



Cisco Catalyst IW9167E Heavy Duty Access Point Configuration Guide, Release 17.14.x

First Published: 2023-12-22

Last Modified: 2024-04-05

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



CONTENTS

CHAPTER 1

Introduction 1

- Overview of the Access Point 1
- Determine Image on IW9167EH 2
- Configuring AP to Boot up with Different Image Options 3
- Upgrade IW9167EH with 17.9.x to Support WGB/uWGB 3
- Related Documentation 4

CHAPTER 2

AP Mode Configuration 7

- Configuring Indoor Deployment for -E Domain 7
- 802.11ax 1600ns and 3200ns Guard Interval Support 10
 - Configuring 802.11ax Long Guard Interval 10
- GNSS Support 11
- RAP Ethernet Daisy Chain 12
 - WSTP Overview 13
 - Comparison with Previous Release 13
 - RAP Ethernet Daisy Chain Configuration 14
 - Preconfiguring RAP Ethernet Daisy Chain Before Field Deployment 14
 - Enabling RAP Ethernet Daisy Chain 16
 - Configuring Super Root 16
 - Configuring Primary Ethernet Port 17
 - Configuring Ethernet Bridging and Ethernet Port 17
 - Show and Debug Command 20

CHAPTER 3

Workgroup Bridges 21

- Overview 21

Limitations and Restrictions	22
Configuring Strong Password in Day0	23
Controller Configuration for WGB	25
uWGB Image Upgrade	25
WGB Configuration	26
Configuring IP Address	27
Configuring IPv4 Address	27
Configuring IPv6 Address	27
Configuring a Dot1X Credential	27
Deauthenticating WGB Wired Client	28
Configuring an EAP Profile	28
Configuring Manual Enrollment of a Trustpoint for Terminal	28
Configuring Auto-Enrollment of a Trustpoint for Workgroup Bridge	29
Configuring Manual Certificate Enrollment Using TFTP Server	30
SSID configuration	31
Creating an SSID Profile	31
Configuring Radio Interface for Workgroup Bridges	32
Configuring WGB/uWGB Timer	33
uWGB Configuration	33
Configuring IP Address	34
Configuring IPv4 Address	34
Configuring IPv6 Address	34
Configuring a Dot1X Credential	34
Configuring an EAP Profile	35
Configuring Manual Enrollment of a Trustpoint for Terminal	35
Configuring Auto-Enrollment of a Trustpoint for Workgroup Bridge	36
Configuring Manual Certificate Enrollment Using TFTP Server	37
SSID configuration	38
Creating an SSID Profile	38
Configuring Radio Interface for uWGB	39
Converting Between WGB and uWGB	40
LED Pattern	40
Configuring HT Speed Limit	40
Radio Statistics Commands	41

Configuring Syslog	44
Event Logging	44
802.11v Support	45
Configuring Aux Scanning	46
Configuring Scanning Only Mode	46
Configuring Aux-Scan Handoff Mode	47
Configuring Layer 2 NAT	48
Configuration Example of Host IP Address Translation	51
Configuration Example of Network Address Translation	52
Configuring Native VLAN on Ethernet Ports	53
Low Latency Profile	53
Configuring WGB optimized-video EDCA Profile	54
Configuring WGB optimized-automation EDCA Profile	54
Configuring WGB customized-wmm EDCA profile	55
Configuring Low Latency Profile on WGB	55
Configuring EDCA Parameters (Wireless Controller GUI)	55
Configuring EDCA Parameters (Wireless Controller CLI)	56
Configuring A-MPDU	57
Configuring WGB/uWGB Radio Parameters	58
Configuring WGB Radio Antenna	58
802.11ax 1600ns and 3200ns Guard Interval	58
Customized Transmit Power	58
Assign Country Code to WGB/uWGB With -ROW PID	58
Indoor Deployment for -E Domain and United Kingdom	59
Configuring WGB Roaming Parameters	59
Importing and Exporting WGB Configuration	60
Verifying the Configuration of WGB and uWGB	60
Configuring and Validating SNMP With WGB	62
Supported SNMP MIB File	63
Configuring SNMP from the WGB CLI	69
Verifying SNMP from WGB CLI	70
Support for QoS ACL Classification and Marking	71
Overview	71
Traffic Classification Based on QoS and ACL	71

Configuring Quality of Service Mapping Profile 74

Verifying WGB Quality of Service Mapping 76

CHAPTER 4

Automated Frequency Coordination 79

AFC Support for 6 GHz Standard Power Mode 79

Verifying AFC Status on AP 80



CHAPTER 1

Introduction

- [Overview of the Access Point, on page 1](#)
- [Determine Image on IW9167EH, on page 2](#)
- [Configuring AP to Boot up with Different Image Options, on page 3](#)
- [Upgrade IW9167EH with 17.9.x to Support WGB/uWGB, on page 3](#)
- [Related Documentation, on page 4](#)

Overview of the Access Point

The Cisco Catalyst IW9167E Heavy Duty Access Point provides reliable wireless connectivity for mission-critical applications in a state-of-the-art platform. It can operate as Cisco Catalyst Wi-Fi (CAPWAP) mode or Cisco Ultra-Reliable Wireless Backhaul (Cisco URWB) mode starting from IOS XE Cupertino 17.9.3 Software Release. The IW9167EH access point has the flexibility to change the operating mode from Wi-Fi to Cisco URWB, and vice versa.

Starting from Cisco IOS XE Dublin 17.11.1, Workgroup Bridge (WGB) and Universal WGB (uWGB) are supported on the Cisco Catalyst IW9167E Heavy Duty Access Points.

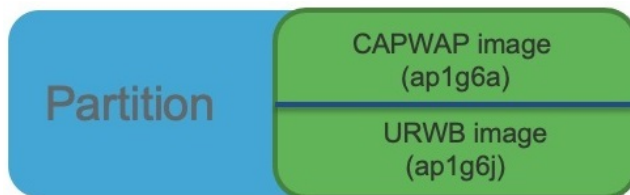
This document covers configuration of CAPWAP mode and WGB/uWGB mode specific to the IW9167EH access points.

For CAPWAP mode, the access points can operate in the following modes:

- Local
- Flexconnect
- Bridge
- Flexconnect + Bridge
- Sniffer
- Monitor
- Site survey

Determine Image on IW9167EH

Software images are stored under different folders on the same partition on IW9167EH.



You need to choose the image to boot up with according to the mode your AP is running, CAPWAP, Cisco URWB, or WGB/uWGB. The following table provides the software images of each mode:

Table 1: IW9167EH Software Images

IW9167EH Mode	Software Image
CAPWAP	ap1g6a-k9w8-xxx.tar
Cisco URWB	Unified Industrial Wireless image ap1g6j-k9c1-xxx.tar
WGB/uWGB	

To determine the image that your IW9167EH is running, use the **show version** command.

