** **Example:** `Device(config-policy-profile-calender)# action deny-client`	Configures deny client session establishment during calendar profile interval. **Note** Client associations are denied daily between timeslot 9:00:00 to 17:00:00. For start and end time details, see #unique_1194.
Step 5	**end** **Example:** `Device(config-policy-profile-calender)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Mapping a Weekly Calendar Profile to a Policy Profile

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile policy** *profile-name* **Example:** `Device(config)# wireless profile policy default-policy-profile`	Creates policy profile for the WLAN. The *profile-name* is the profile name of the policy profile.
Step 3	**calender-profile name** *calendar-profile-name* **Example:** `Device(config-wireless-policy)# calender-profile name weekly_calendar_profile`	Maps a calender profile to a policy profile. The *calendar-profile-name* is the name of the calendar profile name created in #unique_1196. **Note** You need to disable Policy Profile before associating a calendar profile to a policy profile. The following needs to be done: `Device(config-wireless-policy)# shutdown`

	Command or Action	Purpose
Step 4	**action deny-client** **Example:** `Device(config-policy-profile-calender)# action deny-client`	Configures deny client session establishment during calendar profile interval. **Note** Client associations are denied daily between timeslot 9:00:00 to 17:00:00. For start and end time details, see #unique_1196. On Monday and Tuesday, clients are denied between 17:30:00 and 19:00:00 besides regular time 9:00:00 to 17:00:00. On 25th of every month, clients are denied between 18:00:00 and 19:00:00 besides regular time 9:00:00 to 17:00:00.
Step 5	**end** **Example:** `Device(config-policy-profile-calender)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Mapping a Monthly Calendar Profile to a Policy Profile

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile policy** *profile-name* **Example:** `Device(config)# wireless profile policy default-policy-profile`	Creates policy profile for the WLAN. The *profile-name* is the profile name of the policy profile.
Step 3	**calender-profile name** *calendar-profile-name* **Example:** `Device(config-wireless-policy)# calender-profile name monthly_calendar_profile`	Maps a calender profile to a policy profile. The *calendar-profile-name* is the name of the calendar profile name created in #unique_1198.
Step 4	**action deny-client** **Example:** `Device(config-policy-profile-calender)# action deny-client`	Configures deny client session establishment for the defined calendar profile interval. **Note**

	Command or Action	Purpose
		Every day client associations are denied between timeslot 9:00:00 to 17:00:00. For start and end time details, see #unique_1198. On Monday and Tuesday, clients are denied between 17:30:00 and 19:00:00 besides regular time 9:00:00 to 17:00:00. On 25th of every month, clients are denied between 18:00:00 and 19:00:00 besides regular time 9:00:00 to 17:00:00.
Step 5	**end** **Example:** `Device(config-policy-profile-calender)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Verifying Calendar Profile Configuration

To view the summary of calendar profiles, use the following command:

```
Device# show wireless profile calendar-profile summary
Number of Calendar Profiles: 3

Profile-Name
--------------------------------
monthly_25_profile
weekly_mon_profile
daily_calendar_profile
```

To view the calendar profile details for a specific profile name, use the following command:

```
Device# show wireless profile calendar-profile detailed daily_calendar_profile
Calendar profiles                          : daily_calendar_profile
-------------------------------------------------------------------
Recurrence                                 : DAILY
Start Time                                 : 09:00:00
End Time                                   : 17:00:00
```

Verifying Policy Profile Configuration

To view the detailed parameters for a specific policy profile, use the following command:

```
Device# show wireless profile policy detailed default-policy-profile
Tunnel Profile
  Profile Name                      : Not Configured
Calendar Profile
  Profile Name                      : monthly_25_profile
  Wlan Enable                       : Not Configured
  Client Block                      : Client Block Configured
  ------------------------------------------------
  Profile Name                      : weekly_mon_profile
```

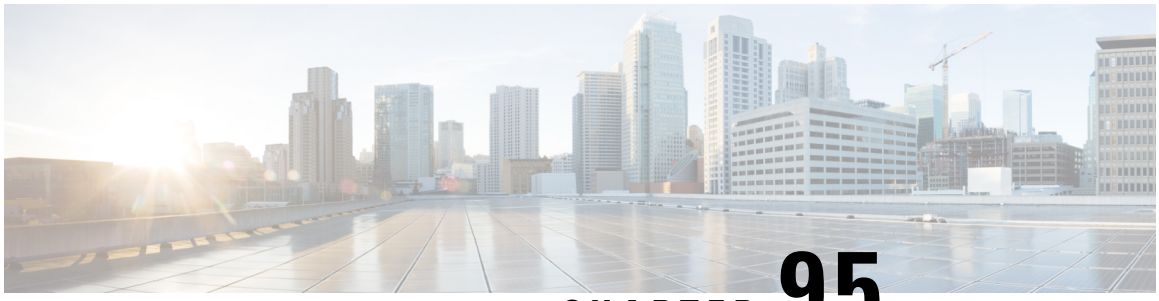
```
  Wlan Enable                      : Not Configured
  Client Block                     : Client Block Configured
  ---------------------------------------------------
  Profile Name                     : daily_calendar_profile
  Wlan Enable                      : Not Configured
  Client Block                     : Client Block Configured
  ---------------------------------------------------
Fabric Profile
  Profile Name                     : Not Configured
```

To view the configured calendar profile information under policy profile, use the following command:

```
Device# show wireless profile policy all
Tunnel Profile
Profile Name : Not Configured
Calendar Profile
Profile Name : daily_calendar_profile
Wlan Enable : Not Configured
Client Block : Client Block Configured
---------------------------------------------------
Profile Name : weekly_calendar_profile
Wlan Enable : Not Configured
Client Block : Client Block Configured
---------------------------------------------------
Fabric Profile
Profile Name : Not Configured
```



Note The anchor priority is always displayed as local. Priorities can be assigned on the foreign controller.



CHAPTER 95

Ethernet over GRE Tunnels

- Introduction to EoGRE, on page 939
- Create a Tunnel Gateway, on page 941
- Configuring a Tunnel Domain, on page 942
- Configuring EoGRE Global Parameters, on page 943
- Configuring a Tunnel Profile, on page 943
- Associating WLAN to a Wireless Policy Profile, on page 945
- Attaching a Policy Tag and a Site Tag to an AP, on page 946
- Verifying the EoGRE Tunnel Configuration, on page 946

Introduction to EoGRE

Ethernet over GRE (EoGRE) is an aggregation solution for grouping Wi-Fi traffic from hotspots. This solution enables customer premises equipment (CPE) devices to bridge the Ethernet traffic coming from an end-host, and encapsulate the traffic in Ethernet packets over an IP Generic Routing Encapsulation (GRE) tunnel. When the IP GRE tunnels are terminated on a service provider's broadband network gateway, the end-host traffic is forwarded and subscriber sessions are initiated.

Client IPv6

EoGRE for WLAN

To enable EoGRE for a WLAN, the wireless policy profile should be mapped to a tunnel profile, which may contain the following:

- AAA override: Allows you to bypass rule filtering for a client.
- Gateway RADIUS proxy: Allows forwarding of AAA requests to tunnel gateways.
- Tunnel rules: Defines the domain to use for each realm. They also define VLAN tagging for the client traffic towards tunnel gateways.
- DHCP option 82: Provides a set of predefined fields.

EoGRE Deployment with Multiple Tunnel Gateways

The embedded wireless controller sends keepalive pings to the primary and secondary tunnel gateways and keeps track of the missed pings. When a certain threshold level is reached for the missed pings, switchover

is performed and the secondary tunnel is marked as active. This switchover deauthenticates all the clients to enable them to rejoin the access points (APs). When the primary tunnel come back online, all the client traffic are reverted to the primary tunnel. However, this behavior depends on the type of redundancy.

Load Balancing in EtherChannels

Load balancing of tunneled traffic over Etherchannels works by hashing the source or destination IP addresses or mac addresses of the tunnel endpoint pair. Because the number of tunnels is very limited when compared to clients (each tunnel carries traffic for many clients), the spreading effect of hashing is highly reduced and optimal utilization of Etherchannel links can be hard to achieve.

Using the EoGRE configuration model, you can use the *tunnel source* option of each tunnel interface to adjust the load-balancing parameters and spread tunnels across multiple links.

You can use different source interfaces on each tunnel for load balancing based on the source or destination IP address. For that choose the source interface IP address in such a way that traffic flows take different links for each src-dest IP pair. The following is an example with four ports:

```
Client traffic on Tunnel1 – Src IP: 40.143.0.72  Dest IP: 40.253.0.2
Client traffic on Tunnel2 – Src IP: 40.146.0.94  Dest IP: 40.253.0.6
Client traffic on Tunnel3 – Src IP: 40.147.0.74  Dest IP: 40.253.0.10
```

Use the **show platform software port-channel link-select interface port-channel 4 ipv4** *src_ip dest_ip* command to determine the link that a particular flow will take.

EoGRE Configuration Overview

The EoGRE solution can be deployed in two different ways:

- Central-Switching: EoGRE tunnels connect the embedded wireless controller to the tunnel gateways.
- Flex or Local-Switching: EoGRE tunnels are initiated on the APs and terminated on the tunnel gateways.

To configure EoGRE, perform the following tasks:

1. Create a set of tunnel gateways.
2. Create a set of tunnel domains.
3. Create a tunnel profile with rules that define how to match clients to domains.
4. Create a policy profile and attach the tunnel profile to it.
5. Map the policy profile to WLANs using policy tags.



Note The EoGRE tunnel fallback to the secondary tunnel is triggered after the *max-skip-count* ping fails in the last measurement window. Based on the starting and ending instance of the measurement window, the fall-back may take more time than the duration that is configured.

Table 54: EoGRE Authentication Methods

Method Name	First Supported Release	Mode
PSK	17.2.1	Local/Flex (central authentication)
Open	16.12.1	Local/Flex (central authentication)
LWA	16.12.1	Local/Flex (central authentication)
Dot1x	16.12.1	Local/Flex (central authentication)
CWA	16.12.1	Local/Flex (central authentication)

Create a Tunnel Gateway

Note In the Cisco Embedded Wireless Controller on Catalyst Access Points, a tunnel gateway is modeled as a tunnel interface.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**interface tunnel** *tunnel_number* **Example:** `Device(config)# interface tunnel 21`	Configures a tunnel interface and enters interface configuration mode.
Step 3	**tunnel source** *source_intf* **Example:** `Device(config-if)# tunnel source 22`	Sets the source address of the tunnel interface. The source interface can be VLAN, Gigabit Ethernet or loopback.
Step 4	**tunnel destination** *tunnel-address* **Example:** `Device(config-if)# tunnel destination 10.11.12.13`	Sets the destination address of the tunnel.
Step 5	**tunnel mode ethernet gre** {**ipv4** | **ipv6**} **p2p** **Example:** `Device(config-if)# tunnel mode ethernet gre ipv4 p2p`	Sets the encapsulation mode of the tunnel to Ethernet over GRE IPv4 or Ethernet over GRE IPv6.

Configuring a Tunnel Domain

Note Tunnel domains are a redundancy grouping of tunnels. The following configuration procedure specifies a primary and a secondary tunnel, along with a redundancy model.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**tunnel eogre domain** *domain* **Example:** `Device(config)# tunnel eogre domain dom1`	Configures EoGRE redundancy domain.
Step 3	**primary tunnel** *primary-tunnel_intf* **Example:** `Device(config-eogre-domain)# primary tunnel 21`	Configures the primary tunnel.
Step 4	**secondary tunnel** *secondary-tunnel_intf* **Example:** `Device(config-eogre-domain)# secondary tunnel 22`	Configures the secondary tunnel.
Step 5	**redundancy revertive** **Example:** `Device(config-eogre-domain)# redundancy revertive`	Sets the redundancy model as revertive. When redundancy is set to revertive and the primary tunnel goes down, a switchover to secondary tunnel is performed. When the primary tunnel comes back up, a switchover to the primary tunnel is performed, because the primary tunnel has priority over the secondary tunnel. When redundancy is not set to revertive, tunnels will have the same priority, and a switchover to the primary tunnel is not performed if the active tunnel is the secondary tunnel and the primary tunnel comes back up.

Configuring EoGRE Global Parameters

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**tunnel eogre heartbeat interval** *interval-value* **Example:** `Device(config)# tunnel eogre heartbeat interval 600`	Sets EoGRE tunnel heartbeat periodic interval.
Step 3	**tunnel eogre heartbeat max-skip-count** *skip-count* **Example:** `Device(config)# tunnel eogre heartbeat max-skip-count 7`	Sets the maximum number of tolerable dropped heartbeats. After reaching the maximum number of heartbeats that can be dropped, the tunnel is declared as down and a switchover is performed.
Step 4	**tunnel eogre source loopback** *tunnel_source* **Example:** `Device(config)# tunnel eogre source loopback 12`	Sets the tunnel EoGRE source interface.
Step 5	**tunnel eogre interface tunnel** *tunnel-intf* **aaa proxy key** *key key-name* **Example:** `Device(config)# tunnel eogre interface tunnel 21 aaa proxy key 0 mykey`	(Optional) Configures AAA proxy RADIUS key for the AAA proxy setup. **Note** When the tunnel gateway is behaving as the AAA proxy server, only this step is required for the configuration.

Configuring a Tunnel Profile

Before you begin

Ensure that you define the destination VLAN on the controller. If you do not define the VLAN, clients will not be able to connect.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile policy** *profile-policy-name* **Example:** `Device(config)# wireless profile policy eogre_policy`	Configures a WLAN policy profile.
Step 3	**tunnel-profile** *tunnel-profile-name* **Example:** `Device(config-wireless-policy)# tunnel-profile tunnel1`	Creates a tunnel profile.
Step 4	**exit** **Example:** `Device(config-wireless-policy)# exit`	Returns to global configuration mode.
Step 5	**wireless profile tunnel** *tunnel-profile-name* **Example:** `Device(config)# wireless profile tunnel wl-tunnel-1`	Configures a wireless tunnel profile.
Step 6	**dhcp-opt82 enable** **Example:** `Device(config-tunnel-profile)# dhcp-opt82 enable`	Activates DHCP Option 82 for the tunneled clients.
Step 7	**dhcp-opt82 remote-id** *remote-id* **Example:** `Device(config-tunnel-profile)# dhcp-opt82 remote-id vlan`	Configures Remote ID options. Choose from the comma-separated list of options such as **ap-mac**, **ap-ethmac**, **ap-name**, **ap-group-name**, **flex-group-name**, **ap-location**, **vlan**, **ssid-name**, **ssid-type**, and **client-mac**.
Step 8	**aaa-override** **Example:** `Device(config-tunnel-profile)# aaa-override`	Enables AAA policy override.
Step 9	**gateway-radius-proxy** **Example:** `Device(config-tunnel-profile)# gateway-radius-proxy`	Enables the gateway RADIUS proxy.

	Command or Action	Purpose
Step 10	**gateway-accounting-radius-proxy** **Example:** `Device(config-tunnel-profile)# gateway-accounting-radius-proxy`	Enables the gateway accounting RADIUS proxy.
Step 11	**rule** *priority* **realm-filter** *realm* **domain** *domain-name* **vlan** *vlan-id* **Example:** `Device(config-tunnel-profile)# rule 12 realm-filter realm domain dom1 vlan 5`	Creates a rule to choose a domain, using the realm filter, for client Network Access Identifier (NAI), tunneling domain name, and destination VLAN.

Associating WLAN to a Wireless Policy Profile

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless tag policy** *policy-tag-name* **Example:** `Device(config)# wireless tag policy eogre_tag`	Configures a policy tag and enters policy tag configuration mode.
Step 3	**wlan** *wlan-name* **policy** *profile-policy-name* **Example:** `Device(config-policy-tag)# wlan eogre_open_eogre policy eogre_policy`	Maps an EoGRE policy profile to a WLAN profile.
Step 4	**end** **Example:** `Device(config-policy-tag)# end`	Saves the configuration, exits configuration mode, and returns to privileged EXEC mode.

Attaching a Policy Tag and a Site Tag to an AP

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**ap** *mac-address* **Example:** `Device(config)# ap 80E8.6FD4.0BB0`	Configures an AP and enters AP profile configuration mode.
Step 3	**policy-tag** *policy-tag-name* **Example:** `Device(config-ap-tag)# policy-tag eogre_tag`	Maps the EoGRE policy tag to the AP.
Step 4	**site-tag** *site-tag-name* **Example:** `Device(config-ap-tag)# site-tag sp-flex-site`	Maps a site tag to the AP.
Step 5	**end** **Example:** `Device(config-ap-tag)# end`	Saves the configuration, exits configuration mode, and returns to privileged EXEC mode.

Verifying the EoGRE Tunnel Configuration

The `show tunnel eogre` command displays the EoGRE clients, domains, gateways, global-configuration, and manager information in the local mode.

To display the EoGRE domain summary in the local mode, use the following command:

```
Device# show tunnel eogre domain summary

Domain Name          Primary GW   Secondary GW      Active GW      Redundancy
-------------------------------------------------------------------------------
domain1              Tunnel1      Tunnel2           Tunnel1        Non-Revertive
eogre_domain         Tunnel1      Tunnel2           Tunnel1        Non-Revertive
```

To display the details of an EoGRE domain in the local mode, use the following command:

```
Device# show tunnel eogre domain detailed domain-name

Domain Name    : eogre_domain
 Primary GW    : Tunnel1
```

```
 Secondary GW  : Tunnel2
 Active GW     : Tunnel1
 Redundancy    : Non-Revertive
```

To view the EoGRE tunnel gateway summary and statistics in the local mode, use the following command:

```
Device# show tunnel eogre gateway summary

Name               Type  Address                                  AdminState  State  Clients
-------------------------------------------------------------------------------------------
Tunnel1             IPv4  9.51.1.11                                 Up          Up     0

Tunnel2             IPv4  9.51.1.12                                 Up          Down   0

Tunnel10            IPv6  fd09:9:8:21::90                           Down        Down   0

Tunnel11            IPv4  9.51.1.11                                 Up          Up     0

Tunnel12            IPv6  fd09:9:8:21::90                           Up          Down   0

Tunnel100           IPv4  9.51.1.100                                Up          Down   0
```

To view the details of an EoGRE tunnel gateway in the local mode, use the following command:

```
Device# show tunnel eogre gateway detailed gateway-name

Gateway : Tunnel1
 Mode   : IPv4
 IP     : 9.51.1.11
 Source : Vlan51 / 9.51.1.1
 State  : Up
 SLA ID : 56
 MTU    : 1480
 Up Time: 4 minutes 45 seconds

 Clients
  Total Number of Wireless Clients      : 0
 Traffic
  Total Number of Received Packets      : 0
  Total Number of Received Bytes        : 0
  Total Number of Transmitted Packets   : 0
  Total Number of Transmitted Bytes     : 0
 Keepalives
  Total Number of Lost Keepalives       : 0
  Total Number of Received Keepalives   : 5
  Total Number of Transmitted Keepalives: 5
  Windows                               : 1
  Transmitted Keepalives in last window : 2
  Received Keepalives in last window    : 2
```

To view the client summary of EoGRE in the local mode, use the following command:

```
Device# show tunnel eogre client summary

Client MAC      AP MAC          Domain                          Tunnel        VLAN  Local
-------------------------------------------------------------------------------------------
74da.3828.88b0  80e8.6fd4.9520  eogre_domain                     N/A           2121   No
```

To view the details of an EoGRE global configuration in the local mode, use the following command:

```
Device# show tunnel eogre global-configuration

Heartbeat interval       : 60
Max Heartbeat skip count : 3
Source Interface         : (none)
```