- If the **show version** output displays **Cisco AP Software, (ap1g6a)** as shown in the following example, it means that AP is running the CAPWAP image **ap1g6a-k9w8-xxx.tar**, which supports the CAPWAP mode.

```
Cisco AP Software, (ap1g6a), C9167, RELEASE SOFTWARE
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2022 by Cisco Systems, Inc.
Compiled Fri Jul 29 01:56:00 PDT 2022
```

```
ROM: Bootstrap program is U-Boot boot loader
BOOTLDR: U-Boot boot loader Version 2022010100
```

```
APFC58.9A16.E648 uptime is 0 days, 1 hours, 03 minutes
Last reload time   : Mon Sep 19 02:23:13 UTC 2022
Last reload reason : Image Upgrade
```

```
cisco IW9167EH-B ARMv8 Processor rev 4 (v8l) with 1757076/1006864K bytes of memory.
```

- If the **show version** output displays **Cisco AP Software (ap1g6j)** as shown in the following example, it means that AP is running **ap1g6j-k9c1-xxx.tar** image, which supports the Cisco URWB mode or Cisco WGB/uWGB.

```
Cisco AP Software, (ap1g6j), C9167, RELEASE SOFTWARE
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2022 by Cisco Systems, Inc.
Compiled Thu Aug 18 01:01:29 PDT 2022
```

```
ROM: Bootstrap program is U-Boot boot loader
BOOTLDR: U-Boot boot loader Version 2022010100
```

```
APFC58.9A16.E464 uptime is 1 days, 3 hours, 58 minutes
```



```
Last reload time   : Wed Sep 7 11:17:00 UTC 2022
Last reload reason : reload command
```

```
cisco IW9167EH-B ARMv8 Processor rev 4 (v8l) with 1759128/1091316K bytes of memory.
```

Configuring AP to Boot up with Different Image Options

To configure the access point to boot up with CAPWAP, URWB, or WGB/uWGB mode, follow these steps:



Note Switching between different modes performs full factory reset. Any configuration and data will be removed completely.

Step 1 enable

Enables privileged EXEC mode. Enter your password if prompted.

Step 2 configure boot mode {capwap | urwb | wgb}

Configures AP to CAPWAP, URWB, or WGB/uWGB mode. AP will reboot with specified mode.

Upgrade IW9167EH with 17.9.x to Support WGB/uWGB

If your IW9167EH is shipped with Cisco IOS XE Cupertino 17.9.3 software and operating as CAPWAP mode, and you want to upgrade your AP to Cisco IOS XE Dublin 17.11.1 to support WGB/uWGB mode, you need to switch your AP to Cisco URWB mode first, and then you can upgrade to 17.11.1.

To determine whether your IW9167EH is running CAPWAP mode or Cisco URWB mode, use the **show version** command.

- If the **show version** output displays **Cisco AP Software (ap1g6a)**, your AP is running as CAPWAP mode.
- If the **show version** output displays **Cisco AP Software (ap1g6j)**, your AP is running as Cisco URWB mode.

Cisco WGB/uWGB mode shares the same image with Cisco URWB. You cannot upgrade the **ap1g6j** image to 17.11.1 in CAPWAP mode (**ap1g6a**). Because the **archive download** command checks image type, upgrade gets aborted if image types mismatch.

Step 1 Convert CAPWAP mode to Cisco URWB mode.

Example:

```
#configure boot mode urwb
Before image swapping device need factory reset. Are you sure to proceed? (Y/N):y
Converting to Cisco URWB Mode...
<rebooting...>
```

Step 2 Log in with default credential (Cisco/Cisco/Cisco).

Step 3 Configure Cisco URWB, to make it work in **Offline** mode.

Example:

```
#configure iotod-iw offline
Switching to IOTOD IW Offline mode...
Will switch from Provisioning Mode to IOTOD IW offline Mode, device need to reboot: Y/N? Y
<rebooting...>
```

Step 4 Configure networking in Cisco URWB (IP/netmask/gateway, passphrase)

Example:

```
Cisco-23.174.76#configure wireless passphrase unit1
Cisco-23.174.76#configure ap address ipv4 static 192.168.1.200 255.255.255.0 192.168.1.1
Cisco-23.174.76#write
Cisco-23.174.76#reload
<rebooting...>
```

Note Passphrase is optional, but it is recommended to assign different passphrases if you are upgrading multiple units at the same time and they are connected to the same Layer 2 network. Because Cisco URWB forms MPLS network automatically if all nodes have the same passphrase, without further MPLS configuration, your IP service might not work properly.

Step 5 Upgrade to 17.11.1.

Example:

```
#archive download-sw /reload tftp://<TFTP_SERVER>/<ap1g6j-FILENAME>
<rebooting...>
```

Step 6 Convert the AP from Cisco URWB mode to Cisco WGB/uWGB mode.

Example:

```
#configure boot mode wgb
<rebooting...>
```

Related Documentation

To view all support information for the Cisco Catalyst IW9167E Heavy Duty Access Point, see <https://www.cisco.com/c/en/us/support/wireless/catalyst-iw9167-series/series.html>.

In addition to the documentation available on the support page, you will need to refer to the following guides:

- For information about IW9167EH hardware, see [Cisco Catalyst IW9167E Heavy Duty Access Point Hardware Installation Guide](#).
- A full listing of the AP's features and specifications is provided in [Cisco Catalyst IW9167E Heavy Duty Access Point Data Sheet](#).
- For more information about the configuration on Cisco Catalyst 9800 Series Wireless Controllers, see <https://www.cisco.com/c/en/us/support/wireless/catalyst-9800-series-wireless-controllers/products-installation-and-configuration-guides-list.html>.
- For information about Cisco URWB mode configuration, see the relevant documents at:

<https://www.cisco.com/c/en/us/support/wireless/catalyst-iw9167-series/series.html>.

- For more information about Cisco IOS XE, see the relevant documents at:

<http://www.cisco.com/c/en/us/products/ios-nx-os-software/ios-xe/index.html>



CHAPTER 2

AP Mode Configuration

- [Configuring Indoor Deployment for -E Domain, on page 7](#)
- [802.11ax 1600ns and 3200ns Guard Interval Support, on page 10](#)
- [GNSS Support, on page 11](#)
- [RAP Ethernet Daisy Chain, on page 12](#)

Configuring Indoor Deployment for -E Domain

IW9167EH supports indoor deployment for -E domain.