To view the details of the global tunnel manager statistics in the local mode, use the following command:

```
Device# show tunnel eogre manager stats global

Tunnel Global Statistics
Last Updated                     : 02/18/2019 23:50:35
EoGRE Objects
  Gateways                       : 6
  Domains                        : 2

EoGRE Flex Objects
  AP Gateways                    : 2
  AP Domains                     : 1
  AP Gateways HA inconsistencies : 0
  AP Domains HA inconsistencies  : 0

Config events
  IOS Tunnel updates             : 806
  IOS Domain updates             : 88
  Global updates                 : 48
  Tunnel Profile updates         : 120
  Tunnel Rule updates            : 16
  AAA proxy key updates          : 0

AP events
  Flex AP Join                   : 1
  Flex AP Leave                  : 0
  Local AP Join                  : 0
  Local AP leave                 : 0
  Tunnel status (rx)             : 4
  Domain status (rx)             : 1
  IAPP stats msg (rx)            : 3
  Client count (rx)              : 6
  VAP Payload msg (tx)           : 4
  Domain config (tx)             : 1
  Global config (tx)             : 1
  Client delete (tx)             : 1
  Client delete per domain (tx)  : 3
  DHCP option 82 (tx)            : 4

Client events
  Add-mobile                     : 2
  Run-State                      : 3
  Delete                         : 1
  Cleanup                        : 0
  Join                           : 2
  Plumb                          : 0
  Join Errors                    : 0
  HandOff                        : 0
  MsPayload                      : 2
  FT Recover                     : 0
  Zombie GW counter increase     : 0
  Zombie GW counter decrease     : 0
  Tunnel Profile reset           : 88
  Client deauth                  : 0
  HA reconciliation              : 0

Client Join Events
```

```
  Generic Error                 : 0
  MSPayload Fail                : 0
  Invalid VLAN                  : 0
  Invalid Domain                : 0
  No GWs in Domain              : 0
  Domain Shut                   : 0
  Invalid GWs                   : 0
  GWs Down                      : 0
  Rule Match Error              : 0
  AAA-override                  : 0
  Flex No Active GW             : 0
  Open Auth join attempt        : 2
  Dot1x join attempt            : 2
  Mobility join attempt         : 0
  Tunnel Profile not valid      : 2
  Tunnel Profile valid          : 2
  No rule match                 : 0
  Rule match                    : 2
  AAA proxy                     : 0
  AAA proxy accounting          : 0
  AAA eogre attributes          : 0
  Has aaa override              : 0
  Error in handoff payload      : 0
  Handoff AAA override          : 0
  Handoff no AAA override       : 0
  Handoff payload received      : 0
  Handoff payload sent          : 0

SNMP Traps
  Client                        : 0
  Tunnel                        : 2
  Domain                        : 0

IPC
  IOSd TX messages              : 0

Zombie Client
  Entries                       : 0
```

To view the tunnel manager statistics of a specific process instance in the local mode, use the following command:

```
Device# show tunnel eogre manager stats instance instance-number

Tunnel Manager statistics for process instance : 0
Last Updated                    : 02/18/2019 23:50:35
EoGRE Objects
  Gateways                      : 6
  Domains                       : 2

EoGRE Flex Objects
  AP Gateways                   : 2
  AP Domains                    : 1
  AP Gateways HA inconsistencies : 0
  AP Domains HA inconsistencies  : 0

Config events
  IOS Tunnel updates            : 102
  IOS Domain updates            : 11
  Global updates                : 6
  Tunnel Profile updates        : 15
  Tunnel Rule updates           : 2
  AAA proxy key updates         : 0
```

```
AP events
  Flex AP Join                    : 1
  Flex AP Leave                   : 0
  Local AP Join                   : 0
  Local AP leave                  : 0
  Tunnel status (rx)              : 4
  Domain status (rx)              : 1
  IAPP stats msg (rx)             : 3
  Client count (rx)               : 6
  VAP Payload msg (tx)            : 4
  Domain config (tx)              : 1
  Global config (tx)              : 1
  Client delete (tx)              : 1
  Client delete per domain (tx)   : 3
  DHCP option 82 (tx)             : 4

Client events
  Add-mobile                      : 2
  Run-State                       : 3
  Delete                          : 1
  Cleanup                         : 0
  Join                            : 2
  Plumb                           : 0
  Join Errors                     : 0
  HandOff                         : 0
  MsPayload                       : 2
  FT Recover                      : 0
  Zombie GW counter increase      : 0
  Zombie GW counter decrease      : 0
  Tunnel Profile reset            : 11
  Client deauth                   : 0
  HA reconciliation               : 0

Client Join Events
  Generic Error                   : 0
  MSPayload Fail                  : 0
  Invalid VLAN                    : 0
  Invalid Domain                  : 0
  No GWs in Domain                : 0
  Domain Shut                     : 0
  Invalid GWs                     : 0
  GWs Down                        : 0
  Rule Match Error                : 0
  AAA-override                    : 0
  Flex No Active GW               : 0
  Open Auth join attempt          : 2
  Dot1x join attempt              : 2
  Mobility join attempt           : 0
  Tunnel Profile not valid        : 2
  Tunnel Profile valid            : 2
  No rule match                   : 0
  Rule match                      : 2
  AAA proxy                       : 0
  AAA proxy accounting            : 0
  AAA eogre attributes            : 0
  Has aaa override                : 0
  Error in handoff payload        : 0
  Handoff AAA override            : 0
  Handoff no AAA override         : 0
  Handoff payload received        : 0
  Handoff payload sent            : 0

SNMP Traps
```

```
  Client                          : 0
  Tunnel                          : 2
  Domain                          : 0

IPC
  IOSd TX messages                : 0

Zombie Client
  Entries                         : 0
```

The `show ap tunnel eogre` command displays the tunnel domain information, EoGRE events, and the tunnel gateway status on the APs, in the flex mode.

To view the summary information of an EoGRE tunnel gateway in the flex mode, use the following command:

```
Device# show ap tunnel eogre domain summary

AP MAC          Domain                              Active Gateway
-------------------------------------------------------------------------------
80e8.6fd4.9520  eogre_domain                        Tunnel1
```

To view the wireless tunnel profile summary, use the following command:

```
Device# show wireless profile tunnel summary

Profile Name                     AAA-Override AAA-Proxy DHCP Opt82 Enabled
-------------------------------- ------------ --------- ---------- ---------
eogre_tunnel                              No        No        Yes       Yes
eogre_tunnel_set                          No        No        Yes        No
eogre_tunnel_snmp                         No        No         No        No
```

To view a wireless tunnel profile's details, use the following command:

```
Device# show wireless profile tunnel detailed profile-name

Profile Name : eogre_tunnel
Status : Enabled
 AAA-Proxy/Accounting-Proxy: Disabled / Disabled
 AAA-Override : Disabled
 DHCP Option82 : Enabled
  Circuit-ID : ap-mac,ap-ethmac,ap-location,vlan
  Remote-ID : ssid-name,ssid-type,client-mac,ap-name

Tunnel Rules

Priority Realm                Vlan Domain (Status/Primary GW/Secondary GW)
-------- -------------------- ---- ---------------------------------------------
1        *                    2121 eogre_domain (Enabled/Tunnel1/Tunnel2)
```

To view detailed information about an EoGRE tunnel domain's status, use the following command:

```
Device# show ap tunnel eogre domain detailed

Domain     : eogre_domain
AP MAC     : 80e8.6fd4.9520
Active GW  : Tunnel1
```

To view the EoGRE events on an AP, use the following command:

```
Device# show ap tunnel eogre events

AP 80e8.6fd4.9520  Event history
```

```
Timestamp               #Times   Event               RC Context
----------------------- -------- ------------------- --
----------------------------------------
02/18/2019 23:50:26.341 6        IAPP_STATS           0 GW Tunnel2 uptime:0s

02/18/2019 23:49:40.222 2        CLIENT_JOIN          0 74da.3828.88b0, (eogre_domain/2121)

02/18/2019 23:48:43.549 1        CLIENT_LEAVE         0 74da.3828.88b0, (eogre_domain/2121)

02/18/2019 23:47:33.127 1        DOMAIN_STATUS        0 eogre_domain Active GW: Tunnel1

02/18/2019 23:47:33.124 4        AP_TUNNEL_STATUS     0 Tunnel2 Dn

02/18/2019 23:47:33.124 1        MSG_CLIENT_DEL       0 GW Tunnel2 (IP: 9.51.1.12)

02/18/2019 23:47:33.124 2        TUNNEL_ADD           0 GW Tunnel2

02/18/2019 23:47:33.120 3        MSG_CLIENT_DEL_PD    0 GW Tunnel1 (IP: 9.51.1.11)

02/18/2019 23:47:31.763 2        AP_DOMAIN_PUSH       0 Delete:eogre_domain_set, 0 GWs

02/18/2019 23:47:31.753 4        AP_VAP_PUSH          0 profile:'eogre_tunnel',
wlan:pyats_eogre
```

To view the summary information of the EoGRE tunnel gateway, use the following command:

```
Device# show ap tunnel eogre gateway summary

AP MAC          Gateway          Type  IP                                          State  Clients
-------------------------------------------------------------------------------------------------
80e8.6fd4.9520  Tunnel1          IPv4  9.51.1.11                                     Up     1

80e8.6fd4.9520  Tunnel2          IPv4  9.51.1.12                                     Down   0
```

To view detailed information about an EoGRE tunnel gateway, use the following command:

```
Device# show ap tunnel eogre gateway detailed gateway-name

Gateway : Tunnel1
 Mode   : IPv4
 IP     : 9.51.1.11
 State  : Up
 MTU    : 1476
 Up Time: 14 hours 25 minutes 2 seconds
 AP MAC : 80e8.6fd4.9520

 Clients
  Total Number of Wireless Clients      : 1
 Traffic
  Total Number of Received Packets      : 6
  Total Number of Received Bytes        : 2643
  Total Number of Transmitted Packets   : 94
  Total Number of Transmitted Bytes     : 20629
  Total Number of Lost Keepalive        : 3
```

To view summary information about the EoGRE tunnel gateway status, use the following command:

```
Device# show ap tunnel eogre domain summary

AP MAC          Domain                          Active Gateway
-------------------------------------------------------------------------------
80e8.6fd4.9520  eogre_domain                    Tunnel1
```

To view information about EoGRE events on an AP, use the following command:

```
Device# show ap name ap-name tunnel eogre events

AP 80e8.6fd4.9520  Event history
Timestamp               #Times   Event               RC Context
----------------------- -------- ------------------- --
----------------------------------------
02/18/2019 23:50:26.341 6        IAPP_STATS           0 GW Tunnel2 uptime:0s

02/18/2019 23:49:40.222 2        CLIENT_JOIN         0 74da.3828.88b0, (eogre_domain/2121)

02/18/2019 23:48:43.549 1        CLIENT_LEAVE        0 74da.3828.88b0, (eogre_domain/2121)

02/18/2019 23:47:33.127 1        DOMAIN_STATUS        0 eogre_domain Active GW: Tunnel1

02/18/2019 23:47:33.124 4        AP_TUNNEL_STATUS     0 Tunnel2 Dn

02/18/2019 23:47:33.124 1        MSG_CLIENT_DEL       0 GW Tunnel2 (IP: 9.51.1.12)

02/18/2019 23:47:33.124 2        TUNNEL_ADD           0 GW Tunnel2

02/18/2019 23:47:33.120 3        MSG_CLIENT_DEL_PD    0 GW Tunnel1 (IP: 9.51.1.11)

02/18/2019 23:47:31.763 2        AP_DOMAIN_PUSH       0 Delete:eogre_domain_set, 0 GWs

02/18/2019 23:47:31.753 4        AP_VAP_PUSH          0 profile:'eogre_tunnel',
wlan:pyats_eogre
```

To view the summary information about EoGRE tunnel domain's status on an AP, use the following command:

```
Device# show ap name ap-name tunnel eogre domain summary

AP MAC          Domain                          Active Gateway
-------------------------------------------------------------------------------
80e8.6fd4.9520  eogre_domain
```

To view the detailed information about EoGRE tunnel domain on an AP, use the following command:

```
Device# show ap name ap-name tunnel eogre domain detailed

Domain Name    : eogre_domain
 Primary GW    : Tunnel1
 Secondary GW  : Tunnel2
 Active GW     : Tunnel1
 Redundancy    : Non-Revertive
 AdminState    : Up
```

To view the summary information about EoGRE tunnel gateways on an AP, use the following command:

```
Device# show ap name ap-name tunnel eogre gateway summary

AP MAC          Gateway          Type  IP                                      State  Clients
-----------------------------------------------------------------------------------------------
80e8.6fd4.9520  Tunnel1          IPv4  9.51.1.11                                 Up     1

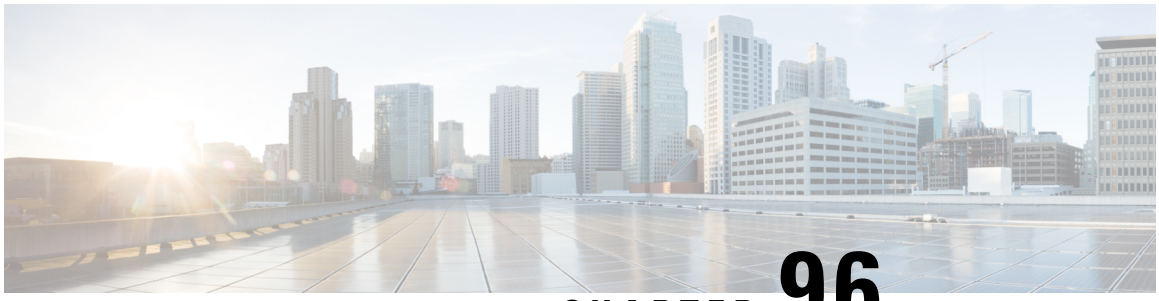
80e8.6fd4.9520  Tunnel2          IPv4  9.51.1.12                                 Down   0
```

To view detailed information about an EoGRE tunnel gateway's status on an AP, use the following command:

```
Device# show ap name ap-name tunnel eogre gateway detailed gateway-name
```

```
Gateway : Tunnel2
 Mode   : IPv4
 IP     : 9.51.1.12
 State  : Down
 MTU    : 0
 AP MAC : 80e8.6fd4.9520

 Clients
  Total Number of Wireless Clients      : 0
 Traffic
  Total Number of Received Packets      : 0
  Total Number of Received Bytes        : 0
  Total Number of Transmitted Packets   : 0
  Total Number of Transmitted Bytes     : 0
  Total Number of Lost Keepalive        : 151
```



CHAPTER 96

Guest Anchor with Centralized EoGRE

- Feature History for Guest Anchor with Centralized EoGRE , on page 955
- Information About Guest Anchor with Centralized EoGRE, on page 955
- Guidelines and Limitations for Guest Anchor with Centralized EoGRE, on page 956
- Enabling Guest Anchor with Centralized EoGRE, on page 956
- Verifying Centralized EoGRE Guest Clients, on page 959

Feature History for Guest Anchor with Centralized EoGRE

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

This feature is also available in all the releases subsequent to the one in which they are introduced in, unless noted otherwise.

Table 55: Feature History for Guest Anchor with Centralized EoGRE

Release	Feature	Feature Information
Cisco IOS XE Cupertino 17.7.1	Guest Anchor with Centralized EoGRE	The Guest Anchor with Centralized EoGRE feature for Cisco Embedded Wireless Controller (EWC) allows you to provide internet services to wireless guest clients.

Information About Guest Anchor with Centralized EoGRE

You can provide internet services to guest wireless clients and also safeguard your company's internal information and infrastructure assets by using the Guest Anchor with Centralized EoGRE feature on the Cisco Embedded Wireless Controller (EWC). The guest anchor feature on EWC uses EoGRE as the tunnel between the primary access point (AP) on the EWC platform and the gateway router. Client traffic flows from the subordinate APs to the primary AP and then to the EoGRE tunnel gateway.

Guidelines and Limitations for Guest Anchor with Centralized EoGRE

Cisco EWC does not support AP and client SSO. After the switchover, guest clients are cleaned up, causing interruption in the client traffic. Guest clients rejoin after switchover and traffic is then re-established.

Enabling Guest Anchor with Centralized EoGRE

To support guest anchoring using centralized EoGRE, complete the following configurations in the given order.

- Required Configuration
  1. Configuring Wireless Profile Tunnel Under Wireless Profile Policy (CLI), on page 956
  2. Configuring Central Forwarding (CLI), on page 958
  3. Configuring DHCP Required Under Policy Profile (CLI), on page 958
- Example of Recommended Configurations
  - Configuration Examples of ACLs for Guest Clients, on page 958

Configuring Wireless Profile Tunnel Under Wireless Profile Policy (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile policy** *policy_profile_name* **Example:** `Device(config)# wireless profile policy open_policy`	Configures wireless policy profile and goes into wireless policy configuration mode.
Step 3	**no central dhcp** **Example:** `Device(config-wireless-policy)# no central dhcp`	Configures local DHCP mode, where the DHCP is performed in an AP.
Step 4	**no central switching** **Example:**	Configures a WLAN for local switching.

	Command or Action	Purpose
	`Device(config-wireless-policy)# no central switching`	
Step 5	**ipv4 dhcp required** **Example:** `Device(config-wireless-policy)# ipv4 dhcp required`	Enables the FlexConnect DHCP-Required feature.
Step 6	**tunnel-profile** *tunnel-profile-name* **Example:** `Device(config-wireless-policy)# tunnel-profile eogre_central`	Configures a tunnel profile.
Step 7	**vlan** *vlan-id* **Example:** `Device(config-wireless-policy)# vlan 2121`	Configures the VLAN name or ID.
Step 8	**no shutdown** **Example:** `Device(config-wireless-policy)# no shutdown`	Enables the profile policy.

Configuring Central Forwarding (GUI)

Procedure

Step 1 From the Cisco Embedded Wireless Controller for Catalyst Access Points GUI, choose **Configuration** > **Tags & Profiles** > **EoGRE**.

Step 2 Click the **Tunnel Profiles** tab.

Step 3 Under the **Tunnel Profiles** tab, click **Add**.
The **Add Tunnel Profile** window is displayed.

Step 4 Click the **Central Forwarding** toggle button to enable the feature.

Step 5 Click **Apply to Device**.

Configuring Central Forwarding (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile tunnel** *tunnel-profile-name* **Example:** `Device(config)# wireless profile tunnel tunnel-profile-name`	Configures wireless tunnel profile and goes into tunnel profile configuration mode.
Step 3	**central-forwarding** **Example:** `Device(config-tunnel-profile)# central-forwarding`	Enables centralized forwarding.

Configuring DHCP Required Under Policy Profile (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile policy** *policy-profile-name* **Example:** `Device(config)# wireless profile policy policy-profile-name`	Configures a policy profile.
Step 3	**ipv4 dhcp required** **Example:** `Device(config-wireless-policy)# ipv4 dhcp required`	Configures the DHCP parameters for a WLAN.

Configuration Examples of ACLs for Guest Clients

Guest clients and local clients use the same network resources. Therefore, to safeguard the local client traffic with respect to the guest traffic, default ACLs are pushed for guest clients.

If a WLAN has an EoGRE guest tunnel profile, you can push the default ACLs to block traffic to the local subnet and ACLs to block the multicast traffic for guest clients.

The following example shows you the recommended configuration of ACLs for guest clients:

IPv4 ACL

```
Device# configure terminal
Device(config)# ip access-list extended igmp
Device(config-ext-nacl)# 10 deny igmp any any
Device(config-ext-nacl)# 20 permit ip any any

Device(config)# wireless profile flex igmp-flex
Device(config-wireless-flex-profile)# acl-policy igmp

Device(config)# wireless tag site sp-flex-site
Device(config-site-tag)# flex-profile igmp-flex
Device(config-site-tag)# no local-site

Device# show ip access-lists
Extended IP access list igmp
    1 deny igmp any any
    2 permit ip any any
```

IPv6 ACL

```
Device(config)# wireless profile flex igmp-flex
Device(config-wireless-flex-profile)# acl-policy igmp
Device(config-wireless-flex-profile)# acl-policy mldv6

Device(config)# ipv6 access-list igmp
Device(config-ipv6-acl)# sequence 10 deny icmp any any mld-query
Device(config-ipv6-acl)# sequence 20 deny icmp any any mld-reduction
Device(config-ipv6-acl)# sequence 30 deny icmp any any mld-report
Device(config-ipv6-acl)# sequence 40 deny icmp any any mld-v2-report
Device(config-ipv6-acl)# sequence 50 permit ipv6 any any
Device(config-ipv6-acl)# acl-policy mldv6

Device# show ipv6 access-list
Extended IPv6 access list mldv6
    10 deny 58 any any
    20 deny 58 any any
    30 deny 58 any any
    40 deny 58 any any
    50 permit ipv6 any any

Device(config)# wireless profile policy policy-name
Device(config-wireless-policy)# ipv4 acl igmp
Device(config-wireless-policy)# ipv6 acl mldv6
```

Verifying Centralized EoGRE Guest Clients

To verify the centralized EoGRE guest clients, run the following command:

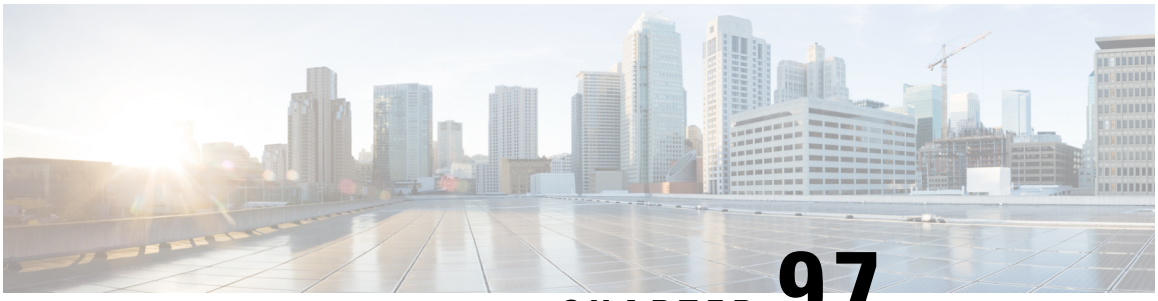
```
Device# show tunnel eogre client central-forwarding summary
Client MAC      AP MAC          Domain                          Tunnel        VLAN
-------------------------------------------------------------------------------------
74xx.38xx.88xx  0cxx.f8xx.9cxx  domain1                         N/A           2121
74xx.38xx.88xx  0cd0.f8xx.9cxx  domain1                         N/A           2121
74xx.38xx.88xx  0cd0.f8xx.9cxx  domain1                         N/A           2121
```



PART XIV

Cisco DNA Service for Bonjour

- Cisco DNA Service for Bonjour Solution Overview, on page 963
- Configuring Local Area Bonjour for Embedded Wireless Controller Access Point Mode, on page 975



CHAPTER 97

Cisco DNA Service for Bonjour Solution Overview

- About the Cisco DNA Service for Bonjour Solution, on page 963
- Solution Components, on page 964
- Supported Platforms, on page 965
- Supported Network Design, on page 966

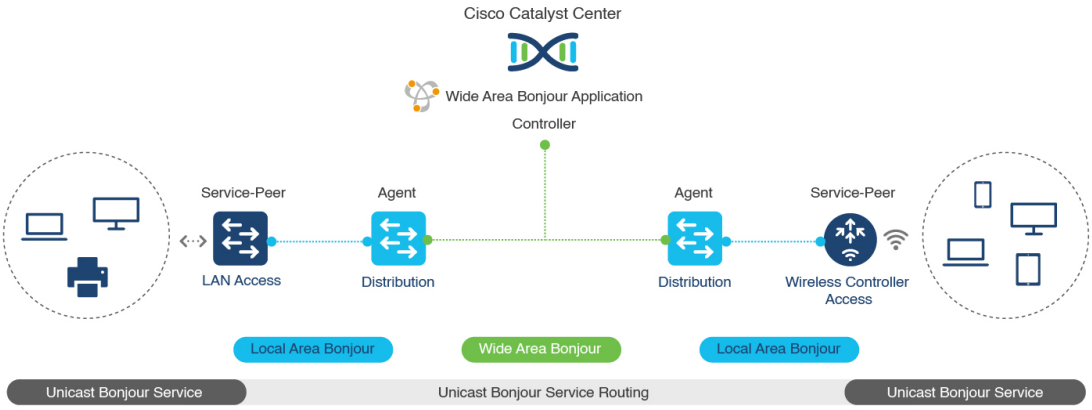
About the Cisco DNA Service for Bonjour Solution

The Apple Bonjour protocol is a zero-configuration solution that simplifies rich services and enables intuitive experience between connected devices, services, and applications. Using Bonjour, you can discover and use IT-managed, peer-to-peer, audio and video, or Internet of Things (IoT) services with minimal intervention and technical knowledge. Bonjour is originally designed for single Layer 2 small to mid-size networks, such as home or branch networks. The Cisco DNA Service for Bonjour solution eliminates the single Layer 2 domain constraint and expands the matrix to enterprise-grade traditional wired and wireless networks, including overlay networks such as Cisco Software-Defined Access (SD-Access) and industry-standard BGP EVPN with VXLAN. The Cisco Catalyst 9000 Series LAN switches, Cisco Nexus 9300 Series Switches, and Cisco Catalyst 9800 Series Wireless Controller follow the industry standard, RFC 6762-based multicast DNS (mDNS) specification to support interoperability with various compatible wired and wireless consumer products in enterprise networks.

The Cisco Wide Area Bonjour application on Catalyst Center enables mDNS service routing to advertise and discover services across enterprise-grade wired and wireless networks. The new-distributed architecture is designed to eliminate mDNS flood boundaries and transition to unicast-based service routing, providing policy enforcement points and enabling the management of Bonjour services.

The following figure illustrates how the Cisco Wide Area Bonjour application operates across two integrated service-routing domains.

Figure 17: Cisco Wide Area Bonjour Solution Architecture



- **Local Area Service Discovery Gateway Domain - Unicast Mode**: The new enhanced Layer 2 unicast policy-based deployment model. The new mDNS service discovery and distribution using the Layer 2 unicast address enables flood-free LAN and wireless networks. Cisco Catalyst 9000 Series Switches and Cisco Catalyst 9800 Series Wireless Controller in Layer 2 mode introduce a new service-peer role, replacing the classic flood-n-learn, for new unicast-based service routing support in the network. The service-peer switch and wireless controller also replace mDNS flood-n-learn with unicast-based communication with any RFC 6762 mDNS-compatible wired and wireless endpoints.
- **Wide-Area Service Discovery Gateway Domain**: The Wide Area Bonjour domain is a controller-based solution. The Bonjour gateway role and responsibilities of Cisco Catalyst and Cisco Nexus 9300 Series Switches are extended from a single SDG switch to an SDG agent, enabling Wide Area Bonjour service routing beyond a single IP gateway. The network-wide distributed SDG agent devices establish a lightweight, stateful, and reliable communication channel with a centralized Catalyst Center controller running the Cisco Wide Area Bonjour application. The SDG agents route locally discovered services based on the export policy.

Note The classic Layer 2 multicast flood-n-learn continues to be supported on wired and wireless networks with certain restrictions to support enhanced security and location-based policy enforcement. The Cisco Catalyst and Cisco Nexus 9300 Series Switches at Layer 3 boundary function as an SDG to discover and distribute services between local wired or wireless VLANs based on applied policies.

Solution Components

The Cisco DNA Service for Bonjour solution is an end-to-end solution that includes the following key components and system roles to enable unicast-based service routing across the local area and Wide Area Bonjour domain:

- **Cisco Service Peer**: Cisco Catalyst Switches and Cisco Wireless Controllers in Layer 2 access function in service peer mode to support unicast-based communication with local attached endpoints and export service information to the upstream Cisco Catalyst SDG agent in the distribution layer.

Note Cisco Nexus 9300 Series Switches don't support unicast-based service routing with downstream Layer 2 access network devices.

- **Cisco SDG Agent**: Cisco Catalyst and Cisco Nexus 9300 Series Switches function as an SDG agent and communicate with the Bonjour service endpoints in Layer 3 access mode. At the distribution layer, the SDG agent aggregates information from the downstream Cisco service peer switch and wireless controller, or local Layer 2 networks, and exports information to the central Catalyst Center controller.

Note Cisco Nexus 9300 Series Switches don't support multilayer LAN-unicast deployment mode.

- **Catalyst Center controller**: The Catalyst Center controller builds the Wide Area Bonjour domain with network-wide and distributed trusted SDG agents using a secure communication channel for centralized services management and controlled service routing.
- **Endpoints**: A Bonjour endpoint is any device that advertises or queries Bonjour services conforming to RFC 6762. The Bonjour endpoints can be in either LANs or WLANs. The Cisco Wide Area Bonjour application is designed to integrate with RFC 6762-compliant Bonjour services, including AirPlay, Google Chrome cast, AirPrint, and so on.

Supported Platforms

The following table lists the supported controllers, along with the supported hardware and software versions.

Table 56: Supported Controllers with Supported Hardware and Software Versions

Supported Controller	Hardware	Software Version
Catalyst Center appliance	DN2-HW-APL DN2-HW-APL-L DN2-HW-APL-XL	Catalyst Center, Release 2.3.7.6
Catalyst Center on ESXi	—	Catalyst Center, Release 2.3.7.6
Cisco Wide Area Bonjour application on Catalyst Center	—	2.4.718.75196
Cisco Wide Area Bonjour application on Catalyst Center on ESXi	—	2.718.77018

The following table lists the supported SDG agents along with their licenses and software requirements.

Table 57: Supported SDG Agents with Supported License and Software Requirements

Supported Platform	Supported Role	Local Area SDG	Wide Area SDG	Minimum Software
Cisco Catalyst 9200 Series Switches	SDG agent Service peer	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Catalyst 9200L Series Switches	SDG agent Service peer	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Catalyst 9300 and 9300-X Series Switches	Service peer SDG agent	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Catalyst 9400 and 9400-X Series Switches	Service peer SDG agent	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Catalyst 9500 and 9500-X Series Switches	Service peer SDG agent	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Catalyst 9500 High Performance Series Switches	Service peer SDG agent	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Catalyst 9600 and 9600-X Series Switches	Service peer SDG agent	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Catalyst 9800 Wireless Controller	Service peer	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Catalyst 9800-L Wireless Controller	Service peer	Cisco DNA Advantage	Cisco DNA Advantage	Cisco IOS XE Release 17.11.1
Cisco Nexus 9300 Series Switches	SDG agent	Cisco DNA Advantage	Cisco DNA Advantage	Cisco NX-OS Release 10.2(3)F

Supported Network Design

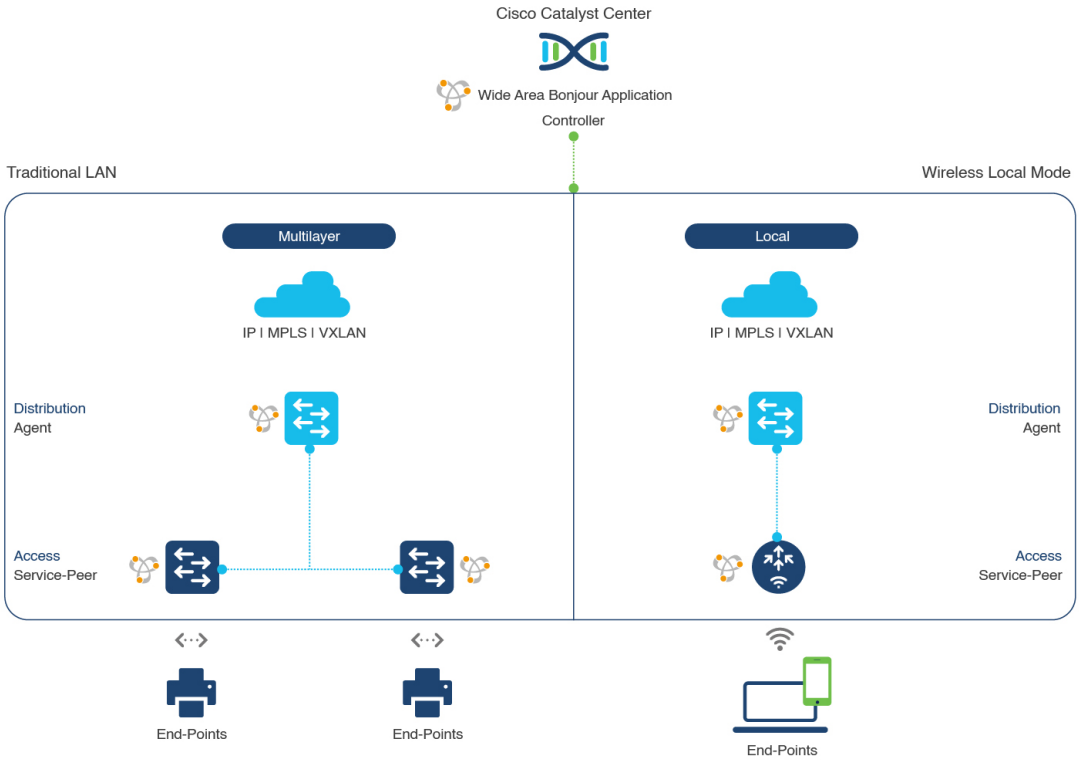
The Cisco DNA Service for Bonjour supports a broad range of enterprise-grade networks. The end-to-end unicast-based Bonjour service routing is supported on traditional, Cisco SD-Access, and BGP EVPN-enabled wired and wireless networks.

Traditional Wired and Wireless Networks

Traditional networks are classic Layer 2 or Layer 3 networks for wired and wireless modes deployed in enterprise networks. Cisco DNA Service for Bonjour supports a broad range of network designs to enable end-to-end service routing and replace flood-n-learn-based deployment with a unicast mode-based solution.

The following figure illustrates traditional LAN and central-switching wireless local mode network designs that are commonly deployed in an enterprise.

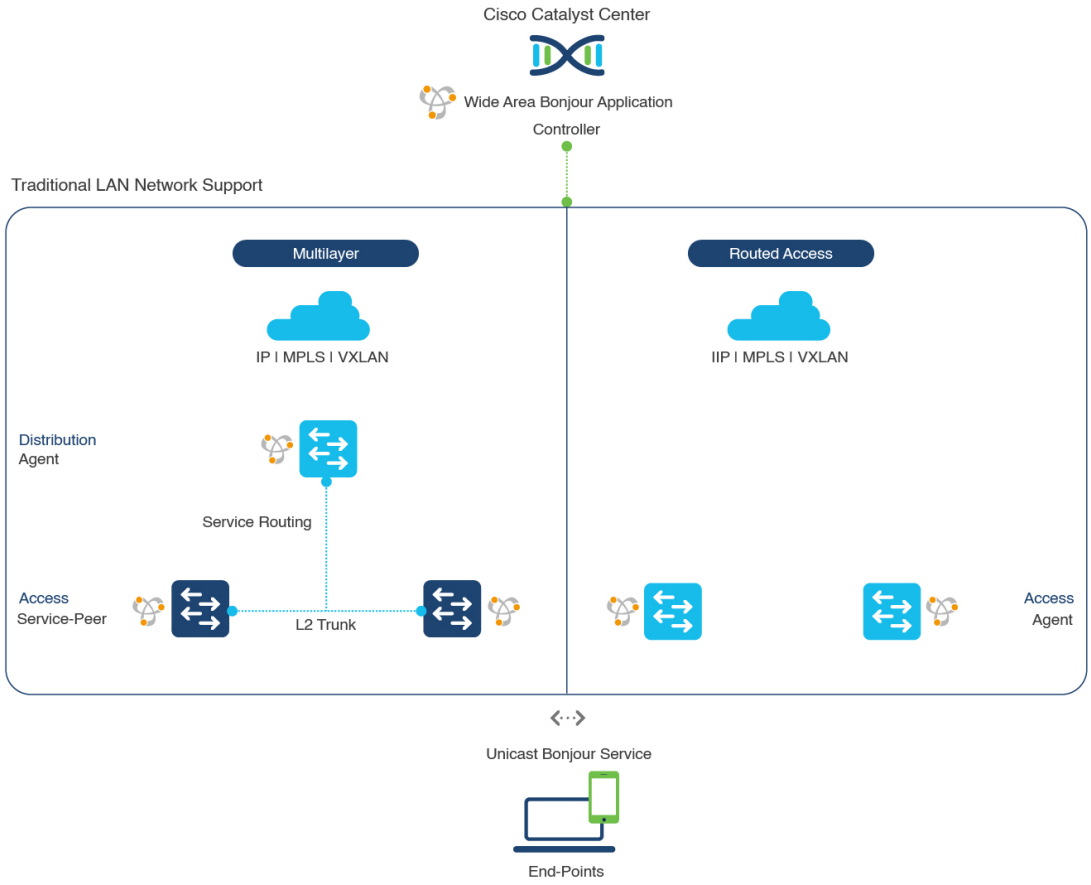
Figure 18: Enterprise Traditional LAN and Wireless Local Mode Network Design



Wired Networks

The following figure shows the supported traditional LAN network designs that are commonly deployed in an enterprise.

Figure 19: Enterprise Wired Multilayer and Routed Access Network Design



The Cisco Catalyst or Cisco Nexus 9300 Series Switches in SDG agent role that provide Bonjour gateway functions are typically IP gateways for wired endpoints that could reside in the distribution layer in multilayer network designs, or in the access layer in Layer 3 routed access network designs:

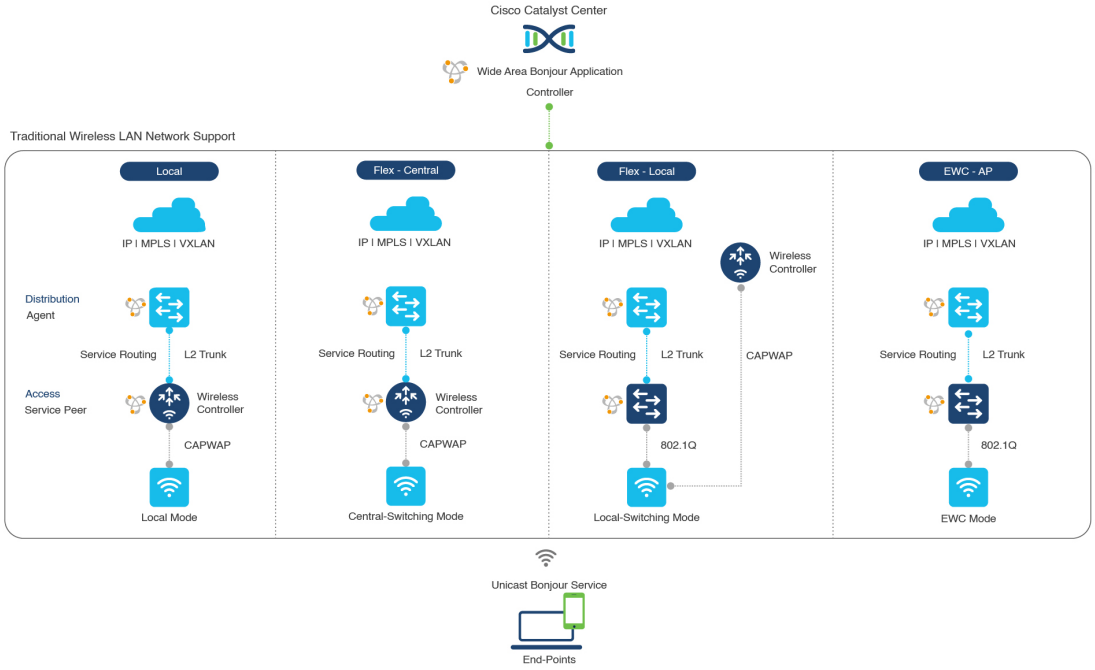
- **Multilayer LAN—Unicast Mode**: In this deployment mode, the Layer 2 access switch provides the first-hop mDNS gateway function to locally attached wired endpoints. In unicast mode, the mDNS services are routed to the distribution layer systems providing IP gateway and SDG agent mode. The policy-based service routing between the SDG agents is performed by the Catalyst Center controller.
- **Multilayer LAN—Flood-n-Learn Mode**: In this deployment mode, the Layer 2 access switch or wireless controller are in mDNS passthrough modes with the Cisco Catalyst or Cisco Nexus 9300 Series Switches operating in the SDG agent mode. The mDNS gateway function at distribution layer in a network enables inter-VLAN mDNS local proxy. It also builds stateful Wide Area Bonjour unicast service routing with the Catalyst Center to discover or distribute mDNS services beyond a single IP gateway.
- **Routed Access**: In this deployment mode, the first-hop Cisco Catalyst or Cisco Nexus 9300 Series Switch is an IP gateway boundary and, therefore, it must also perform the SDG agent role. The policy-based service routing between the SDG agents is performed by the Catalyst Center controller.