By default, indoor deployment is disabled, and the 5G radio supports channels 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140. After factory reset, indoor deployment configuration is reset to default, which is disabled.

You can check AP mode by using the **show ap name <ap-name> config general | section Indoor** command. In the command output, "Enabled" means AP is in indoor mode, and "Disabled" means AP is in outdoor mode, as shown in the following example.

```
#show ap name APFC58.9A15.C9A4 config general | inc Indoor
  AP Indoor Mode                               : Disabled
```

Edit Radios 5 GHz Band
✕

Configure
Detail

General

AP Name: APFC58.9A15.C9A4

AP Mode: Local

Admin Status: ENABLED

Mesh Backhaul: Disabled

Mesh Designated Downlink: Disabled

Antenna Parameters

Antenna Type: External

Antenna Mode: Omni

Self-Identifying Antenna (SIA): Not Present

Radio Profile: [roaming-radio-profile](#)

Number of Antennas Selected: 1

Supported Antenna Modes: 1x1, 2x2, 4x4

Antenna Port Mapping: 4

Antenna Gain (in .5 dBi units):

Download [Core Dump](#) to bootflash

RF Channel Assignment

Current Channel: 100

Channel Width: 20 MHz

Assignment Method: Custom

Channel Number: 100

- 100
- 104
- 108
- 112
- 116
- 120
- 124
- 128

Tx Power Level Assignment:

Current Tx Power Level: 112

Assignment Method:

BSS Color

BSS Color Configuration: Global

BSS Color Global Admin Status: Disabled

BSS Color Radio Operational Status: Disabled

BSS Color Radio Admin Status: ENABLED

Current BSS Color:

To configure the AP to indoor mode, use the **ap name** *<ap-name>* **indoor** command from wireless LAN controller. This command triggers an AP rebooting. After AP registers to the wireless LAN controller after rebooting, you need to assign corresponding country code to the AP. When indoor deployment is enabled, 5G radio supports channels 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140.



Note To disable indoor deployment, use the **ap name** *<ap-name>* **no indoor** command.

The screenshot shows the Cisco Catalyst 9800-L Wireless Controller interface. On the left is a navigation sidebar with options like Dashboard, Monitoring, Configuration, Administration, Licensing, and Troubleshooting. The main area is divided into two panes. The left pane shows 'All Access Points' with a table listing APs and their details. The right pane is the 'Edit AP' configuration for APFC58.9A15.C9A4, with the 'Advanced' tab selected. A red box highlights the 'Country Code' dropdown menu, which is set to 'FR'. Other configuration options include VLAN Tag, AP Image Management, AP Crash Data, and Hardware Reset.

Edit Radios 5 GHz Band

Configure Detail

The screenshot shows the 'Edit Radios 5 GHz Band' configuration page. It is divided into two main sections: 'General' and 'RF Channel Assignment'. The 'General' section includes fields for AP Name (APFC58.9A15.C9A4), AP Mode (Local), Admin Status (ENABLED), Mesh Backhaul (Disabled), and Mesh Designated Downlink (Disabled). The 'Antenna Parameters' section includes Antenna Type (External) and Antenna Mode (Omni). The 'RF Channel Assignment' section includes Current Channel (36), Channel Width (20 MHz), Assignment Method (Custom), Channel Number (36), Tx Power Level Assignments (40, 44, 48, 52, 56, 60, 64), and BSS Color (64). A red box highlights the 'Channel Number' dropdown menu, which is set to 36.



Note Channel list extends from U-NII-2c to U-NII-1, U-NII-2a, U-NII-2c (channel 144 is excluded).

802.11ax 1600ns and 3200ns Guard Interval Support

802.11ac has two Guard Interval (GI) options – long GI (800ns) and short GI (400ns). 802.11ax introduces new guard interval options. It has three types of GI – 800ns, 1600ns, and 3200ns. Longer guard intervals provide improved performance in environments with multi-path and delay spread. It improves link reliability for longer-range outdoor deployments and helps to prevent inter-symbol interference in outdoor environments and therefore improve coverage and performance.

The following table compares 802.11ax to the previous two standards.

Table 2: 802.11ax Guard Interval Comparing With Previous Standards

Capabilities	802.11n	802.11ac	802.11ax
Physical Layer (PHY)	High Throughput (HT)	Very High Throughput (VHT)	High-Efficiency (HE)
Guard Interval	800/400 ns	800/400 ns	800/1600/3200 ns

Configuring 802.11ax Long Guard Interval

HE mode guard intervals should be configured in RF profiles.

Step 1 Enters global configuration mode.

```
Device#configure terminal
```

Example:

```
Device#conf t
Enter configuration commands, one per line. End with CNTL/Z.
```

Step 2 Configures RF profile and enters RF profile configuration mode

```
ap dot11 {24ghz|5ghz} rf-profile <profile-name>
```

Example:

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

Step 3 Configures guard interval for the RF profile.

```
guard-interval {GUARD_INTERVAL_1600NS | GUARD_INTERVAL_3200NS | GUARD_INTERVAL_400NS
| GUARD_INTERVAL_800NS}
```

Example:

```
Device(config-rf-profile)#guard-interval GUARD_INTERVAL_1600NS
```

- GUARD_INTERVAL_1600NS: Set 1600 ns guard interval (only in HE mode)
- GUARD_INTERVAL_3200NS: Set 3200 ns guard interval (only in HE mode)
- GUARD_INTERVAL_400NS: Set 400 ns guard interval (HT VHT mode)
- GUARD_INTERVAL_800NS: Set 800 ns guard interval

Note Valid guard interval values are 800, 1600, and 3200 ns for HE mode. By default, GI is 800 ns.

Step 4 Exit global configuration mode.

end

Example:

Device(config)#**end**

Use the following command to verify the configuration on wireless controller:

```
#show ap rf-profile name Demo-24G-RF-profile detail | inc Guard
Guard Interval      : 1600ns
#show ap rf-profile name Demo-5G-RF-profile detail | inc Guard
Guard Interval      : 3200ns
```

Example

1. Define GI in RF profile

```
ap dot11 24ghz rf-profile Demo-24G-RF-profile
shutdown
guard-interval GUARD_INTERVAL_1600NS
no shutdown
ap dot11 5ghz rf-profile Demo-5G-RF-profile
shutdown
guard-interval GUARD_INTERVAL_3200NS
no shutdown
```

2. Associate RF profile to RF tag

```
wireless tag rf Demo-Guard-Interval-RF-tag
24ghz-rf-policy Demo-24G-RF-profile
5ghz-rf-policy Demo-5G-RF-profile
```

3. Associate RF tag to AP

```
ap fc58.9a15.c83c
rf-tag Demo-Guard-Interval-RF-tag
```

GNSS Support

From Cisco IOS XE Dublin 17.11.1, GNSS is supported on IW9167EH. The AP tracks GPS information for devices deployed in the outdoor environment and sends the GNSS information to the wireless controller.