Wireless Networks

The Cisco DNA Service for Bonjour extends the single wireless controller mDNS gateway function into the Wide Area Bonjour solution. The mDNS gateway on Cisco Catalyst 9800 Series Wireless Controller can be deployed in an enhanced mode as a service peer. In this mode, the wireless controller builds unicast service routing with an upstream Cisco Catalyst gateway switch for end-to-end mDNS service discovery. It replaces the classic flood-n-learn mDNS services from wired network using mDNS AP or other methods.

The following figure shows the supported traditional wireless LAN network designs that are commonly deployed in an enterprise. Based on the wireless network design, the mDNS gateway function may be on the wireless controller, or first-hop Layer 2 or Layer 3 Ethernet switch of an Access Point in local-switching mode.

Figure 20: Enterprise Traditional Wireless LAN Network Design



The Cisco DNA Service for Bonjour supports the following modes for wireless LAN networks:

- **Local Mode**: In the central switching wireless deployment mode, the m-DNS traffic from local mode Cisco access points is terminated on the Cisco Catalyst 9800 Series Wireless Controller. The Cisco Catalyst 9800 Series Wireless Controller extends the mDNS gateway function to the new service peer mode. The wireless controller can discover and distribute services to local wireless users and perform unicast service routing over a wireless management interface to the upstream Cisco Catalyst Switch in the distribution layer, which acts as the IP gateway and the SDG agent.
- **FlexConnect—Central**: The mDNS gateway function for Cisco access point in FlexConnect central switch SSID functions consistently as described in **Local Mode**. The new extended mDNS gateway mode on the Cisco Wireless Controller and upstream service routing with SDG agent operate consistently to discover services across network based on policies and locations.
- **FlexConnect—Local**: In FlexConnect local switching mode, the Layer 2 access switch in mDNS gateway service peer mode provides the policy-based mDNS gateway function to locally attached wired and wireless users. The Cisco Catalyst Switches in the distribution layer function as SDG agents and enable

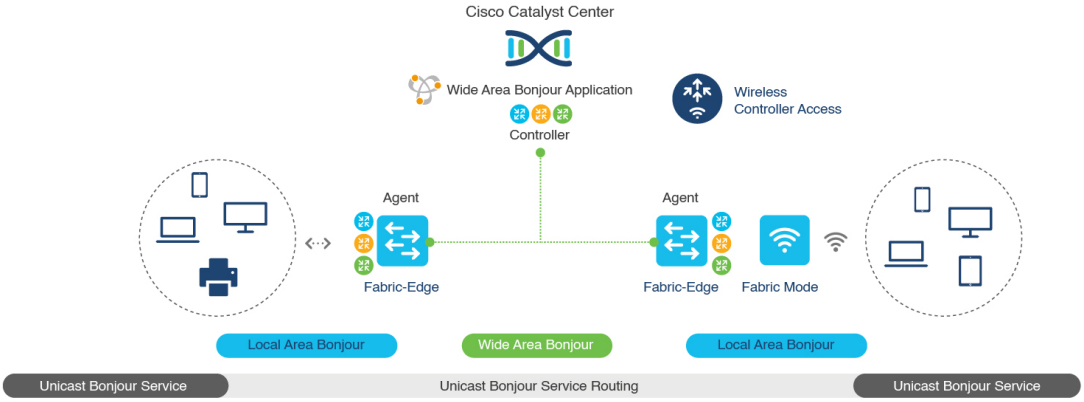
mDNS service-routing across all Layer 2 ethernet switches to support unicast-based service routing to LAN and wireless LAN user groups.

- **Embedded Wireless Controller—Access Point**: The Layer 2 access switch in service peer mode provides unified mDNS gateway function to wired and wireless endpoints associated with Cisco Embedded Wireless Controller on Cisco Catalyst 9100 Series Access Points. The SDG agent in the distribution layer provides unicast service routing across all Layer 2 service peer switches in the Layer 2 network block without any mDNS flooding.

Cisco SD-Access Wired and Wireless Networks

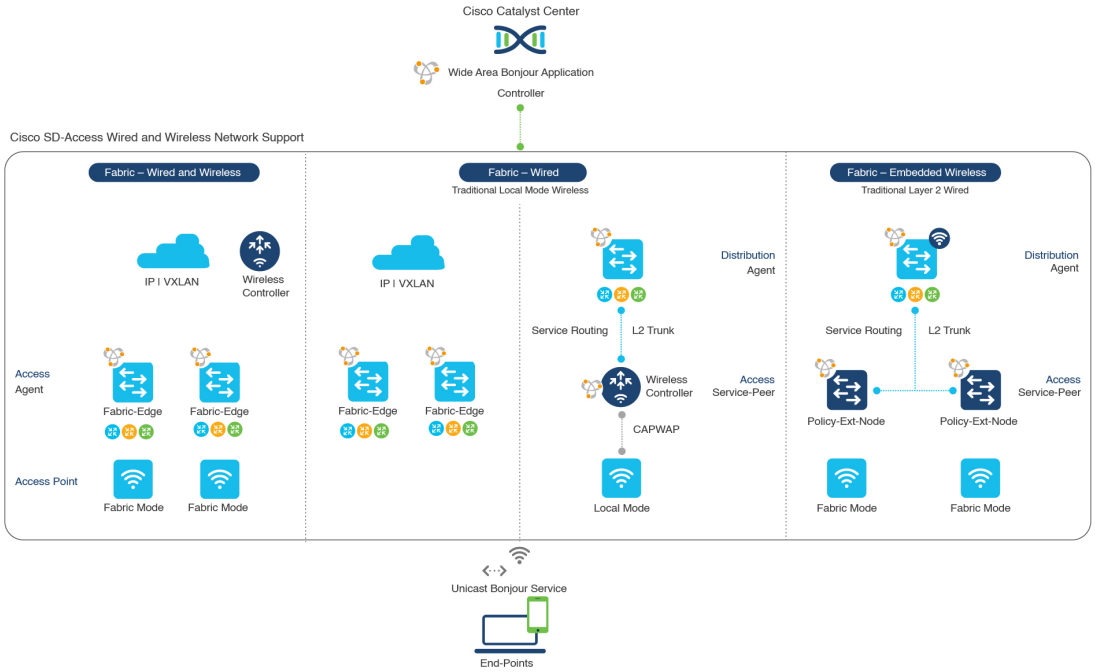
Cisco SD-Access-enabled wired and wireless networks support Cisco DNA Service for Bonjour across fabric networks. The Cisco Catalyst 9000 Series Switches support VRF-aware Wide Area Bonjour service routing to provide secure and segmented mDNS service discovery and distribution management for virtual networks. The VRF-aware unicast service routing eliminates the need to extend Layer 2 flooding, and improves the scale and performance of the fabric core network and endpoints.

Figure 21: Cisco SD-Access Wired and Wireless Network Design



Cisco SD-Access supports flexible wired and wireless network design alternatives to manage fully distributed, integrated, and backward-compatible traditional network infrastructure. Wide Area Bonjour service routing is supported in all network designs providing intuitive user experience. The following figure illustrates the various SD-Access enabled wired and wireless network design alternatives.

Figure 22: Cisco SD-Access Wired and Wireless Network Design Alternatives



The Cisco DNA Service for Bonjour for SD-Access enabled wired and fabric, or traditional mode-wireless networks use two-tier service routing providing end-to-end unicast-based mDNS solution. Based on the network design, each solution component is enabled in a unique role to support the Wide Area Bonjour domain:

- **Fabric Edge SDG Agent**: The Layer 3 Cisco Catalyst Fabric Edge switch in the access layer configured as SDG agent provides unicast-based mDNS gateway function to the locally attached wired and wireless endpoints. The VRF-aware mDNS service policy provides network service security and segmentation in a virtual network environment. The mDNS services can be locally distributed and routed through centralized Catalyst Center.
- **Policy Extended Node**: The Layer 2 Cisco Catalyst access layer switch enables first-hop mDNS gateway function without flooding across the Layer 2 broadcast domain. The unicast-based service routing with upstream Fabric Edge switch in the distribution layer enables mDNS service routing within the same Layer 2 network block. It can also perform remote service discovery and distribution from centralized Catalyst Center.
- **Cisco Wireless Controller**: Based on the following wireless deployment modes, Cisco Wireless Controller supports unique function to enable mDNS service routing in Cisco SD-Access enabled network:
  - **Fabric-Enabled Wireless**: Cisco Wireless Controller doesn't require any mDNS gateway capability to be enabled in distributed fabric-enabled wireless deployments.
  - **Local Mode Wireless**: As Cisco Wireless Controller provides central control and data plane termination, it provides mDNS gateway in service peer mode for wireless endpoints. The wireless controller provides mDNS gateway between locally associated wireless clients. The wireless controller builds service routing with upstream SDG agent Catalyst switch providing IP gateway and service routing function for wireless endpoints.
  - **Embedded Wireless Controller—Switch**: The Cisco Embedded Wireless Controller solution enables the lightweight integrated wireless controller function within the Cisco Catalyst 9300 Series

Switch. The Cisco Catalyst switches in the distribution layer function as SDG agents to the wired and wireless endpoints. The SDG agent in the distribution layer provides unicast service routing across all wireless access points and Layer 2 service peer switches without mDNS flooding.

- **Catalyst Center Controller**: The Cisco Wide Area Bonjour application on Catalyst Center supports policy and location-based service discovery, and distribution between network-wide distributed Fabric Edge switches in SDG agent mode.

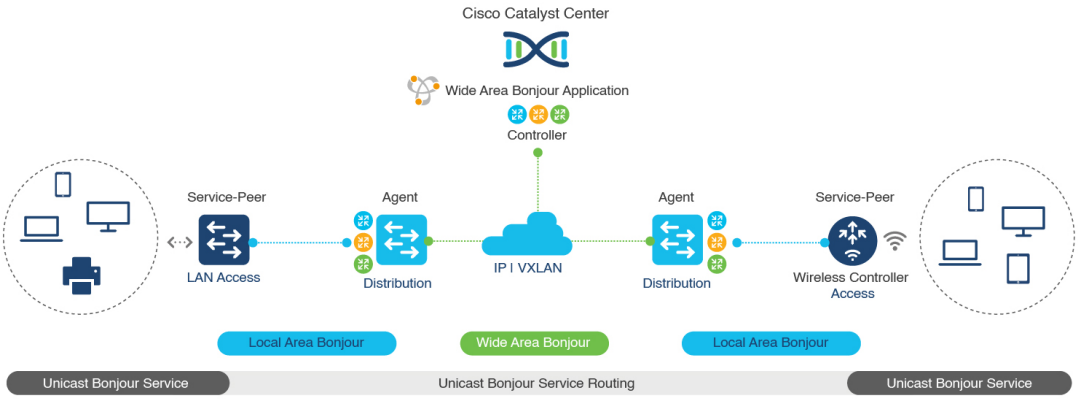
The Wide Area Bonjour communication between the SDG agent and controller takes place through the network underlay. Based on policies, the SDG agent forwards the endpoint announcements or queries to the Catalyst Center. After discovering a service, the endpoints can establish direct unicast communication through the fabric overlay in the same virtual network. The inter-virtual network unicast communication takes place through the Fusion router or external Firewall system. This communication is subject to the configured overlay IP routing and Security Group Tag (SGT) policies.

BGP EVPN Networks

The BGP EVPN-based technology provides a flexible Layer 3 segmentation and Layer 2 extension overlay network. The VRF and EVPN VXLAN-aware Wide Area Bonjour service routing provides secure and segmented mDNS service solution. The overlay networks eliminate mDNS flooding over EVPN-enabled Layer 2 extended networks and solve the service reachability challenges for Layer 3 segmented routed networks in the fabric.

The following figure shows the BGP EVPN leaf switch in the distribution layer, supporting overlay Bonjour service routing for a BGP EVPN-enabled traditional Layer 2 wired access switch and traditional wireless local mode enterprise network interconnected through various types of Layer 2 networks and Layer 3 segmented VRF-enabled networks.

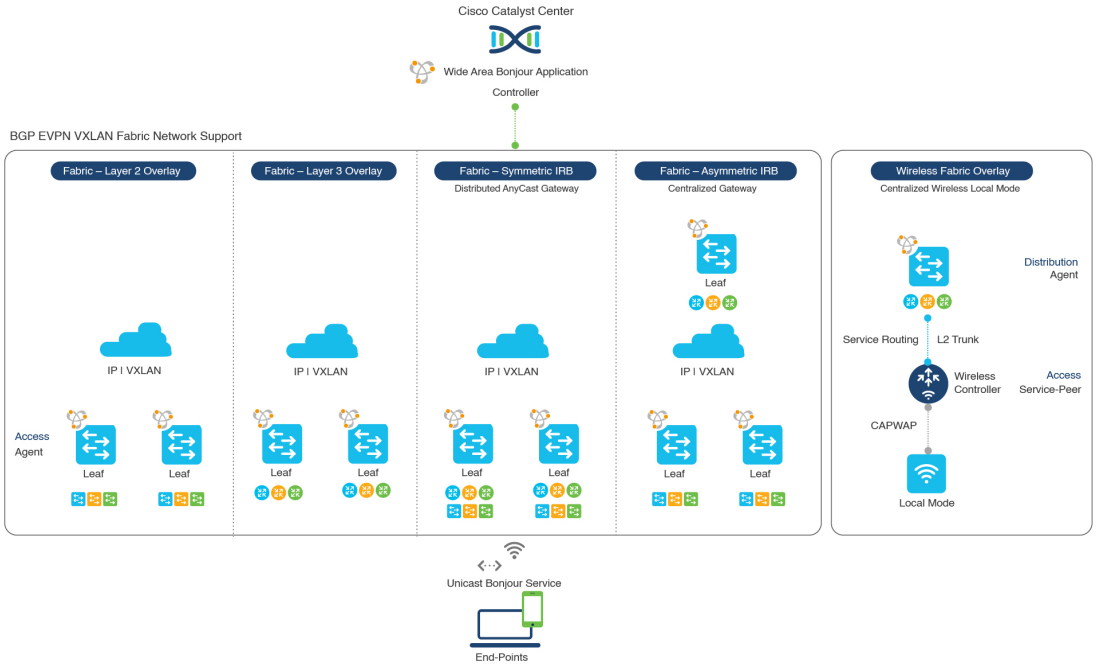
Figure 23: Overlay Bonjour Service for a BGP EVPN-Enabled Enterprise Network



Cisco DNA Service for Bonjour supports all the industry-standard overlay network designs enabling end-to-end unicast-based mDNS service routing, and preventing flooding and service boundary limitation across wired and wireless networks.

The following figure illustrates the various BGP EVPN VXLAN reference overlay network design alternatives. This network design enables end-to-end mDNS service discovery and distribution based on overlay network policies.

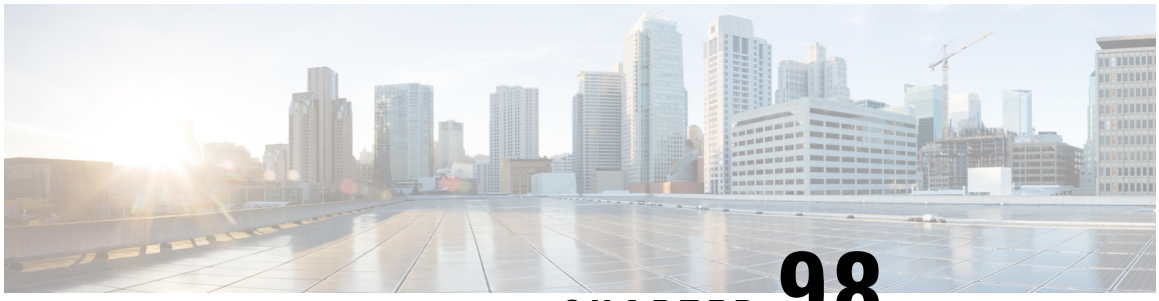
Figure 24: BGP EVPN VXLAN Wired and Wireless Design Alternatives



The Cisco Catalyst and Cisco Nexus 9000 Series Switches can be deployed in Layer 2 or Layer 3 leaf roles supporting mDNS service routing for a broad range of overlay networks. In any role, the mDNS communication is limited locally and supports end-to-end unicast-based service routing across Wide Area Bonjour domain:

- **Layer 2 Leaf SDG Agent**: The Cisco Catalyst or Cisco Nexus switches can be deployed as Layer 2 leaf supporting end-to-end bridged network with IP gateway within or beyond BGP EVPN VXLAN fabric network. By default, the mDNS is flooded as Broadcast, Unknown Unicast, Multicast (BUM) over the fabric-enabled core network. This mDNS flooding may impact network performance and security. The Layer 2 leaf, enabled as SDG agent, prevents mDNS flooding over VXLAN and supports unicast-based service routing.
- **Layer 3 Leaf SDG Agent**: The Cisco Catalyst or Cisco Nexus switches can be deployed as SDG agent supporting Layer 3 overlay network in BGP EVPN VXLAN fabric. The IP gateway and mDNS service boundary is terminated at the SDG agent switches and remote services can be discovered or distributed through centralized Catalyst Center.
- **Local Mode Wireless**: The centralized wireless local mode network can be terminated within or outside the EVPN VXLAN fabric domain to retain network segmentation and service discovery for wireless endpoints. The Cisco Catalyst 9800 Series Wireless Controller in service peer mode can build unicast service routing with distribution layer IP and SDG agent Cisco Catalyst switch to discover services from BGP EVPN VXLAN fabric overlay network.
- **Catalyst Center**: Catalyst Center supports Wide Area Bonjour capability to dynamically discover and distribute mDNS services based on Layer 2 or Layer 3 Virtual Network ID (VNID) policies to route the mDNS services between SDG agent switches in the network.

For more information about BGP EVPN networks, see *Cisco DNA Service for Bonjour Configuration Guide, Cisco IOS XE Bengaluru 17.6.x (Catalyst 9600 Switches)*.



CHAPTER 98

Configuring Local Area Bonjour for Embedded Wireless Controller Access Point Mode

- Overview of Local Area Bonjour for Embedded Wireless Controller - Access Point Mode, on page 975
- Restrictions for Local Area Bonjour for Embedded Wireless Controller - Access Point Mode, on page 976
- Prerequisites for Local Area Bonjour for Embedded Wireless Controller - Access Point Mode, on page 976
- Understanding EWC Mode mDNS Gateway Alternatives, on page 977
- Understanding Local Area Bonjour for Embedded Wireless Controller Access Point Mode, on page 978
- Configuring Local Area Bonjour for Embedded Wireless Controller Access Point Mode, on page 979
- Verifying Local Area Bonjour in Service-Peer Mode, on page 993
- Verifying Local Area Bonjour in SDG Agent Mode, on page 994
- Reference, on page 996

Overview of Local Area Bonjour for Embedded Wireless Controller - Access Point Mode

The Cisco Embedded Wireless Controller on Catalyst Access Points introduces unicast mode function in Local Area Bonjour network domain. The enhanced gateway function at the first hop of wired and wireless networks communicate directly with any industry standard RFC 6762 compliant multicast DNS (mDNS) end point in Layer 2 unicast mode.

The Cisco Catalyst 9100 series Access Points (AP) support distributed wireless forwarding with Embedded Wireless Controller (EWC) in Local-Switching mode. The Catalyst 9000 series LAN switch introduces new Service-Peer mode to support mDNS gateway for locally attached wired and wireless endpoints in Unicast mode. The mDNS service discovery and distribution boundary is expanded from single-gateway to end-to-end service-routing with upstream SDG Agent switch to enable unicast-mode, increased scale, performance, and resiliency in the network.

Restrictions for Local Area Bonjour for Embedded Wireless Controller - Access Point Mode

- The mDNS gateway on EWC Cisco Catalyst 9100 series Access Points does not support service-peer mode to enable service-routing and unicast mode mDNS communication.
- The mDNS gateway on EWC Catalyst 9100 series Access Points must be in disabled state.
- The mDNS bridging is required, allowing mDNS service discovery and distribution from locally attached mDNS gateway Layer 2 access switch in Service-Peer mode.
- The Catalyst 9000 series switches in Service-Peer mode supports per Layer 2 access switch level Location-Based service for wireless users connected to EWC mode Access Point and Wired endpoints.

Prerequisites for Local Area Bonjour for Embedded Wireless Controller - Access Point Mode

The EWC mode Cisco Catalyst 9100 series Access Points must be successfully configured and operational before implementing Cisco Local Area Bonjour for EWC AP mode wireless networks.

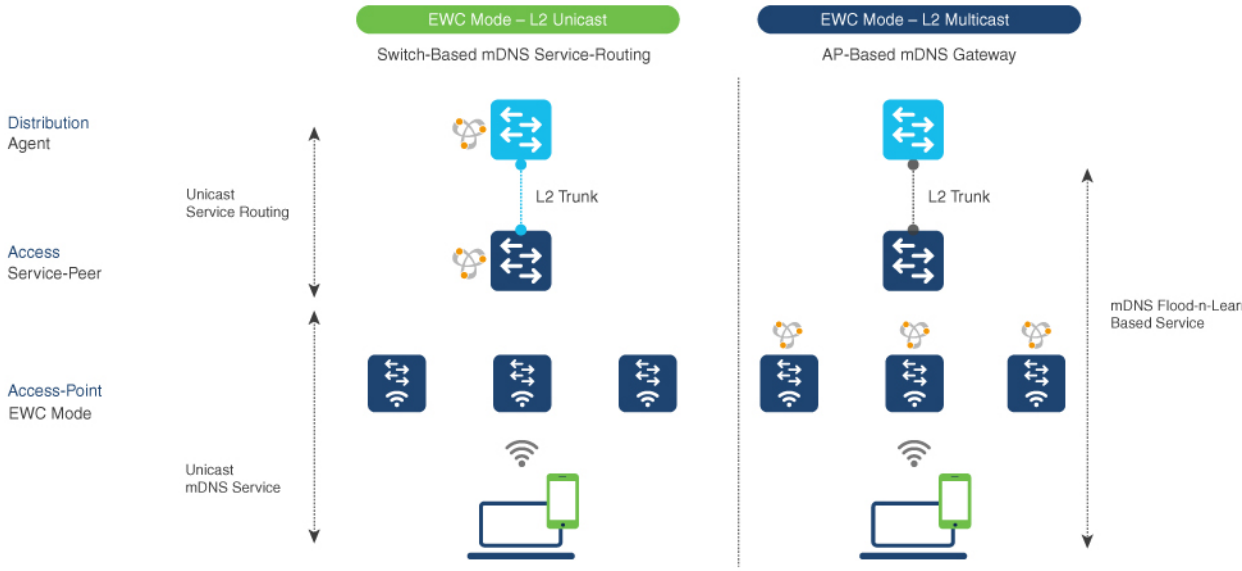
The following are the pre-requisites verified on EWC mode AP and the Layer 2 access Cisco Catalyst 9000 series switches deployed in Service-Peer mode supporting mDNS gateway for wired and wireless users:

- The EWC mode Cisco Catalyst 9100 series Access Point must be pre-configured to implement wireless network and other advanced parameters. For more information, see the Cisco Embedded Wireless Controller on Catalyst Access Points Configuration Guide .
- The EWC mode Cisco Catalyst 9100 series Access Point may run operate recommended IOS-XE software version. There are no mDNS requirements and software version dependency on EWC mode AP to enable Local Area Bonjour gateway.
- Ensure that the targeted controller for Service-Peer role has the required Cisco IOS XE software version.
- Ensure that the controller runs a valid Cisco DNA-Advantage license.
- Ensure that the upstream distribution-layer Cisco Catalyst switch in SDG-Agent mode runs a valid Cisco DNA-Advantage license.
- Ensure that the controller is interconnected as Layer 2 trunk in multi-layer network, when Layer 2 Unicast service-routing is running between SDG-Agent in distribution-layer and the controller service-peer.
- Ensure the Catalyst 9000 access layer switches have IP reachability to upstream Cisco Catalyst 9000 series switches in SDG Agent mode over IPv4 subnet. that is, switch management IP network

Understanding EWC Mode mDNS Gateway Alternatives

The Cisco Catalyst controllers continue to innovate mDNS gateway function to address evolving business and technical requirements in enterprise networks. The EWC mode Access Point based wireless networks can implement mDNS gateway using following two methods as displayed in figure below:

Figure 25: EWC Mode Access Point mDNS Gateway Alternatives



The mDNS gateway for EWC mode Access Point wireless network can be implemented using in either mode to address service discovery and distribution based on operating network environment:

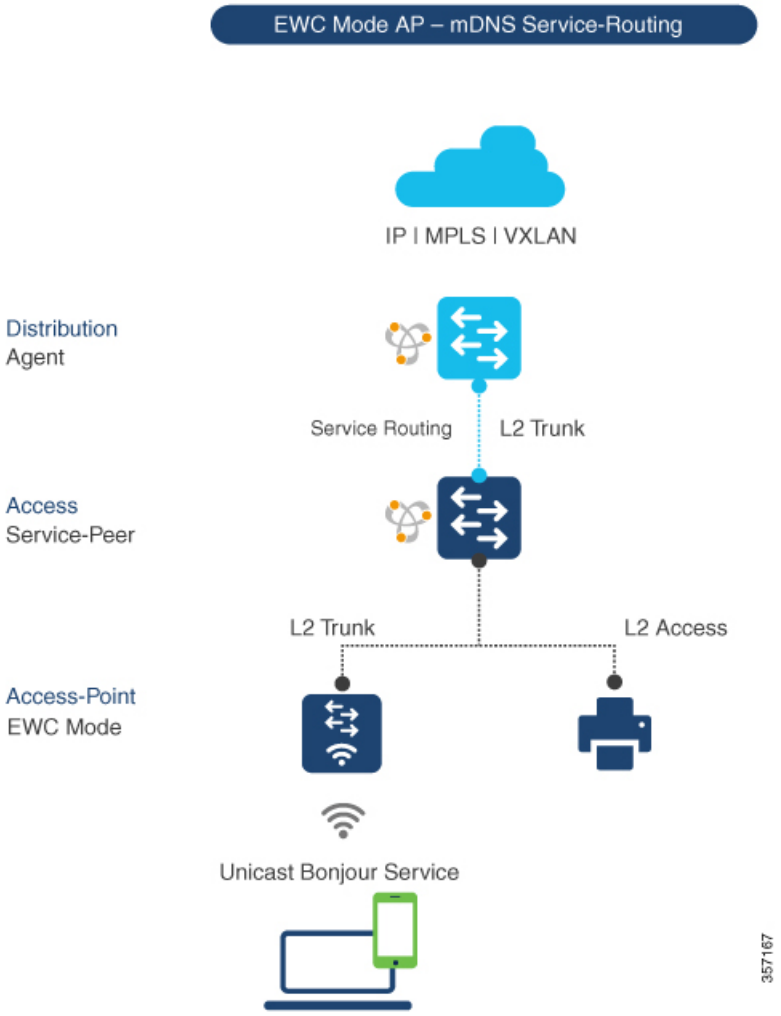
- **Switch Based mDNS Gateway**– Catalyst 9000 series switch in Layer 2 access can be implemented as mDNS gateway in Service-Peer role supporting following key benefits:
  - Replaces flood-n-learn with new enhanced Unicast-based mDNS communication with locally attached wired and EWC mode Access Point wireless users.
  - The Catalyst 9000 eliminates mDNS flood with Unicast service-routing to LAN distribution. The Unicast service-routing between LAN distribution and Layer 2 access layer switches forms Local Area Bonjour domain to enable policy and location-based service discovery and distribution. The unicast based service-routing over Layer 2 trunk eliminates mDNS flood-free and enables service-oriented wired and wireless networks.
  - The switch-based mDNS gateway solution eliminates requirement to forward wired network traffic to wireless APs improving wireless scale, performance and network reliability.
- **AP Based mDNS Gateway** – The Cisco EWC mode Access Point can alternatively be implemented as mDNS gateway in case if connected to unsupported LAN access switch. In this classic method the mDNS service discovery and distribution follows flood-n-learn mechanic over the Layer 2 wired and wireless network. Refer to Multicast Domain Name System chapter module for Cisco Embedded Wireless Controller Configuration Guide, Release 17.3.1 to implement AP based mDNS gateway.

Understanding Local Area Bonjour for Embedded Wireless Controller Access Point Mode

The Cisco Catalyst LAN switches and WLC supported mDNS gateway function with various advancements for broad range of Wired and Wireless network types. As the enterprise requirements expands it drives IT organization to introduce new network deployment models, supporting mobile devices and distributed zero-configuration services following increased scale, granular security control and resiliency for mission critical networks. The common unified Cisco IOS-XE operating system across Catalyst 9000 series LAN switches and EWC mode Catalyst 9100 series Access Points enables distributed Bonjour gateway function at network edge and with end-to-end Wide Area Bonjour service-routing the new solution enables service-oriented enterprise networks with intuitive user-experience.

The figure below displays the Cisco Catalyst 9000 series switches connected to EWC mode Access Points that supports the mDNS gateway function to the locally attached EWC mode wireless users and wired users.

Figure 26: Cisco Catalyst Switch and EWC Mode Access Point



The Cisco Catalyst 9000 series switches in Layer 2 access layer and at Layer 3 distribution layer must be configured in following mDNS gateway mode to enable Unicast-based mDNS service-routing between wired and EWC mode Access Points mode wireless users within same Layer 2 network block.

- **Service-Peer**- The Layer 2 access switch connecting Wireless Access-Point in EWC mode must be configured with mDNS gateway in Service-Peer mode. Each Layer 2 access switch provides mDNS gateway function between locally attached wired and EWC mode Access Point wireless users. The Unicast-based mDNS service discovery and distribution within same or different VLANs is supported with bi-directional mDNS policies on single Layer 2 access switch.
- **SDG Agent**- The mDNS flood-n-learn based method in Layer 2 network is replaced with simple Unicast based service-routing between Layer 2 access switch in Service-Peer mode and upstream distribution-layer in mDNS gateway SDG Agent mode. The Unicast based mDNS service-routing eliminates mDNS flood over Layer 2 trunk ports providing increase bandwidth, enhanced security, location-based services and flood control management in wired and EWC mode Access Point wireless network.

Configuring Local Area Bonjour for Embedded Wireless Controller Access Point Mode

This topic describes the configuration steps to implement Layer 2 access layer Cisco Catalyst 9000 series switch as mDNS gateway and enable Service-Peer on Layer 2 access layer switch and the SDG Agent mode. To enable mDNS service discovery and distribution between multiple Layer 2 access switches, service-routing must be enabled with upstream distribution-layer Cisco Catalyst 9000 series switch in SDG Agent mode to build Local Area Bonjour service-routing domain.



Note mDNS gateway must be globally disabled on Catalyst 9100 series Access Point in EWC mode.

Configuring mDNS Gateway Mode (CLI)

To enable mDNS gateway and service-peer mode on Layer 2 access switch and SDG Agent mode on Layer 3 distribution layer switch, follow the procedure given below:

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 the global configuration mode.

	Command or Action	Purpose
Step 3	**mdns-sd gateway** **Example:** `Device(config)# mdns-sd gateway`	Enables mDNS on the Layer 2 Catalyst switch and enters the mDNS gateway configuration mode. (Optional) You can configure the following additional parameters: • **air-print-helper**: Enables communication between Apple iOS devices like iPhone or iPad to discover and use older printers that does not support driverless AirPrint function. • **cache-memory-max**: Configures the percentage memory for cache. • **ingress-client**: Configures Ingress client packet tuners. • **rate-limit**: Enables rate limiting of incoming mDNS packets. • **service-announcement-count**: Configures maximum advertisements. • **service-announcement-timer**: Configures advertisements announcement timer periodicity. • **service-query-count**: Configures maximum queries. • **service-query-timer**: Configures query forward timer periodicity. • **service-type-enumeration**: Configures service enumeration. **Note** For **cache-memory-max**, **ingress-client**, **rate-limit**, **service-announcement-count**, **service-announcement-timer**, **service-query-count**, **service-query-timer**, and **service-type-enumeration** commands, you can retain the default value of the respective parameter for general deployments. Configure a different value, if required, for a specific deployment.
Step 4	**mode** {**service-peer** | **sdg-agent**} **Example:**	Configures mDNS gateway in one of the following modes based on the system settings:

	Command or Action	Purpose
	`Device(config-mdns-sd)# mode service-peer`	• **Service-Peer**– Enables Layer 2 Catalyst access switch in mDNS Service-Peer mode. • **SDG Agent**– Default. Enables Layer 3 distribution layer Catalyst switch in SDG Agent mode to peer with central Cisco DNA Center controller for Wide Area Bonjour service routing.
Step 5	**exit** **Example:** `Device(config-mdns-sd)# exit`	Exits mDNS gateway configuration mode.

Configuring mDNS Service Policy (CLI)

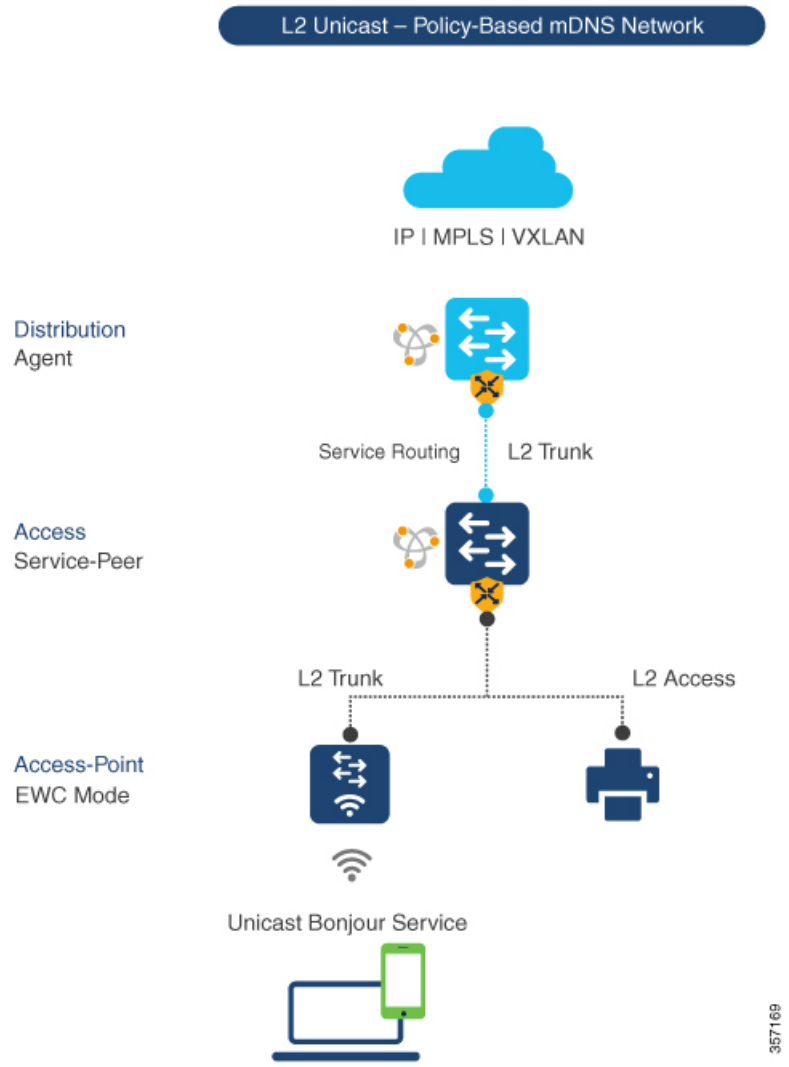
To configure an mDNS service policy, follow the steps given below:

1. Create service-list to permit built-in or user-defined custom service types.
2. Associate service-list to a service-policy to enforce ingress or egress direction.
3. Apply the service policy to the new VLAN configuration mode.

Note You will need this configuration in service-peer mode for Layer 2 Catalyst switch and SDG agent mode for Layer 3 Catalyst switch.

The figure given below displays how to configure mDNS policies on the Catalyst switch in service-peer and SDG agent modes:

Figure 27: Catalyst Service-Peer and SDG Agent mDNS Service Policy Configuration



To build and apply service-policies on target VLAN in service-peer and SDG agent modes, follow the procedure given below:

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 the global configuration mode.

	Command or Action	Purpose

Step 3	**mdns-sd service-list** *service-list-name* {**in** | **out**}
	Example:
	`Device(config)# mdns-sd service-list VLAN100-LIST-IN in`
	`Device(config)# mdns-sd service-list VLAN100-LIST-OUT out`
		Configure mDNS service-list to classify one or more service types. Unique service-list is required to process incoming mDNS message and outbound response to request locally locally connected wired or EWC mode Access Point wireless end points.

Step 4	**match** *service-definition-name* [**message-type** {**any** | **announcement** | **query**}]
	Example:
	`Device(config)# mdns-sd service-list VLAN100-LIST-IN in`
	`Device(config-mdns-sl-in)# match APPLE-TV`
	`Device(config-mdns-sl-in)# match PRINTER-IPPS message-type announcement`
		Matches inbound service-list.
		The Catalyst switch validates to accept or drop incoming mDNS service-type (such as, Apple TV) advertisement or query matching message type from locally connected wired or EWC mode Access Point wireless end points. The service-list contains implicit deny at the end.
		The default message-type used is **any**.

Step 5	**match** *service-definition-name* [**message-type** {**any** | **announcement** | **query**}]
	Example:
	`Device(config)# mdns-sd service-list VLAN100-LIST-OUT out`
	`Device(config-mdns-sl-in)# match APPLE-TV`
	`Device(config-mdns-sl-in)# match PRINTER-IPPS`
		Matches outbound service-list.
		The Catalyst switch provides local service proxy function by responding matching service-type to the requesting end point(s). For example, the Apple-TV and Printer learnt from VLAN 100 will be distributed to EWC mode Access Point wireless in same VLAN 100. The service-list contains implicit deny at the end.
		The message-type for outbound service-list is not required.

Step 6	**mdns-sd service-policy** *service-policy-name* **Example:** `Device(config)# mdns-sd service-policy VLAN100-POLICY`	Creates a unique mDNS service-policy in the global configuration mode.

Step 7	**service-list** *service-list-name* {**in** | **out**}
	Example:
	`Device(config)# mdns-sd service-policy VLAN100-POLICY`
	`Device(config-mdns-ser-policy)# service-list VLAN100-LIST-IN in`
	`Device(config-mdns-ser-policy)# service-list VLAN100-LIST-OUT out`
		Configures an mDNS service-policy to associate service-list for each direction.

Step 8	**vlan configuration** *ID* **Example:** `Device(config)# vlan configuration 100`	Enables wired or wireless EWC mode Access Point user VLAN configuration for advanced service parameters. One or more VLANs can be created for the same settings.