Use the following command to display the GNSS information on the AP:

```
ap# show gnss info.
```

Use the following commands to display the GPS location of the AP:

```
controller# show ap geolocation summary
```

```
controller# show ap name <Cisco AP> geolocation detail
```

RAP Ethernet Daisy Chain

The RAP Ethernet Daisy Chain feature enhances the existing Ethernet bridging functionality. It forces the bridge AP to stick to the Ethernet link, and block the selecting of wireless link for uplink backhaul. Even the Ethernet link failure happens, the access point will never select a parent over wireless backhaul.

The following figure shows an example of RAP Ethernet Daisy Chain topology. Standalone DC power source is provided to each RAP.

Figure 1: RAP Ethernet Daisy Chain Topology

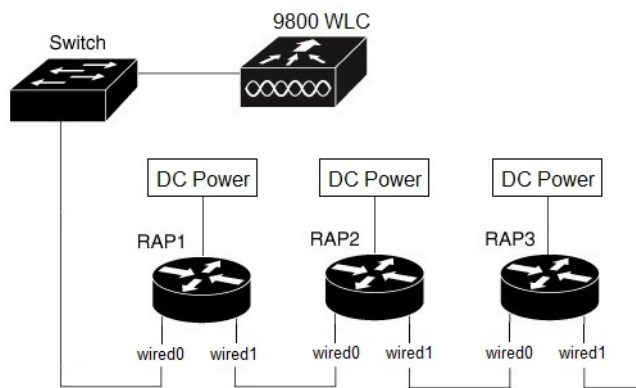


Table 3: Port Mapping

Panel Label	SW Interface
mGig POE-IN port	wired 0
SFP	wired 1



Note The supported SFP module for this feature is the 1000BASE-T rugged SFP (Cisco PID: GLC-T-RGD).

Follow these guidelines when you configure this feature:

- All APs in daisy chain is operating in mesh bridge mode or Flex+Bridge mode with Root AP role. The PoE-IN (wired0) and SFP (wired1) port can be used as uplink port and the PoE-IN (wired0) port has the higher priority than SFP (wired1).
- VLAN transparency should be disabled on all daisy-chained RAPs.
- To enable VLAN support on each root AP:
 - 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.
 - For Flex+Bridge APs, you must configure the native VLAN ID under the corresponding flex profile.

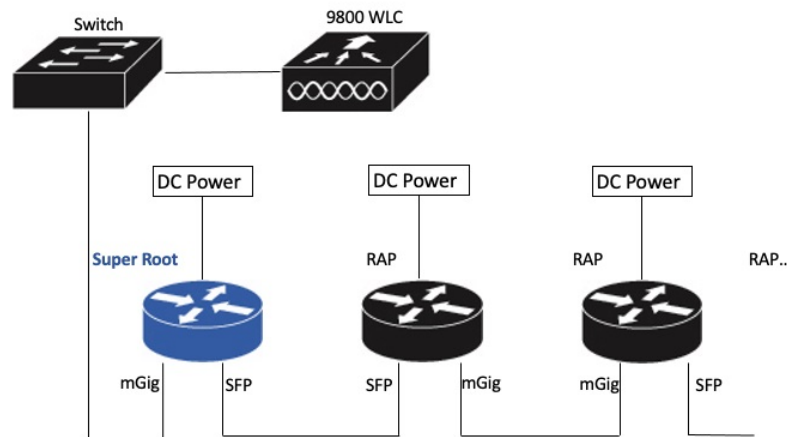
The RAP Ethernet Daisy Chain feature is already supported on Cisco IOS XE Cupertino 17.9.3, while it has the following limitations:

- Primary ethernet port (mGig port) must be used as uplink. In this case, SFP port to SFP port connection is not supported, which impacts network throughput (no 2.5Gbps or 5Gbps copper SFP available when SFP connect to mGig port).
- Reuse an existing command **persistant-ssid** to enable the RAP Ethernet Daisy Chain feature, which is misleading.

In Cisco IOS XE Dublin 17.11.1, the RAP Ethernet Daisy Chain feature is enhanced to support the following functions:

- Wireless Spanning Tree Protocol (WSTP) hello is enabled to support auto root port detection, so that RAP can use any port as its uplink. See the following topology.

Figure 2: RAP Ethernet Daisy Chain With WSTP Topology



- A separate and dedicated command **rap-eth-daisychain** is introduced to enable the feature.

WSTP Overview

Wireless LAN spanning tree protocol (WSTP) organizes a Cisco mesh network into a loop-free spanning tree topology. It quickly configure a mesh network into a stable, loop-free, optimal spanning tree topology, where an optimal topology provides least-cost paths to the primary Ethernet LAN. WSTP Hello messages are used to build the WSTP topology.

The WSTP super root is a single RAP that is elected as the highest level “super” root for the entire WSTP spanning tree. The super root is directly attached to the primary LAN. The super root transmits zero-cost WSTP SR Hello messages on its Ethernet root port to advertise the primary LAN to RAPs.

Comparison with Previous Release

The following table compares the daisy chain features in current release and prior to 17.11:

	Prior to Release 17.11.1	Release 17.11.1
Topology	Fixed topology RAP must use its mGig port as uplink in daisy chain topology	Flexible topology RAP can use either mGig port or SFP port as uplink in daisy chain topology by enabling WSTP on AP
Feature enablement	Persistent-ssid in AP profile 1	rap-eth-daisychain in Mesh profile
Ring Topology	Not supported 2	Not supported

¹ **Persistent-ssid** is still supported in 17.11, so that daisy chain function will not be impacted after upgrading from previous release to 17.11 with old configuration. But **Persistent-ssid** is not recommended in 17.11, and the new **rap-eth-daisychain** command is recommended.

² Supported only on IW6300 access point, by enabling **daisychain-stp-redundancy**. For more information, see the [RAP Ethernet Daisy Chain Redundancy for STP Ring Topology](#) section in [Cisco Catalyst IW6300 Heavy Duty Series and 6300 Series Embedded Services Access Point Software Configuration Guide](#).