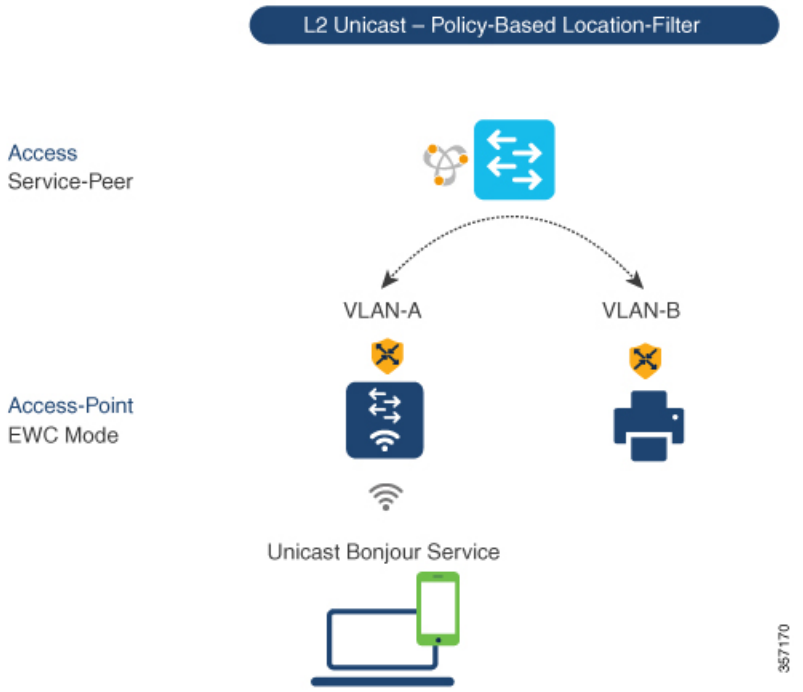
	Command or Action	Purpose
		Here, *ID* refers to the VLAN configuration ID. For example, *vlan configuration 101-110,200* range allows you to configure consecutive and non-consecutive VLAN ID(s) range.
Step 9	**mdns-sd gateway** **Example:** `Device(config-vlan)# mdns-sd gateway`	Enables mDNS gateway on configured wired or EWC mode Access Point wireless user VLAN ID(s).
Step 10	**service-policy** *service-policy-name* **Example:** `Device(config-vlan-mdns)# service-policy VLAN100-POLICY`	Associates mDNS service-policy to the configured wired or EWC mode Access Point wireless user VLAN ID(s).
Step 11	**exit** **Example:** `Device(config-vlan-mdns)# exit`	Exits the mDNS gateway configuration mode.

Configuring mDNS Location-Filter (CLI)

The Layer 2 Cisco Catalyst access-layer switch in the service-peer mode, by default provides local service proxy between mDNS service provider and receiver connected in the same Layer 2 VLAN associated to wired or EWC mode Access Point wireless user networks. Optionally, you can configure mDNS location-filter to allow service discovery and distribution between locally configured VLAN IDs associated to wired or EWC mode Access Point wireless user networks.

The following figure displays and references location-filter policy on Catalyst switch in service-peer mode permitting discovery and distribution of mDNS services between wired and EWC mode Access Point wireless user VLANs.

Figure 28: Catalyst Service-Peer mDNS Location-Filter Configuration



To enable local service proxy on Cisco Catalyst switch in service-peer mode and to discover mDNS services between local wired and wireless EWC mode Access Point user VLANs, follow the procedure given below:

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 the global configuration mode.
Step 3	**mdns-sd location-filter** *location-filter-name* **Example:** `Device(config)# mdns-sd location-filter LOCAL-PROXY`	Configures a unique location-filter in the global configuration mode.
Step 4	**match location-group** {**all** | **default** | **ID**} **vlan** [*ID*] **Example:**	Configures the match criteria to mutually distribute the permitted services between grouped VLANs. For example, mDNS services can be discovered and distributed using the

	Command or Action	Purpose
	`Device(config-mdns-loc-filter)# match location-group default vlan 100` `Device(config-mdns-loc-filter)# match location-group default vlan 101`	unicast-mode between Wireless EWC mode Access Point user VLAN ID 100 and wired user VLAN ID 101.
Step 5	**mdns-sd service-list** *service-list-name* {**in** | **out**} **Example:** `Device(config)# mdns-sd service-list VLAN100-LIST-OUT out`	Configures the mDNS service-list to classify one or more service types. Unique service-list is required to process incoming mDNS message and response outbound requesting wired or EWC mode Access Point user end points.

Step 6	**match** *service-definition-name* [**message-type** {**any** | **announcement** | **query**}]
	Example:
	`Device(config)# mdns-sd service-list VLAN100-LIST-OUT out`
	`Device(config-mdns-sl-out)# match APPLE-TV location-filter LOCAL-PROXY`
		Associates location-filter to one or more service types to enable local proxy between local VLANs. For example, the Apple-TV learnt from VLAN 100 and VLAN 101 will be distributed to receiver in VLAN 100.
		Note
		The service-list contains implicit deny at the end.
		You do not require a **message-type** for the outbound service-list.

Step 7	**mdns-sd service-policy** *service-policy-name* **Example:** `Device(config)# mdns-sd service-policy VLAN100-POLICY`	Creates a unique mDNS service-policy in the global configuration mode.

Step 8	**service-list** *service-list-name* {**in** | **out**}
	Example:
	`Device(config)# mdns-sd service-policy VLAN100-POLICY`
	`Device(config-mdns-ser-policy)# service-list VLAN100-LIST-OUT out`
		Configures an mDNS service-policy to associate the service-list for each direction.

Step 9	**vlan configuration** *ID* **Example:** `Device(config)# vlan configuration 100`	Enables VLAN configuration for advanced service parameters. You can create one or more VLANs with the same settings. Here, *ID* refers to the VLAN configuration ID. For example, *vlan configuration 101-110,200* range allows you to configure consecutive and non-consecutive VLAN ID range.
Step 10	**mdns-sd gateway** **Example:** `Device(config-vlan-config)# mdns-sd gateway`	Enables the mDNS gateway on the configured VLAN ID(s).

	Command or Action	Purpose
Step 11	**service-policy** *service-policy-name* **Example:** `Device(config-vlan-mdns-sd)# service-policy VLAN100-POLICY`	Associates mDNS service-policy to the configured VLAN ID(s).
Step 12	**exit** **Example:** `Device(config-vlan-mdns-sd)# exit`	Exits the mDNS gateway configuration mode.

Configuring Custom Service Definition (CLI)

The Cisco IOS-XE supports various built-in mDNS service-definition types that map to key mDNS PTR records and user-friendly names. For example, built-in Apple-TV service-type is associated with _airplay._tcp.local and _raop._tcp.local PTR records to successfully enable service in the network. Network administrators create custom service-definition with matching mDNS PTR records to enable end mDNS service-routing in the network.

To associate the custom service-definition to the service-list, follow the procedure given below:

Procedure

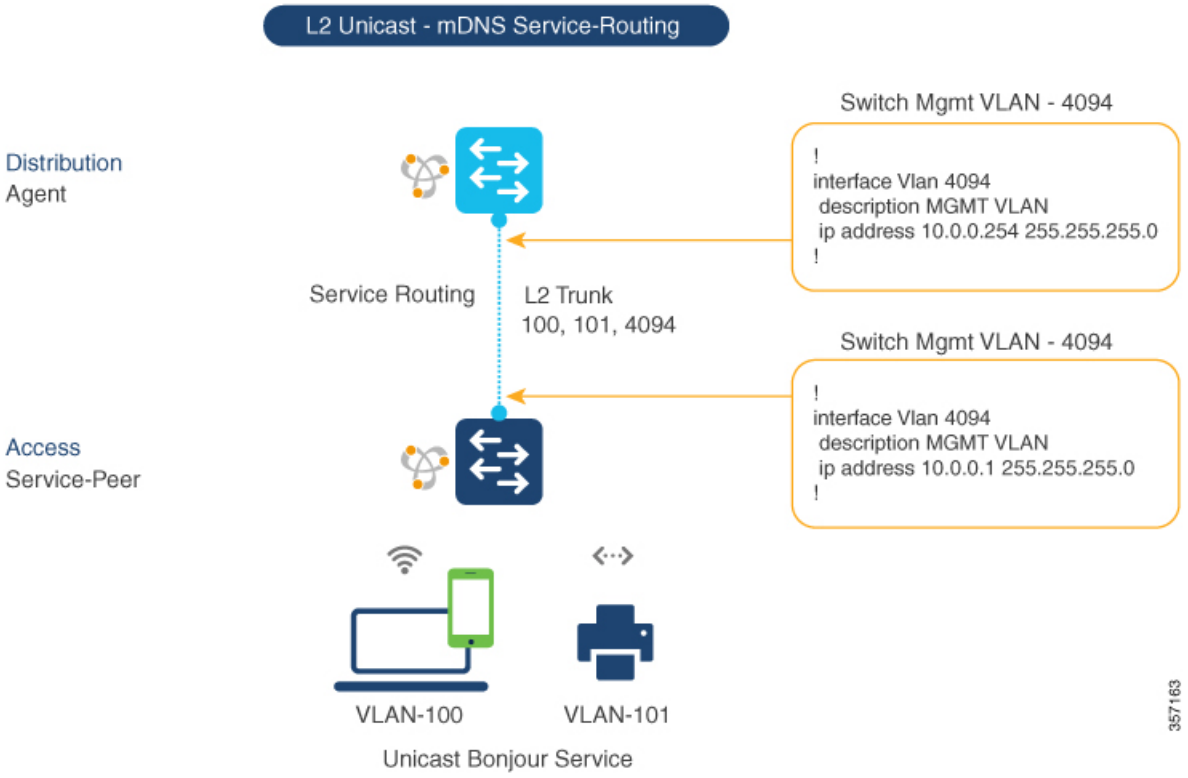
	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables Privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters the global configuration mode.
Step 3	**mdns-sd service-definition** *service-definition-name* **Example:** `Device(config)# mdns-sd service-definition APPLE-CLASSROOM`	Creates a unique service-definition name for custom service-types.
Step 4	**service-type** *custom-mDNS-PTR* **Example:** `Device(config-mdns-ser-def)# service-type _classroom._tcp.local`	Configures a regular-expression string for custom mDNS PoinTeR(PTR) record.
Step 5	**exit** **Example:** `Device(config-mdns-ser-def)# exit`	Exits the mDNS gateway configuration mode.

Configuring Service-Routing on Service-Peer (CLI)

The Layer 2 Cisco Catalyst switch in service-peer mode builds a service-routing with an upstream distribution-layer switch in the SDG Agent mode. To build service-routing, the Layer 2 Cisco Catalyst switch requires at least one interface with valid IP address to reach the upstream SDG Agent Catalyst switch. The switch management port is unsupported.

The following figure displays the topology to enable unicast-based service-routing over Layer 2 trunk between access-layer Catalyst switch in the service-peer mode and distribution-layer Catalyst switch in SDG Agent mode.

Figure 29: Catalyst Service-Peer Service-Routing Configuration



To enable service-routing on Cisco Catalyst switch in service-peer mode and setup mDNS trust interface settings, follow the procedure given below:

Procedure

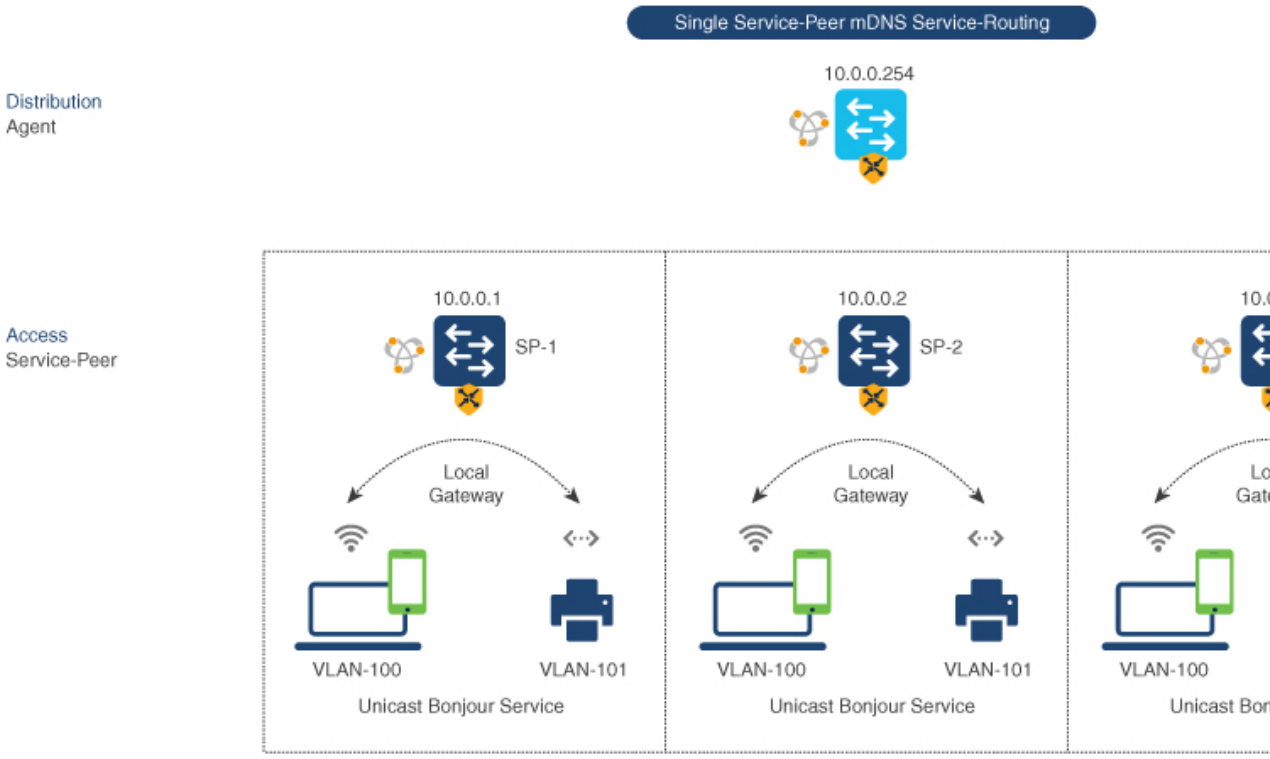
	Command or Action	Purpose
Step 1	**enable** **Example:** `Device# enable`	Enables Privileged EXEC mode. Enter your password, if prompted.
Step 2	**configure terminal** **Example:**	Enters global configuration mode.

	Command or Action	Purpose
	`Device# configure terminal`	
Step 3	**vlan configuration** *ID* **Example:** `Device(config)# vlan configuration 100`	Enables wired and EWC mode AP wireless user VLAN configuration for advanced service parameters. One or more VLANs can be created for the same settings. Here, *ID* refers to the VLAN configuration ID. For example, *vlan configuration 101-110, 200* range, allows to configure consecutive and non-consecutive VLAN ID(s).
Step 4	**mdns-sd gateway** **Example:** `Device(config-vlan-config)# mdns-sd gateway`	Enables mDNS gateway on configured VLAN ID(s). To enable the respective functionalities, enter the following commands in the mDNS gateway configuration mode: • **active-query timer [sec]**: Configure to enable refresh discovered services and their records with periodic mDNS Query message for permitted service types. The valid range is from 60 to 3600 seconds. The recommended value is 3600 seconds. • **service-mdns-query {ptr | srv | txt}**: Permits processing specific Query type. The default query type is PTR. • **transport {ipv4 | ipv6 | both}**: Permits processing for IPv4, IPv6, or both. It is recommended to use one network type to reduce redundant processing and respond with the same information over two network types. The default network type is IPv4.
Step 5	**source-interface** *ID* **Example:** `Device(config-vlan-mdns-sd)# source-interface vlan 4094`	Selects the interface with a valid IP address to source service-routing session with the upstream Cisco Catalyst SDG Agent switch. Typically, the management VLAN interface can be used.
Step 6	**sdg-agent** [*IPv4_address*] **Example:** `Device(config-vlan-mdns-sd)# sdg-agent 10.0.0.254`	Configures the SDG Agent IPv4 address, typically, the management VLAN gateway address. If FHRP mode, then use the FHRP virtual IP address of the management VLAN.
Step 7	**exit** **Example:** `Device(config-vlan-mdns-sd)# exit`	Exits the mDNS gateway configuration mode.

Configuring Location-Based mDNS

By default, the Layer 2 Catalyst switch in the service-peer mode enables per-switch mDNS discovery and distribution between wired and EWC mode Access Point wireless users attached locally to the switch. This default per-switch location-based mDNS is supported even when wired and EWC mode Access Point wireless users VLANs may be extended between multiple Layer 2 Catalyst switches for user mobility purpose. The mDNS service-policy configuration SDG Agent is required to accept policy-based mDNS service provider and receiver information from downstream service-peer access-layer switch.

Figure 30: Per-Switch Location-Based Wired and EWC Mode Access Point Configuration



Note Configure the mDNS service policy on the distribution layer SDG Agent switch before proceeding to the next configuration step. For more information, see the Configuring mDNS Service Policy (CLI), on page 981 section.

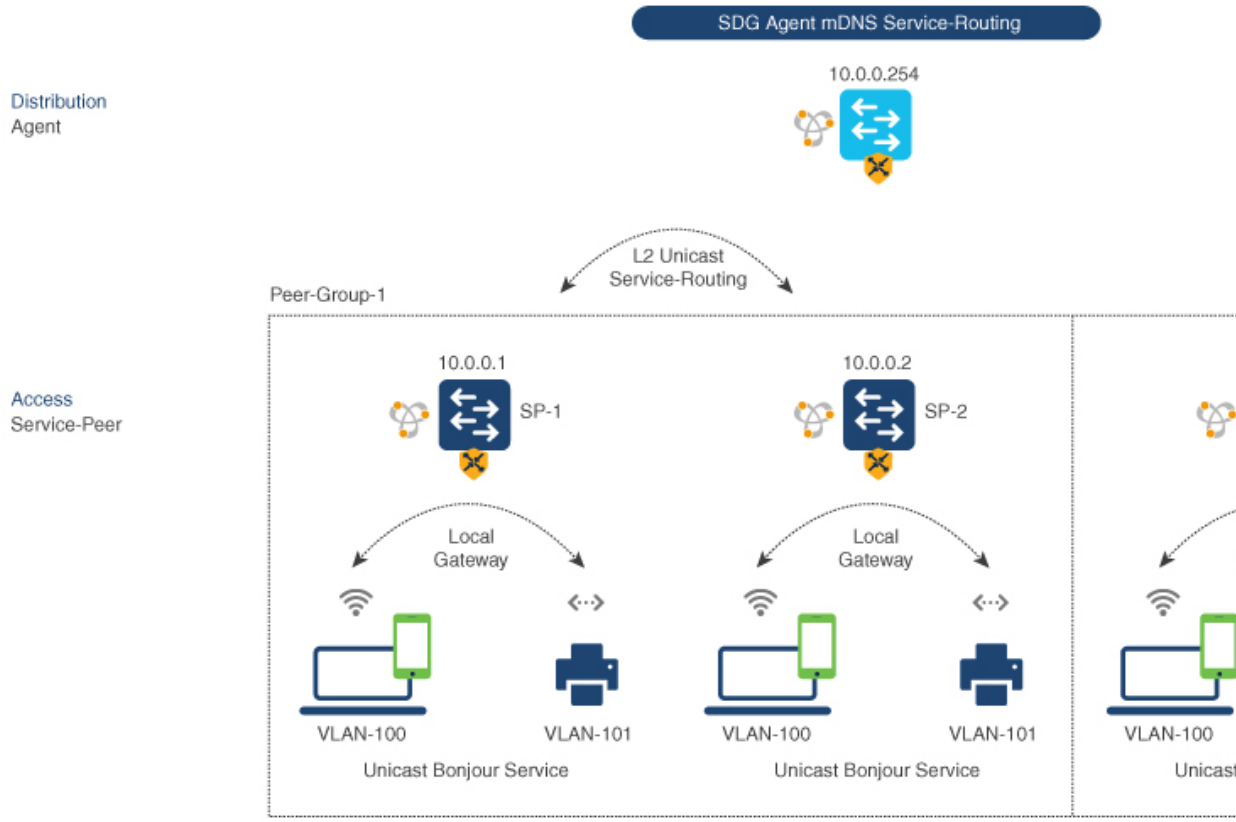
Configuring Service-Routing on SDG Agent (CLI)

The Cisco Catalyst 9000 series switches support SDG Agent mode automatically at the distribution layer and enables Unicast mode Bonjour service-routing with the downstream Layer 2 access-layer Ethernet switches connected to wired and EWC mode Access Point wireless users. The SDG Agent must be configured with mDNS service-policy on wired or EWC mode Access Point wireless user VLAN to accept mDNS service cache from downstream service-peer switches.

This section provides the step-by-step configuration to enable policy-based service discovery and distribution between locally paired Layer 2 access network switches in the service-peer mode.