RAP Ethernet Daisy Chain Configuration

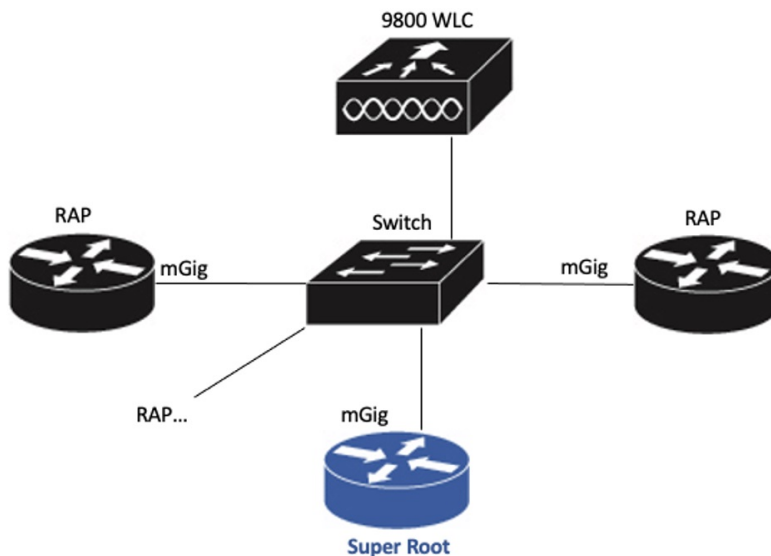
This section provides procedures for the RAP Ethernet daisy chain configuration.

Preconfiguring RAP Ethernet Daisy Chain Before Field Deployment

This section provides the preconfiguration that you should complete in lab before you set up in field deployment.

Step 1 Unpack, connect, and power on the AP.

Step 2 Join each AP to controller with mGig port. See the following figure for details.



Step 3 Configure AP to bridge mode and configure AP role to Root AP.

For detailed configuration procedures, see https://www.cisco.com/c/en/us/td/docs/wireless/controller/9800/17-11/config-guide/b_wl_17_eleven_cg/m_mesh_ewlc.html#task_pnb_bwy_mlb.

Step 4 Configuring RAP Ethernet Daisy Chain.

- a) Create mesh profile and enable the Rap Ethernet Daisy chain feature.
See [Enabling RAP Ethernet Daisy Chain, on page 16](#).
- b) Attach the profile to all the RAP.
- c) Configure one AP as Super Root which should be the first hop to the wireless controller.
See [Configuring Super Root, on page 16](#).
- d) Configure primary Ethernet port on the Super Root AP if you use SFP port as uplink.
See [Configuring Primary Ethernet Port, on page 17](#).

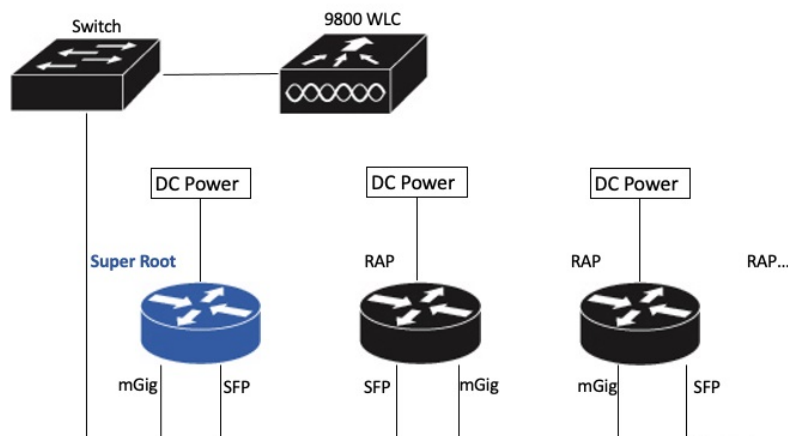
Step 5 Enable Ethernet Bridging and Configure Ethernet port.

See [Configuring Ethernet Bridging and Ethernet Port, on page 17](#).

- a) Enable Ethernet Bridging.
- b) Ethernet port configuration on both Port 0 and Port 1, including port mode and vlan. It is recommended to configure port to trunk mode.

Step 6 Verify the behavior in daisy chain topology.

- a) Connecting the RAP via wired port one by one.



Note The RAP which is the first hop from wireless controller should be configured as Super Root, as shown in the above figure.

- b) Make sure that RAP of each hop can join the controller.

Note In field deployment, just repeat Step 6 of this procedure. Make sure you configure the first hop as Super Root.

Enabling RAP Ethernet Daisy Chain

To enable RAP Ethernet Daisy Chain feature, use the **rap-eth-daisychain** command, or configure from GUI.

The following example shows enabling the feature from CLI:

```
#configure terminal
(config)#wireless profile mesh default-mesh-profile
(config-wireless-mesh-profile)#ethernet-bridging
(config-wireless-mesh-profile)#rap-ethernet-daisychain
```

The following figure shows enabling the feature from GUI:

The screenshot shows the 'Edit Mesh Profile' configuration page with two tabs: 'General' and 'Advanced'. The 'General' tab is active. On the right side, there is a list of checkboxes for various features. The 'RAP Ethernet Daisy Chain' checkbox is checked and circled in red. Other checked checkboxes include 'Backhaul amsdu', 'Backhaul Client Access', 'Battery State for an AP', 'Full sector DFS status', and 'MAP Fast Ancestor Find'. Other unchecked checkboxes include 'Daisychain STP Redundancy' and 'LSC'.

To verify the configuration, use the **show wireless profile mesh detailed** command or **show wireless mesh ethernet daisy-chain summary** command from wireless controller, as shown in the following examples:

```
#show wireless profile mesh detailed <profile name>
...
RAP ethernet daisychain      : ENABLED

#show wireless mesh ethernet daisy-chain summary
AP Name      BVI MAC      BGN      Backhaul      Ethernet      STP Red      Super
Root
-----
APxxxxxxx   xxxxxxxx   xxxxxx   Ethernet0     Up Up        NA
Enabled
```

Or use the **show mesh config** command on AP, as shown in the following example:

```
#show mesh config
...
RAP Ethernet Daisy Chain: Enabled
Daisy Chain Root: Disabled
```

Configuring Super Root

The first RAP which connects to the upstream switch should be configured as super root, which means it's the source of all WSTP hello. Other RAPs only start hello after receiving a hello.

You can configure the super root from wireless controller or from AP.

- From wireless controller, use the **ap name <name> [no] mesh rap-eth-daisychain super-root** command to configure a super root.

To verify the configuration, use the following command:

```
#show ap name <name> config general
...
RAP ethernet daisychain           : Enabled
Super Root                        : Enabled
```

- On AP, use the **capwap ap mesh wstp super-root** command to configure a super root.

To verify the configuration, use the following command:

```
#show mesh config
...
RAP Ethernet Daisy Chain: Enabled
Daisy Chain Root: Enabled
```

Configuring Primary Ethernet Port

Super root must use its primary Ethernet port to connect to upstream switch. For IW9167EH, the default primary Ethernet port is Ethernet port 0. To manually configure the primary Ethernet port, use the **ap name <name> mesh backhaul ethernet <0/1>** command from wireless controller.

To verify the configuration, use the following command from wireless controller:

```
#show ap name <name> config general
...
AP Primary Ethernet port          : 1
RAP ethernet daisychain           : Enabled
Super Root                        : Disabled
```

Or use the following commands on AP:

```
#show mesh config
...
RAP Ethernet Daisy Chain: Enabled
Daisy Chain Root: Enabled
AP Primary ethernet backhaul interface: 1

#show mesh adjacency parent
AdjInfo: Wired Backhaul: 1 [xx:xx:xx:xx:xx:xx]
```

Configuring Ethernet Bridging and Ethernet Port

Configuring Ethernet Bridging (CLI)

The Ethernet port on the MAPs are disabled by default. It can be enabled only by configuring Ethernet bridging on the Root AP and the other respective MAPs. Follow these steps to enable Ethernet bridging on the AP.

Step 1 Enters global configuration mode.

```
Device#configure terminal
```

Step 2 Creates a mesh profile.

```
wireless profile mesh profile-name
```

Configuring Ethernet Bridging (GUI)

Example:

```
(config)#wireless profile mesh rap-eth-daisy
```

Step 3 ethernet-bridging

Example:

```
(config-wireless-mesh-profile)#ethernet-bridging
```

Connects remote wired networks to each other.

Step 4 Disables VLAN transparency to ensure that the bridge is VLAN aware.

```
no ethernet-vlan-transparent
```

Example:

```
(config-wireless-mesh-profile)#no ethernet-vlan-transparent
```

Step 5 Exit global configuration mode.

```
end
```

Example:

```
(config-wireless-mesh-profile)#end
```

Example

Use the following command to verify the configuration:

```
#show wireless profile mesh detailed rap-eth-daisy
```

```
Mesh Profile Name      : rap-eth-daisy
-----
Description            :
Bridge Group Name     : unconfigured
Strict match BGN      : DISABLED
Amsdu                  : ENABLED
Background Scan       : DISABLED
Channel Change Notification : DISABLED
Backhaul client access : DISABLED
Ethernet Bridging     : ENABLED
Ethernet Vlan Transparent : DISABLED
Daisy Chain SP Redundancy : DISABLED
Full Sector DFS       : ENABLED
```

Configuring Ethernet Bridging (GUI)

Follow these steps to configure Ethernet Bridging from wireless controller GUI:

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 **Advanced** tab, uncheck the **VLAN Transparent** check box to disable VLAN transparency.

Step 5 In **Advanced** tab, check the **Ethernet Bridging** check box.

Step 6 Click **Apply to Device**.

The screenshot shows the Cisco Wireless LAN Controller GUI. On the left, the 'Profiles' table lists two profiles: 'rap-eth-daisy' and 'default-mesh-profile'. The 'rap-eth-daisy' profile is selected. On the right, the 'Edit Mesh Profile' dialog is open for the 'rap-eth-daisy' profile. The 'Advanced' tab is active, showing the 'Security' section with 'Method' set to 'EAP', and 'Authentication Method' and 'Authorization Method' both set to 'Enter Method'. In the 'Ethernet Bridging' section, 'VLAN Transparent' is unchecked and 'Ethernet Bridging' is checked. In the 'Bridge Group' section, 'Bridge Group Name' is set to 'duplo-mesh' and 'Strict Match' is checked.

Configuring Ethernet Port (CLI)

RAP Ethernet secondary port supports Access mode and Trunk mode. Follow these steps to configure Ethernet port mode.

- Use the following command to configure access mode.

```
#ap name ap-name mesh ethernet 1 mode access Vlan-ID
```

- Use the following commands to configure trunk mode. VLAN support must be enabled in advance, and VLAN transparent should be disabled in your mesh profile.

- Configure a trunk VLAN on the corresponding RAP.

```
#ap name ap-name mesh vlan-trunking native Vlan-ID
```

- Configure the native VLAN for the trunk port.

```
#ap name ap-name mesh ethernet 1 mode trunk vlan native Vlan-ID
```

- Configure the allowed VLANs for the trunk port. Permits VLAN filtering on an ethernet port of any Mesh or Root Access Point. Active only when VLAN transparency is disabled in the mesh profile.

```
#ap name ap-name mesh ethernet 1 mode trunk allowed Vlan-ID
```

Configuring Ethernet Port (GUI)

Follow these steps to configure Ethernet port from wireless controller GUI:

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 Click the configured mesh AP.

The **Edit AP** window is displayed.

- Step 3** Choose the **Mesh** tab.
- Step 4** In the **Ethernet Port Configuration** section, from the **Port** drop-down list, choose the port to configure.
- Step 5** From the **Mode** drop-down list, choose access mode or trunk mode.
- Step 6** In the **Native VLAN ID** field, enter the native VLAN for the trunk port.
- Step 7** Click **Update and Apply to Device**.

The screenshot shows the 'Edit AP' configuration interface. The 'Mesh' tab is selected. Under the 'Ethernet Port Configuration' section, the following settings are visible and highlighted with a red box:

- Port: 1
- Mode: trunk
- Native VLAN ID*: 2155
- Allowed VLAN IDs: 0-4094

A yellow warning message is displayed: "Ethernet Bridging on the associated Mesh Profile should be enabled to configure this section successfully".

Show and Debug Command

- Use the following command to debug WTP:

```
AP#debug mesh wstp
error    Mesh wstp error debugs
events   Mesh wstp events debugs
packets  Mesh wstp packet debugs
```

```
03:05:24.5918] chatter: wstp_ctl :: WstpControl: RX Hello(00) - BID:FC:58:9A:15:C8:04 SR:FC:58:9A:15:C8:04/0 Flags:02 Port:wired0
03:05:24.5918] chatter: wstp_ctl :: WstpControl - wired_hello_only, hello received, update parent record
03:05:24.5946] chatter: wstp_ctl :: WstpControl: TX Hello(00) - BID:FC:58:9A:17:58:EC SR:FC:58:9A:15:C8:04/0 Flags:02 Port:wired1
03:05:26.5918] chatter: wstp_ctl :: WstpControl: RX Hello(00) - BID:FC:58:9A:15:C8:04 SR:FC:58:9A:15:C8:04/0 Flags:02 Port:wired0
03:05:26.5918] chatter: wstp_ctl :: WstpControl - wired_hello_only, hello received, update parent record
03:05:26.5946] chatter: wstp_ctl :: WstpControl: TX Hello(00) - BID:FC:58:9A:17:58:EC SR:FC:58:9A:15:C8:04/0 Flags:02 Port:wired1
```