The following figure displays the unicast service-routing on SDG Agent and downstream Layer 2 access network switches in the service-peer mode:

Figure 31: Catalyst SDG Agent Service-Routing Configuration



Note Configure the mDNS service policy on the distribution layer SDG Agent switch before proceeding to the next configuration step. For more information, see the Configuring mDNS Service Policy (CLI), on page 981 section.

To enable the mDNS service policy and peer-group on SDG Agent switch, and enable unicast mode service-routing with Layer 2 access network switches in Service-Peer mode, follow the steps given below:

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 the global configuration mode.
Step 3	**mdns-sd service-peer group** *service-peer-group-name* **Example:** `Device(config)# mdns-sd service-peer group service-peer-group-name`	Configures a unique service-peer group in the global configuration mode.
Step 4	**peer-group** [*ID*] **Example:** `Device(config-mdns-svc-peer)# peer-group 1`	Assigns a unique peer-group ID to the service-peers pair permitting mDNS service discovery and distribution within the assigned group list. The valid peer-group range is from 1 to 1000 for each SDG Agent switch.
Step 5	**service-policy** *service-policy-name* **Example:** `Device(config-mdns-svc-peer-grp)# service-policy VLAN100-POLICY`	Associates an mDNS service policy to accept service advertisements and query from the paired service-peers.

Step 6	**service-peer** [*IPv4_address*] **location-group** {**all** | **default** | **id**}
	Example:
	`Device(config-mdns-svc-peer-grp)# service-peer 10.0.0.1 location-group default`
	`Device(config-mdns-svc-peer-grp)# service-peer 10.0.0.2 location-group default`
		Configures atleast one service-peer to accept the mDNS service advertisement or query message. When a group has more than one service-peers, the SDG Agent provides Layer 2 unicast mode routing between the configured peers.
		For example, the SDG Agent provides unicast based service gateway function between three (10.0.0.1 and 10.0.0.2) Layer 2 service-peer switches matching the associated service-policy.
		The mDNS service information from the unpaired Layer 2 service-peer (10.0.0.3) cannot announce or receive mDNS services with the other grouped service-peers (10.0.0.1 and 10.0.0.2).

Step 7	**exit** **Example:** `Device(config-mdns-svc-peer-grp)# exit`	Exits the mDNS gateway configuration mode.

Verifying Local Area Bonjour in Service-Peer Mode

This section provides guidelines to verify various Local Area Bonjour domain mDNS service configuration parameters, cache records, statistics and more on the controller in service-peer mode

Table 58:

Command or Action	Purpose
show mdns-sd cache {all | interface | mac | name | service-peer | static | type | vlan}	Displays available mDNS cache records supporting multiple variables providing granular source details received from wired or EWC mode AP wireless user VLANs. The variables are as follows: • all – Displays all available cache records discovered from multiple source connections of a system. • interface – Displays available cache records discovered from the specified Layer 3 interface. • mac - Displays available cache records discovered from the specified MAC address. • name - Displays available cache records based on the service provider announced name. • service-peer - Displays available cache records discovered from the specified Layer 2 Service-Peer. • static – Displays locally configured static mDNS cache entry. • type – Displays available cache records based on the specific mDNS record type, such as, PTR, SRV, TXT, A or AAAA. • vlan - Displays available cache records discovered from the specified Layer 2 VLAN ID in the Unicast mode.
show mdns-sd service-definition {name | type}	Displays built-in and user-defined custom service-definition that maps service name to the mDNS PTR records. The service-definition can be filtered by name or type.
show mdns-sd service-list {direction | name}	Displays inbound or outbound direction list of configured service-list to classify matching service-types for service-policy. The list can be filtered by name or specific direction.

Command or Action	Purpose
show mdns-sd service-policy {interface | name}	Displays list of mDNS service-policy mapped with inbound or outbound service-list. The service-policy list can be filtered by an associated specified interface or name.
show mdns-sd statistics {all | cache | debug | interface | service-list | service-policy | services | vlan}	Displays detailed mDNS statistics processed bi-directionally by the system on each mDNS gateway enabled VLAN configured mDNS in Unicast mode. The expanded keyword for mDNS statistics can provide detailed view on interface, policy, service-list, and services.
show mdns-sd summary {interface | vlan}	Displays brief information about mDNS gateway and key configuration status on all wired and EWC mode AP wireless user VLANs, and interfaces of the system.

Verifying Local Area Bonjour in SDG Agent Mode

This section provides guidelines to verify various Local Area Bonjour domain mDNS service configuration parameters, cache records, statistics and more on the controller in SDG Agent mode.

Table 59:

Command or Action	Purpose
show mdns-sd cache {all | interface | mac | name | service-peer | static | type | vlan | vrf}	Displays available mDNS cache records supporting multiple variables providing granular source details. The variables are as follows: • all – Displays all available cache records discovered from multiple source connections of a system. • interface – Displays available cache records discovered from the specified Layer 3 interface. • mac - Displays available cache records discovered from the specified MAC address. • name - Displays available cache records based on the service provider announced name. • service-peer - Displays available cache records discovered from the specified Layer 2 Service-Peer. • static – Displays locally configured static mDNS cache entry. • type – Displays available cache records based on the specific mDNS record type, such as, PTR, SRV, TXT, A or AAAA. • vlan - Displays available cache records discovered from the specified Layer 2 VLAN ID in the Unicast mode. • vrf - Displays per-VRF available cache records based on specific mDNS record type, that is, PTR, SRV, TXT, A or AAAA.
show mdns-sd service-definition {name | type}	Displays built-in and user-defined custom service-definition that maps service name to the mDNS PTR records. The service-definition can be filtered by name or type.
show mdns-sd service-list {direction | name}	Displays inbound or outbound direction list of the configured service-list to classify matching service-types for service-policy. The list can be filtered by name or specific direction.
show mdns-sd service-policy {interface | name}	Displays list of mDNS service-policy mapped with inbound or outbound service-list. The service-policy list can be filtered by an associated specified interface or name.

Command or Action	Purpose
show mdns-sd statistics {all | cache | debug | interface | service-list | service-policy | services | vlan}	Displays detailed mDNS statistics processed bi-directionally by the system on each mDNS gateway enabled VLAN configured mDNS in Unicast mode. The expanded keyword for mDNS statistics can provide detailed view on interface, policy, service-list, and services.
show mdns-sd summary {interface | vlan}	Displays brief information about mDNS gateway and key configuration status on all VLANs and interfaces of the system.

Reference

Table 60: Reference

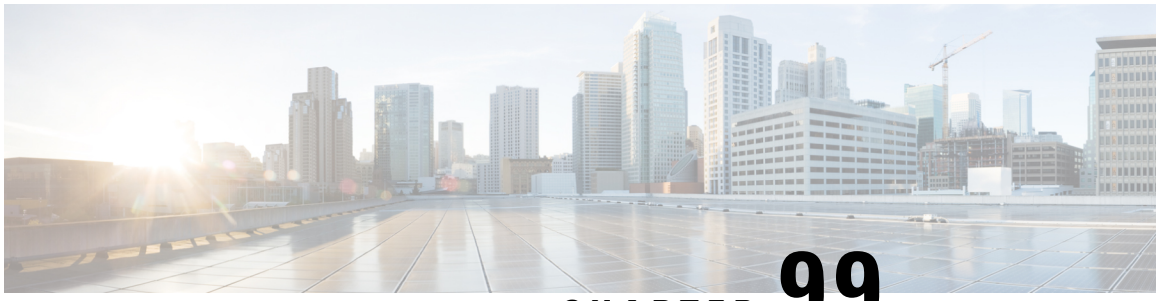
Related Topic	Document Title
Cisco Embedded Wireless Controller on Catalyst Access Points CCO Configuration Guide	Cisco Embedded Wireless Controller on Catalyst Access Points Configuration Guide, IOS XE Bengaluru 17.5.x
DNA Service for Bonjour Deployment on Cisco Catalyst 9600 Switch	Cisco Catalyst 9600 Series Switch Software Configuration Guide, Release 17.4.X
DNA Service for Bonjour Deployment on Cisco Catalyst 9500 Switch	Cisco Catalyst 9500 Series Switch Software Configuration Guide, Release 17.4.X
DNA Service for Bonjour Deployment on Cisco Catalyst 9400 Switch	Cisco Catalyst 9400 Series Switch Software Configuration Guide, Release 17.4.X
DNA Service for Bonjour Deployment on Cisco Catalyst 9300 Switch	Cisco Catalyst 9300 Series Switch Software Configuration Guide, Release 17.4.X
DNA Service for Bonjour Deployment on Cisco Catalyst 9800 Wireless LAN Controller	Cisco Catalyst 9800 Series Wireless Controller Software Configuration Guide, Cisco IOS XE Bengaluru 17.5.x
Cisco Wide Area Bonjour Application on Cisco DNA Center User Guide	Cisco Wide Area Bonjour Application on Cisco DNA Center User Guide, Release 2.2.x



PART XV

Multicast Domain Name System

- Multicast Domain Name System, on page 999



CHAPTER 99

Multicast Domain Name System

- Introduction to mDNS Gateway, on page 999
- Enabling mDNS Gateway (GUI), on page 1000
- Enabling or Disabling mDNS Gateway (CLI), on page 1000
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Introduction to mDNS Gateway

Multicast Domain Name System (mDNS) is an Apple service discovery protocol which locates devices and services on a local network with the use of mDNS service records.

The Bonjour protocol operates on service announcements and queries. Each query or advertisement is sent to the Bonjour multicast address ipv4 224.0.0.251 (ipv6 FF02::FB). This protocol uses mDNS on UDP port 5353.

The address used by the Bonjour protocol is link-local multicast address and therefore is only forwarded to the local L2 network. As, multicast DNS is limited to an L2 domain for a client to discover a service it has to be part of the same L2 domain, This is not always possible in any large scale deployment or enterprise.

In order to address this issue, the Cisco Catalyst 9800 Series Wireless Controller acts as a Bonjour Gateway. The controller then listens for Bonjour services, caches these Bonjour advertisements (AirPlay, AirPrint, and so on) from the source or host. For example, Apple TV responds back to Bonjour clients when asked or requested for a service. This way you can have sources and clients in different subnets.

By default, the mDNS gateway is disabled on the controller. To enable mDNS gateway functionality, you must explicitly configure mDNS gateway using CLI or Web UI.

Prerequisite

Since the Cisco Catalyst 9800 Series Wireless Controller will respond and advertise for services cached when acting as a Bonjour Gateway, it must have an SVI interface with a valid IP address on every VLAN where mDNS is allowed or used. This will be the source IP address of those mDNS packets that are coming out from the controller acting as mDNS Gateway.

Enabling mDNS Gateway (GUI)

Procedure

Step 1 Choose **Configuration > Services > mDNS**.

Step 2 In the **Global** section, toggle the slider to enable or disable the **mDNS Gateway**.

Step 3 From the **Transport** drop-down list, choose one of the following types:

- **ipv4**
- **ipv6**
- **both**

Step 4 Enter an appropriate timer value in **Active-Query Timer**. The valid range is between 15 to 120 minutes. The default is 30 minutes.

Step 5 From the **mDNS-AP Service Policy** drop-down list, choose an mDNS service policy.

Note
Service policy is optional only if mDNS-AP is configured. If mDNS-AP is not configured, the system uses default-service-policy.

Step 6 Click **Apply**.

Enabling or Disabling mDNS Gateway (CLI)

Note

- mDNS gateway is disabled by default globally on the controller.
- You need both global and WLAN configurations to enable mDNS gateway.

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	**mdns-sd gateway** **Example:** `Device(config)# mdns-sd gateway`	Enables mDNS gateway.
Step 4	**transport** {**ipv4** | **ipv6** | **both**} **Example:** `Device(config-mdns-sd)# transport ipv4`	Processes mDNS message on a specific transport. Here, **ipv4** signifies that the IPv4 mDNS message processing is enabled. This is the default value. **ipv6** signifies that the IPv6 mDNS message processing is enabled. **both** signifies that the IPv4 and IPv6 mDNS message is enabled for each network.
Step 5	**active-query timer** *active-query-periodicity* **Example:** `Device(config-mdns-sd)# active-query timer 15`	Changes the periodicity of mDNS multicast active query. **Note** An active query is a periodic mDNS query to refresh dynamic cache. Here, *active-query-periodicity* refers to the active query periodicity in Minutes. The valid range is from 15 to 120 minutes. Active query runs with a default periodicity of 30 minutes.
Step 6	**exit** **Example:** `Device(config-mdns-sd)# exit`	Returns to global configuration mode.

Creating Custom Service Definition (GUI)

Procedure

Step 1 Choose **Configuration > Services > mDNS**.

Step 2 In the **Service Definition** section, click **Add**.

Step 3 In the **Quick Setup: Service Definition** page that is displayed, enter a name and description for the service definition.

Step 4 Enter a service type and click + to add the service type.

Step 5 Click **Apply to Device**.

Creating Custom Service Definition

Service definition is a construct that provides an admin friendly name to one or more mDNS service types or A pointer (PTR) Resource Record Name.

By default, few built-in service definitions are already predefined and available for admin to use.

In addition to built-in service definitions, admin can also define custom service definitions.

You can execute the following command to view the list of all the service definitions (built-in and custom):

```
Device# show mdns-sd master-service-list
```

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	**mdns-sd service-definition** *service-definition-name* **Example:** `Device(config)# mdns-sd service-definition CUSTOM1`	Configures mDNS service definition. **Note** • All the created custom service definitions are added to the primary service list. • Primary service list comprises of a list of custom and built-in service definitions.

	Command or Action	Purpose
Step 4	**service-type** *string* **Example:** `Device(config-mdns-ser-def)# service-type _custom1._tcp.local`	Configures mDNS service type.
Step 5	**exit** **Example:** `Device(config-mdns-ser-def)# exit`	Returns to global configuration mode.

Creating Service List (GUI)

Procedure

Step 1 Choose **Configuration > Services > mDNS**.

Step 2 In the **Service List** section, click **Add**.

Step 3 In the **Quick Setup: Service List** page that is displayed, enter a name for the service list.

Step 4 From the **Direction** drop-down list, choose **IN** for inbound filtering or **OUT** for outbound filtering.

Step 5 From the **Available Services** drop-down list, choose a service type to match the service list.

Note
To allow all services, choose the **all** option.

Step 6 Click **Add Services**.

Step 7 From the **Message Type** drop-down list, choose the message type to match from the following options:

- **any**—To allow all messages.
- **announcement**—To allow only service advertisements or announcements for the device.
- **query**—To allow only a query from the client for a service in the network.

Step 8 Click **Save** to add services.

Step 9 Click **Apply to Device**.

Creating Service List

mDNS service list is a collection of service definitions.

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	**mdns-sd service-list** *service-list-name* {**IN** | **OUT**}
	Example:
	`Device(config)# mdns-sd service-list Basic-In IN`
	`Device(config)# mdns-sd service-list Basic-Out OUT`
		Configures mDNS service list.
		• **IN**: Provides inbound filtering.
		• **Out**: Provides outbound filtering.

Step 4	**match** *service-definition-name* **message-type** {**announcement** | **any** | **query**} **Example:** `Device(config-mdns-sl-in)# match CUSTOM1 message-type query`	Matches the service to the message type. Here, *service-definition-name* refers to the names of services, such as, airplay, airserver, airtunes, and so on. **Note** To add a service, the service name must be part of the primary service list. If the mDNS service list is set to IN, you get to view the following command: **match service-definition-name message-type {announcement | any | query}**. If the mDNS service list is set to Out, you get to view the following command: **match service-definition-name**.
Step 5	**show mdns-sd service-list {direction | name }**	Displays inbound or outbound direction list of the configured service-list to classify matching service-types for service-policy. The list can be filtered by name or specific direction.
Step 6	**exit** **Example:** `Device(config-mdns-sl-in)# exit`	Returns to global configuration mode.

Creating Service Policy (GUI)

Procedure

Step 1 Choose **Configuration > Services > mDNS**.
Step 2 In the **Service Policy** section, click **Add**.
Step 3 In the **Quick Setup: Service Policy** page that is displayed, enter a name for the service policy.
Step 4 From the **Service List Input** drop-down list, choose one of the types.
Step 5 From the **Service List Output** drop-down list, choose one of the types.
Step 6 From the **Location** drop-down list, choose the location you want to associate with the service list.
Step 7 Click **Apply to Device**.

Creating Service Policy

mDNS service policy is used for service filtering while learning services or responding to queries.

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	**mdns-sd service-policy** *service-policy-name* **Example:** `Device(config)# mdns-sd service-policy mdns-policy1`	Enables mDNS service policy.
Step 4	**location** {**lss** | **site-tag**} **Example:** `Device(config-mdns-ser-pol)# location lss`	Filters mDNS service types based on LSS or site-tag. **Note** In Location Specific Services (LSS) based filtering, the mDNS gateway responds with the service instances learnt from the neighboring APs of the querying client AP. Other service instances for the rest of APs are filtered.

	Command or Action	Purpose
		In Site tag based filtering, the mDNS gateway responds with the service instances that belong to the same site-tag as that of querying client. The mDNS gateway responds back with wired services even if the location based filtering is configured.
Step 5	**service-list** *service-list-name* {**IN** | **OUT**} **Example:** `Device(config-mdns-ser-pol)# service-list VLAN100-list IN`	Configures various service-list names for IN and OUT directions. **Note** If an administrator decides to create or use a custom service policy, then the custom service policy must be configured with service-lists for both directions (IN and OUT); otherwise, the mDNS Gateway will not work (will not learn services if there is no IN service-list, or will not reply or announce services learned if there is no OUT service-list).
Step 6	**exit** **Example:** `Device(config-mdns-ser-pol)# exit`	Returns to global configuration mode.

Configuring a Local or Native Profile for an mDNS Policy

When an administrator configures local authentication and authorization and does not expect to get any mDNS policy from the AAA server, the administrator can configure a local or native profile to select a mDNS policy based on user, role, or device type. When this local or native profile is mapped to the wireless profile policy, mDNS service policy is applied on the mDNS packets that are processed on that WLAN.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**service-template** *template-name* **Example:** `Device(config)# service-template mdns`	Configures the service-template or identity policy.
Step 3	**mdns-service-policy** *mdns-policy-name* **Example:**	Configures the mDNS policy.

	Command or Action	Purpose
	`Device(config-service-template)# mdns-service-policy mdnsTV`	
Step 4	**exit** **Example:** `Device(config-service-template)# exit`	Returns to global configuration mode.

Configuring an mDNS Flex Profile (GUI)

Procedure

Step 1 Choose **Configuration > Services > mDNS**.

Step 2 In the **mDNS Flex Profile** section, click **Add**.
The **Add mDNS Flex Profile** window is displayed.

Step 3 In the **Profile Name** field, enter the flex mDNS profile name.

Step 4 In the **Service Cache Update Timer** field, specify the service cache update time. The default value is 1 minute. The valid range is from 1 to 100 minutes.

Step 5 In the **Statistics Update Timer** field, specify the statistics update timer. The default value is 1 minute. The valid range is from 1 to 100 minutes.

Step 6 In the **VLANs** field, specify the VLAN ID. You can enter multiple VLAN IDs separated by commas, or enter a range of VLAN IDs. Maximum number of VLANs allowed is 16.

Step 7 Click **Apply to Device**.

Configuring an mDNS Flex Profile (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**mdns-sd flex-profile** *mdns-flex-profile-name* **Example:** `Device(config)# mdns-sd flex-profile mdns-flex-profile-name`	Enters the mDNS Flex Profile mode.
Step 3	**update-timer service-cache** *service-cache timer-value <1-100>*	Configures the mDNS update service cache timer for the flex profile.

	Command or Action	Purpose
	Example: `Device(config-mdns-flex-profile)# update-timer service-cache 60`	The default value is 1 minute. Value range is between 1 minute and 100 minutes.
Step 4	**update-timer statistics** *statistics timer-value <1-100>* **Example:** `Device(config-mdns-flex-profile)# update-timer statistics 65`	Configures the mDNS update statistics timer for the flex profile. The default value is 1 minute. The valid range is from 1 to 100 minutes.
Step 5	**wired-vlan-range** *wired-vlan-range value* **Example:** `Device(config-mdns-flex-profile)# wired-vlan-range 10 - 20`	Configures the mDNS wired VLAN range for the flex profile between 10 - 20.

Applying an mDNS Flex Profile to a Wireless Flex Connect Profile (GUI)

Procedure

Step 1 Choose **Configuration > Tags & Profiles > Flex**.

Step 2 Click **Add**.
The **Add Flex Profile** window is displayed.

Step 3 Under the **General** tab, from the **mDNS Flex Profile** drop-down list, choose a flex profile name from the list.

Step 4 Click **Apply to Device**.

Applying an mDNS Flex Profile to a Wireless Flex Connect Profile (CLI)

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.

	Command or Action	Purpose
Step 2	**wireless profile flex** *wireless-flex-profile-name* **Example:** `Device# wireless profile flex wireless-flex-profile-name`	Enters wireless flex profile configuration mode.
Step 3	**mdns-sd** *mdns-flex-profile* **Example:** `Device(config-wireless-flex-profile)# mdns-sd mdns-flex-profile-name`	Enables the mDNS features for all the APs in the profile

Location-Based Service Filtering

Prerequisite for Location-Based Service Filtering

You need to create the Service Definition and Service Policy. For more information, see Creating Custom Service Definition section and Creating Service Policy section.

Configuring mDNS Location-Based Filtering Using SSID

When a service policy is configured with the SSID as the location name, the response to the query will be the services that were learnt on that SSID.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**mdns-sd service-policy** *service-policy-name* **Example:** `Device(config)# mdns-sd service-policy mdns-policy1`	Configures the service policy.
Step 3	**location ssid** **Example:** `Device(config-mdns-ser-pol)# location ssid`	Configures location-based filtering using SSID.
Step 4	**end** **Example:** `Device(config-mdns-ser-pol)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring mDNS Location-Based Filtering Using AP Name

When a service policy is configured with the AP name as the location, the response to the query will be the services that were learnt on that AP.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**mdns-sd service-policy** *service-policy-name* **Example:** `Device(config)# mdns-sd service-policy mdns-policy1`	Configures the service policy.
Step 3	**location ap-name** **Example:** `Device(config-mdns-ser-pol)# location ap-name`	Configures location-based filtering using an AP name.
Step 4	**end** **Example:** `Device(config-mdns-ser-pol)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring mDNS Location-Based Filtering Using AP Location

When a service policy is configured with location as the AP-location, the response to the query will be the services that were learnt on all the APs using the same AP "location" name (not to be confused with "site-tag").

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**mdns-sd service-policy** *service-policy-name* **Example:** `Device(config)# mdns-sd service-policy mdns-policy1`	Configures the service policy.
Step 3	**location ap-location** **Example:**	Configures location-based filtering using the AP location.

	Command or Action	Purpose
	`Device(config-mdns-ser-pol)# location ap-location`	
Step 4	**end** **Example:** `Device(config-mdns-ser-pol)# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

Configuring mDNS Location-Based Filtering Using Regular Expression

- When a service policy is configured with the location as a regular expression that matches the corresponding AP name, the response to the query will be the services that were learnt on a group of APs based on the AP name.
- When a service policy is configured with the location as a regular expression that matches the corresponding AP location, the response to the query will be the services that were learnt on a group of APs based on the AP location.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**mdns-sd service-policy** *service-policy-name* **Example:** `Device(config)# mdns-sd service-policy mdns-policy1`	Configures the service policy.

Step 3	**location regex** {**ap-location** *regular-expression* | **ap-name** *regular-expression*}
	Example:
	`Device(config-mdns-ser-pol)# location regex ap-location dns_location`
	`Device(config-mdns-ser-pol)# location regex ap-name dns_name`
		Configures location-based filtering using regular expression.

Step 4	**end** **Example:** `Device(config-mdns-ser-pol)# end` **Note** To filter the services for which AP names have the specific keyword such as *AP-2FLR-SJC-123*, you can use the regex AP	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

	Command or Action	Purpose
	name as *AP-2FLR-* to match the services that are learnt from the set of access points.	

Configuring mDNS AP

In most of the deployments, the services may be available in VLANs that the APs can hear in the wired side (allowed in the switchport where the AP is directly connected: its own VLAN, or even more VLANs if switchport is a trunk).

The following procedure shows how to configure mDNS AP:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**mdns-sd gateway** **Example:** `Device(config)# mdns-sd gateway`	Configures the mDNS gateway.
Step 3	**ap name** *ap-name* **mdns-ap enable vlan** *vlan-id* **Example:** `Device# ap name ap1 mdns-ap enable vlan 22`	Enables mDNS on the AP, and configures a VLAN for the mDNS AP.
Step 4	**ap name** *ap-name* **mdns-ap vlan add** *vlan-id* **Example:** `Device# ap name ap1 mdns-ap vlan add 200`	Adds a VLAN to the mDNS AP. *vlan-id* ranges from 1 to 4096.
Step 5	**ap name** *ap-name* **mdns-ap vlan del** *vlan-id* **Example:** `Device# ap name ap1 mdns-ap vlan del 2`	Deletes a VLAN from the mDNS AP.
Step 6	**ap name** *ap-name* **mdns-ap disable** **Example:** `Device# ap name ap1 mdns-ap disable`	(Optional) Disables the mDNS AP.
Step 7	**end** **Example:** `Device# end`	Returns to privileged EXEC mode. Alternatively, you can also press **Ctrl-Z** to exit global configuration mode.

	Command or Action	Purpose
		Note You can configure a maximum of 10 VLANs per AP.

Associating mDNS Service Policy with Wireless Profile Policy (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **Policy**.

Step 2 Click the **policy profile** name.

Step 3 In the **Advanced** tab, choose the mDNS service policy from the **mDNS Service Policy** drop-down list.

Step 4 Click **Update & Apply to Device**.

Associating mDNS Service Policy with Wireless Profile Policy

Note You must globally configure the mDNS service policy before associating it with the wireless profile policy.

A default mDNS service policy is already attached once the wireless profile policy is created. You can use the following commands to override the default mDNS service policy with any of your service policy:

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wireless profile policy** *profile-policy* **Example:** `Device(config)# wireless profile policy default-policy-profile`	Configures wireless profile policy. Here, *profile-policy* refers to the name of the WLAN policy profile.
Step 3	**mdns-sd service-policy** *custom-mdns-service-policy*	Associates an mDNS service policy with the wireless profile policy.

	Command or Action	Purpose
	Example: `Device(config-wireless-policy)# mdns-sd service-policy custom-mdns-service-policy`	The default mDNS service policy name is **default-mdns-service-policy**. **Note** The **default-mdns-profile-policy** uses **default-mdns-service-list** configuration for filtering mDNS service announcement and queries. In wireless network, the mDNS packets are consumed by the mDNS gateway and clients or device is deprived of learning this service. To share the service with the device and provide ease of configuration to the administrator, a list of few standard service types are shared by default on the wireless network. The list of such standard service types is termed as default service policy that comprises a set of service types. The table covers a sample service list in the default service policy. ***Table 61: Default Name and mDNS Service Type*** **Default Name** / **mDNS Service Type** Apple HomeSharing / _home-sharing._tcp.local Printer-IPPS / _ipps._tcp.local Google-chromecast / _googlecast._tcp.local **Note** • Location would be disabled on mDNS default service policy. • You cannot change the contents of the mDNS default service policy. However, you can create separate mDNS service policies and associate them under the wireless policy profile.
Step 4	**exit** **Example:** `Device(config-wireless-policy)# exit`	Returns to global configuration mode.

Enabling or Disabling mDNS Gateway for WLAN (GUI)

Procedure

Step 1 Choose **Configuration** > **Tags & Profiles** > **WLANs**.

Step 2 Click on the WLAN.

Step 3 In the **Advanced** tab, choose the mode in **mDNS Mode** drop-down list.

Step 4 Click **Update & Apply to Device**.

Enabling or Disabling mDNS Gateway for WLAN

Note Bridging is the default behaviour. This means that the mDNS packets are always bridged.

Procedure

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 2	**wlan** *profile-name wlan-id ssid-name* **Example:** `Device(config)# wlan test 24 ssid1`	Specifies the WLAN name and ID. • *profile-name* is the WLAN name which can contain 32 alphanumeric characters • *wlan-id* is the wireless LAN identifier. The valid range is from 1 to 512. • *ssid-name* is the SSID which can contain 32 alphanumeric characters. **Note** Global configuration must be in place for mDNS gateway to work.

Step 3	**mdns-sd-interface** {**gateway** | **drop**}
	Example:
	`Device(config-wlan)# mdns-sd gateway`
	`Device(config-wlan)# mdns-sd drop`
		Enables or disables mDNS gateway and bridge functions on WLAN.

	Command or Action	Purpose
Step 4	**exit** **Example:** `Device(config-wlan)# exit`	Returns to global configuration mode.
Step 5	**show wlan name** *wlan-name* | **show wlan all** **Example:** `Device# show wlan name test | show wlan all`	Verifies the status of mDNS on WLAN.
Step 6	**show wireless profile policy** **Example:** `Device# show wireless profile policy`	Verifies the service policy configured in WLAN.

Verifying mDNS Gateway Configurations

To verify the mDNS summary, use the following command:

```
Device# show mdns-sd summary
mDNS Gateway: Enabled
Active Query: Enabled
  Periodicity (in minutes): 30
Transport Type: IPv4
```

To verify the mDNS cache, use the following command:

```
Device# show mdns-sd cache
------------------------------------------------------------ PTR Records
----------------------------------------
RECORD-NAME                     TTL      WLAN   CLIENT-MAC       RR-RECORD-DATA

-------------------------------------------------------------------------------------------------------
_airplay._tcp.local             4500     30     07c5.a4f2.dc01   CUST1._airplay._tcp.local

_ipp._tcp.local                 4500     30     04c5.a4f2.dc01   CUST3._ipp._tcp.local2

_ipp._tcp.local                 4500     15     04c5.a4f2.dc01   CUST3._ipp._tcp.local4

_ipp._tcp.local                 4500     10     04c5.a4f2.dc01   CUST3._ipp._tcp.local6

_veer_custom._tcp.local         4500     10     05c5.a4f2.dc01
CUST2._veer_custom._tcp.local8
```

To verify the mDNS cache from wired service provider, use the following command:

```
Device# show mdns-sd cache wired
------------------------------------------------------------ PTR Records
----------------------------------------
RECORD-NAME                               TTL      VLAN      CLIENT-MAC       RR-RECORD-DATA

-------------------------------------------------------------------------------------------------------
_airplay._tcp.local                         4500     16        0866.98ec.97af
wiredapple._airplay._tcp.local
_raop._tcp.local                            4500     16        0866.98ec.97af
086698EC97AF@wiredapple._raop._tcp.local
```

```
------------------------------------------------------------ SRV Records
----------------------------------------
RECORD-NAME                                TTL      VLAN      CLIENT-MAC       RR-RECORD-DATA

-------------------------------------------------------------------------------------------------------------
wiredapple._airplay._tcp.local               4500     16        0866.98ec.97af   0 0 7000
wiredapple.local
086698EC97AF@wiredapple._raop._tcp.local   4500     16        0866.98ec.97af   0 0 7000
wiredapple.local

------------------------------------------------------------ A/AAAA Records
----------------------------------------
RECORD-NAME                                TTL      VLAN      CLIENT-MAC       RR-RECORD-DATA

-------------------------------------------------------------------------------------------------------------
wiredapple.local                             4500     16        0866.98ec.97af
2001:8:16:16:e5:c446:3218:7437

------------------------------------------------------------ TXT Records
----------------------------------------
RECORD-NAME                                TTL      VLAN      CLIENT-MAC       RR-RECORD-DATA

-------------------------------------------------------------------------------------------------------------
wiredapple._airplay._tcp.local               4500     16        0866.98ec.97af
[343]'acl=0''deviceid=08:66:98:EC:97:AF''features=
086698EC97AF@wiredapple._raop._tcp.local   4500     16        0866.98ec.97af
[193]'cn=0,1,2,3''da=true''et=0,3,5''ft=0x5A7FFFF7
```

To verify the mdns-sd type PTR, use the following command:

```
Device# show mdns-sd cache type {PTR | SRV | A-AAA | TXT}
RECORD-NAME                                TTL      WLAN      CLIENT-MAC
RR-Record-Data
-------------------------------------------------------------------------------------------------------------
_custom1._tcp.local                          4500     2         c869.cda8.77d6
service_t1._custom1._tcp.local
_custom1._tcp.local                          4500     2         c869.cda8.77d6
vk11._custom1._tcp.local
_ipp._tcp.local                              4500     2         c869.cda8.77d6
service-4._ipp._tcp.local
```

To verify the mdns-sd cache for a client MAC, use the following command:

```
Device# show mdns-sd cache {ap-mac <ap-mac> | client-mac <client-mac> | wlan-id <wlan-id>
| wired}
RECORD-NAME                                TTL      WLAN      CLIENT-MAC
RR-Record-Data
-------------------------------------------------------------------------------------------------------------
_custom1._tcp.local                          4500     2         c869.cda8.77d6
service_t1._custom1._tcp.local
_custom1._tcp.local                          4500     2         c869.cda8.77d6
vk11._custom1._tcp.local
_ipp._tcp.local                              4500     2         c869.cda8.77d6
service-4._ipp._tcp.local

------------------------------------------------------------ SRV Records
----------------------------------------
RECORD-NAME                                TTL      WLAN      CLIENT-MAC
RR-Record-Data
-------------------------------------------------------------------------------------------------------------
service-4._ipp._tcp.local                    4500     2         c869.cda8.77d6   0 0 1212
 mDNS-Client1s-275.local
vk11._custom1._tcp.local                     4500     2         c869.cda8.77d6   0 0 987
 mDNS-Client1s-275.local
```

```
service_t1._custom1._tcp.local                  4500     2         c869.cda8.77d6   0 0 197
 mDNS-Client1s-275.local

------------------------------------------------------------ A/AAAA Records
------------------------------------------------------------
RECORD-NAME                                      TTL      WLAN      CLIENT-MAC
RR-Record-Data
-------------------------------------------------------------------------------------------
mDNS-Client1s-275.local                         4500     2         c869.cda8.77d6   120.1.1.33


------------------------------------------------------------ TXT Records
------------------------------------------------------------
RECORD-NAME                                      TTL      WLAN      CLIENT-MAC
RR-Record-Data
-------------------------------------------------------------------------------------------
service-4._ipp._tcp.local                       4500     2         c869.cda8.77d6   'CLient1'

vk11._custom1._tcp.local                         4500     2         c869.cda8.77d6
'txtvers=11'
service_t1._custom1._tcp.local                   4500     2         c869.cda8.77d6
'txtvers=12'
```

To verify the mdns-sd cache in detail, use the following command:

```
Device# show mdns-sd cache detail

Name: _custom1._tcp.local
  Type: PTR
  TTL: 4500
  WLAN: 2
  WLAN Name: mdns120
  VLAN: 120
  Client MAC: c869.cda8.77d6
  AP Ethernet MAC: 7069.5ab8.33d0
  Expiry-Time: 09/09/18 21:50:47
  Site-Tag: default-site-tag
  Rdata: service_t1._custom1._tcp.local
```

To verify the mdns-sd statistics, use the following command:

```
Device# show mdns-sd statistics

------------------------------------------------------
Consolidated mDNS Packet Statistics
------------------------------------------------------
mDNS stats last reset time: 03/11/19 04:17:35
mDNS packets sent: 61045
  IPv4 sent: 30790
    IPv4 advertisements sent: 234
    IPv4 queries sent: 30556
  IPv6 sent: 30255
    IPv6 advertisements sent: 17
    IPv6 queries sent: 30238
  Multicast sent: 57558
    IPv4 sent: 28938
    IPv6 sent: 28620
mDNS packets received: 72796
  advertisements received: 13604
  queries received: 59192
  IPv4 received: 40600
    IPv4 advertisements received: 6542
    IPv4 queries received: 34058
  IPv6 received: 32196
    IPv6 advertisements received: 7062
```

```
    IPv6 queries received: 25134
mDNS packets dropped: 87

-------------------------------------------------------
Wired mDNS Packet Statistics
-------------------------------------------------------
mDNS stats last reset time: 03/11/19 04:17:35
mDNS packets sent: 61033
  IPv4 sent: 30778
    IPv4 advertisements sent: 222
    IPv4 queries sent: 30556
  IPv6 sent: 30255
    IPv6 advertisements sent: 17
    IPv6 queries sent: 30238
  Multicast sent: 57558
    IPv4 sent: 28938
    IPv6 sent: 28620
mDNS packets received: 52623
  advertisements received: 1247
  queries received: 51376
  IPv4 received: 32276
    IPv4 advertisements received: 727
    IPv4 queries received: 31549
  IPv6 received: 20347
    IPv6 advertisements received: 520
    IPv6 queries received: 19827
mDNS packets dropped: 63

-------------------------------------------------------
mDNS Packet Statistics, for WLAN: 2
-------------------------------------------------------
mDNS stats last reset time: 03/11/19 04:17:35
mDNS packets sent: 12
  IPv4 sent: 12
    IPv4 advertisements sent: 12
    IPv4 queries sent: 0
  IPv6 sent: 0
    IPv6 advertisements sent: 0
    IPv6 queries sent: 0
  Multicast sent: 0
    IPv4 sent: 0
    IPv6 sent: 0
mDNS packets received: 20173
  advertisements received: 12357
  queries received: 7816
  IPv4 received: 8324
    IPv4 advertisements received: 5815
    IPv4 queries received: 2509
  IPv6 received: 11849
    IPv6 advertisements received: 6542
    IPv6 queries received: 5307
mDNS packets dropped: 24
```

To verify the default service list details, use the following command:

```
Device# show mdns-sd default-service-list

-------------------------------------------
        mDNS Default Service List
-------------------------------------------

Service Definition: airplay
Service Names: _airplay._tcp.local

Service Definition: airtunes
```

```
Service Names: _raop._tcp.local

Service Definition: homesharing
Service Names: _home-sharing._tcp.local

Service Definition: printer-ipp
Service Names: _ipp._tcp.local

Service Definition: printer-lpd
Service Names: _printer._tcp.local

Service Definition: printer-ipps
Service Names: _ipps._tcp.local

Service Definition: printer-socket
Service Names: _pdl-datastream._tcp.local

Service Definition: google-chromecast
Service Names: _googlecast._tcp.local

Service Definition: itune-wireless-devicesharing2
Service Names: _apple-mobdev2._tcp.local
```

To verify the primary service list details, use the following command:

```
Device# show mdns-sd master-service-list

-----------------------------------------
        mDNS Master Service List
-----------------------------------------

Service Definition: fax
Service Names: _fax-ipp._tcp.local

Service Definition: roku
Service Names: _rsp._tcp.local

Service Definition: airplay
Service Names: _airplay._tcp.local

Service Definition: scanner
Service Names: _scanner._tcp.local

Service Definition: spotify
Service Names: _spotify-connect._tcp.local

Service Definition: airtunes
Service Names: _raop._tcp.local

Service Definition: airserver
Service Names: _airplay._tcp.local
               _airserver._tcp.local

.
.
.

Service Definition: itune-wireless-devicesharing2
Service Names: _apple-mobdev2._tcp.local
```

To verify the mDNS-AP configured on the controller and VLAN(s) associated with it, use the following command:

```
Device# show mdns-sd ap
```

```
Number of mDNS APs.............................. 1

AP Name   Ethernet MAC   Number of Vlans   Vlanidentifiers
-----------------------------------------------------------------------------------------------------
AP3600-1   7069.5ab8.33d0          1      300
```

Further Debug

To debug mDNS further, use the following procedure:

1. Run this command at the controller:

   ```
   set platform software trace wncd <0-7> chassis active R0 mdns debug
   ```

2. Reproduce the issue.
3. Run this command to gather the traces enabled:

```
show wireless loadbalance ap affinity wncd 0

AP MAC   Discovery Timestamp  Join Timestamp                Tag    Vlanidentifiers
-------------------------------------------------------------------------------------
0cd0.f894.0600      06/30/21 12:39:48    06/30/21 12:40:021 default-site-tag     300
```