- Use the following command to display the WSTP statistics:

```
AP#show mesh stats
WSTP stats:
Attach-Cnt Hello-TX Hello-Rx TCN-TX TCN-RX SR-Chg-Cnt ST-Roam-Cnt
          0      58      58      0      0      0      0      0
```



CHAPTER 3

Workgroup Bridges

- [Overview, on page 21](#)
- [Limitations and Restrictions, on page 22](#)
- [Configuring Strong Password in Day0, on page 23](#)
- [Controller Configuration for WGB, on page 25](#)
- [uWGB Image Upgrade, on page 25](#)
- [WGB Configuration, on page 26](#)
- [uWGB Configuration, on page 33](#)
- [Converting Between WGB and uWGB, on page 40](#)
- [LED Pattern, on page 40](#)
- [Configuring HT Speed Limit, on page 40](#)
- [Radio Statistics Commands, on page 41](#)
- [Configuring Syslog, on page 44](#)
- [Event Logging, on page 44](#)
- [802.11v Support, on page 45](#)
- [Configuring Aux Scanning, on page 46](#)
- [Configuring Layer 2 NAT, on page 48](#)
- [Configuring Native VLAN on Ethernet Ports, on page 53](#)
- [Low Latency Profile, on page 53](#)
- [Configuring WGB/uWGB Radio Parameters, on page 58](#)
- [Assign Country Code to WGB/uWGB With -ROW PID, on page 58](#)
- [Indoor Deployment for -E Domain and United Kingdom, on page 59](#)
- [Configuring WGB Roaming Parameters, on page 59](#)
- [Importing and Exporting WGB Configuration, on page 60](#)
- [Verifying the Configuration of WGB and uWGB, on page 60](#)
- [Configuring and Validating SNMP With WGB, on page 62](#)
- [Support for QoS ACL Classification and Marking, on page 71](#)

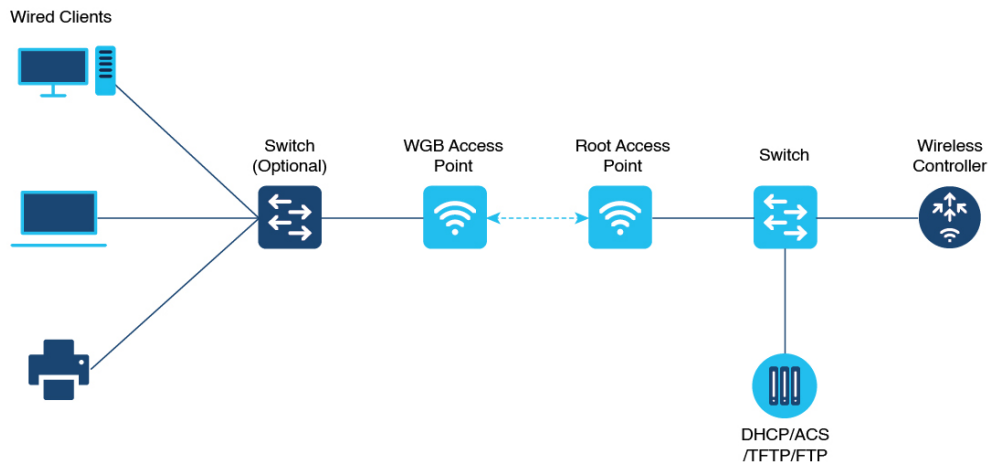
Overview

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.

Universal WGB (uWGB) is a complementary mode of WGB feature that acts as a wireless bridge between the wired client connected to uWGB and wireless infrastructure including Cisco and non-Cisco wireless network. One of the wireless interface is used to connect with the access point. The radio MAC is used to associate AP.

Figure 3: Example of a WGB



Starting from Cisco IOS XE Dublin 17.11.1, WGB is supported on the Cisco Catalyst IW9167E Heavy Duty Access Points.

Limitations and Restrictions

This section provides limitations and restrictions for WGB and uWGB modes.

- The WGB can associate only with Cisco lightweight access points. The universal WGB can associate to a third party access point.
- Per-VLAN Spanning Tree (PVST) and packets are used to detect and prevent loops in the wired and wireless switching networks. WGB transparently bridge STP packets. WGB can bridge STP packets between two wired segments. Incorrect or inconsistent configuration of STP in the wired segments can cause WGB wireless link to be blocked by the connected switch(es) to Access Point or WGB. This could cause WGB to disconnect from AP or AP disconnection to Controller to drop, and wired clients not receiving IP addresses, as STP begins to block switch port in the wired network. If administrator needs to disable bridging of STP between the wired segments by the WGB, we recommend disabling the STP on the directly connected switches in the wireless network.
- The following features are not supported for use with a WGB:
 - Idle timeout
 - Web authentication

- With Layer 3 roaming, if you plug a wired client into the WGB network after the WGB has roamed to another controller (for example, to a foreign controller), the wired client's IP address displays only on the anchor controller, not on the foreign controller.
- When you deauthenticate a WGB record from a controller, all of the WGB wired clients' entries are also deleted.
- These features are not supported for wired clients connected to a WGB:
 - MAC filtering
 - Link tests
 - Idle timeout
- Associating a WGB to a WLAN that is configured for Adaptive 802.11r is not supported.
- WGB supports IPv6 only when IPv4 is enable. But there is no impact on WGB wired clients IPv6 traffic.
- WGB management IPv6 does not work after WGB uplink association is completed. WGB can get an IPv6 address when the association is successful. But IPv6 ping will not be passed from or to WGB. SSH from wireless or wired client to WGB management IPv6 is not working. The workaround to bypass the pingable issue is to re-enable IPv6, even though IPv6 has already been enabled and the IPv6 address has been assigned.
- uWGB mode does not support SSH connecting to itself.
- uWGB mode supports neither TFTP nor SFTP. For software upgrade, you should perform it from WGB mode. For more information, see [uWGB Image Upgrade, on page 25](#).
- uWGB does not support host IP service. Some functions, such as image upgrade via radio uplink and remote management via SSH session, are not supported.
- For IW9167EH WGB/uWGB mode, the **packet retries [N] drop** command does not work in IOS XE Release 17.11.1.
- DFS channels are supported on IW9167EH WGB/uWGB from Release 17.13.1.
- Only Dot11Radio 0 and Dot11Radio 1 interfaces can be used as wireless uplink on IW9167EH WGB/uWGB.

Configuring Strong Password in Day0

It is required to set a strong password for WGB/uWGB after first login. The username and strong password should follow these rules:

1. Username length is between 1 and 32 characters.
2. Password length is between 8 to 120 characters.
3. Password must contain at least one uppercase character, one lowercase character, one digit, and one punctuation.
4. Password can contain alphanumeric characters and special characters (ASCII decimal code from 33 to 126), but the following special characters are not permitted: " (double quote), ' (single quote), ? (question mark).

5. Password cannot contain three sequential characters.
6. Password cannot contain three same characters consecutively.
7. Password cannot be the same as or reverse of the username.
8. New password must have at least four different characters compared to the current password.

For example, by default, the credential is

- username: Cisco
- password: Cisco
- enable password: Cisco

To reset the credential with the following strong password:

- username: demouser
- password: DemoP@ssw0rd
- enable password: DemoE^aP@ssw0rd

```
User Access Verification
Username: Cisco
Password: Cisco

% First Login: Please Reset Credentials

Current Password:Cisco
Current Enable Password:Cisco
New User Name:demouser
New Password:DemoP@ssw0rd
Confirm New Password:DemoP@ssw0rd
New Enable Password:DemoE^aP@ssw0rd
Confirm New Enable Password:DemoE^aP@ssw0rd

% Credentials changed, please re-login

[*04/18/2023 23:53:44.8926] chpasswd: password for user changed
[*04/18/2023 23:53:44.9074]
[*04/18/2023 23:53:44.9074] Management user configuration saved successfully
[*04/18/2023 23:53:44.9074]
```

```
User Access Verification
Username: demouser
Password: DemoP@ssw0rd
APFC58.9A15.C808>enable
Password:DemoE^aP@ssw0rd
APFC58.9A15.C808#
```



Note In above example, all passwords are displayed in plain text for demonstration purpose. In real case, they are hidden by asterisks (*).

Controller Configuration for WGB

For a WGB to join a wireless network, you need to configure specific settings on the WLAN and related policy profile on the controller.

Follow these steps to configure the Cisco Client Extensions option and set the support of Aironet IE in the WLAN:

1. Enter WLAN configuration submode. The *profile-name* is the profile name of the configured WLAN.

```
#wlan profile-name
```

2. Configure the Cisco Client Extensions option and set the support of Aironet IE on the WLAN.

```
#ccx aironet-iesupport
```



Note Without this configuration, WGB is not able to associate to AP.

Follow these steps to configure WLAN policy profile:

1. Enter wireless policy configuration mode.

```
#wireless profile policy profile-policy
```

2. Assign the profile policy to the VLAN.

```
#vlan vlan-id
```

3. Configure WGB VLAN client support.

```
#wgb vlan
```

uWGB Image Upgrade

uWGB mode does not support TFTP or SFTP. To perform a software upgrade, follow these steps:

Step 1 Connect a TFTP or SFTP server to wired 0 port of uWGB.

Step 2 Turn radio interfaces into Administratively Down state.

```
configure Dot11Radio <0|1> disable
```

Example:

```
#configure Dot11Radio 0 disable
#configure Dot11Radio 1 disable
```

Step 3 Convert uWGB to WGB mode.

```
configure Dot11Radio slot_id mode wgb ssid-profile ssid_profile_name
```

Example:

```
#configure Dot11Radio 1 mode wgb ssid-profile a_uwgb_demo_ssid
```

This command will reboot with downloaded configs.
Are you sure you want continue? <**confirm**>

Note `ssid_profile_name` can be any existing SSID profile configured by users.

Step 4 After rebooting, assign a static IP address to the WGB.

configure ap address ipv4 static *IPv4_address netmask Gateway_IPv4_address*

Example:

```
#configure ap address ipv4 static 192.168.1.101 255.255.255.0 192.168.1.1
```

Step 5 Verify the ICMP ping works.

ping *server_IP*

Example:

```
#ping 192.168.1.20
Sending 5, 100-byte ICMP Echos to 192.168.1.20, timeout is 2 seconds

PING 192.168.1.20
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0.858/0.932/1.001 ms
```

Step 6 Upgrade the software.

archive download /reload <**tftp** | **sftp** | **http**>://*server_ip/file_path*

Step 7 Convert WGB back to uWGB.

configure Dot11Radio *slot_id mode uwgb wired_client_mac_addr ssid-profile ssid_profile_name*

Example:

```
#configure Dot11Radio 1 mode uwgb 00b4.9e00.a891 ssid-profile a_uwgb_demo_ssid
```

WGB Configuration

The typical WGB configuration involves the following steps:

1. Create an SSID profile.
2. Configure radio as workgroup, and associate the SSID profile to the radio.
3. Turn on the radio.

WGB uplink supports various security methods, including:

- Open (unsecured)
- PSK
- Dot1x (LEAP, PEAP, FAST-EAP, TLS)

The following is an example of Dot1x FAST-EAP configuration:

```
configure dot1x credential demo-cred username demouser1 password Dem0Pass!@
configure eap-profile demo-eap-profile dot1x-credential demo-cred
```



```

configure eap-profile demo-eap-profile method fast
configure ssid-profile demo-FAST ssid demo-fast authentication eap profile demo-eap-profile
  key-management wpa2
configure dot11radio 0 mode wgb ssid-profile demo-FAST
configure dot11radio 0 enable

```

The following sections provide detailed information about WGB configuration.

Configuring IP Address

Configuring IPv4 Address

Configure the IPv4 address of the AP by entering the following commands:

- To configure IPv4 address by DHCP, use the following command:

```
#configure ap address ipv4 dhcp
```

- To configure the static IPv4 address, use the following command. By doing so, you can manage the device via wired interface without uplink connection.

```
#configure ap address ipv4 static ipv4_addr netmask gateway
```

- To display current IP address configuration, use the following command:

```
#show ip interface brief
```

Configuring IPv6 Address

Configure the IPv6 address of the AP by entering the following commands:

- To configure the static IPv6 address, use the following command. By doing so, you can manage the device via wired interface without uplink connection.

```
#configure ap address ipv6 static ipv6_addr prefixlen [gateway]
```

- **#configure ap address ipv6 auto-config {enable|disable}**



Note The **configure ap address ipv6 auto-config enable** command is designed to enable IPv6 SLAAC. However, SLAAC is not applicable for cos WGB. This CLI will configure IPv6 address with DHCPv6 instead of SLAAC.

- To configure IPv6 address by DHCP, use the following command:

```
#configure ap address ipv6 dhcp
```

- To display current IP address configuration, use the following command:

```
#show ipv6 interface brief
```

Configuring a Dot1X Credential

Configure a dot1x credential by entering this command:

```
# configure dot1x credential profile-name username name password pwd
```

View the WGB EAP dot1x profile summary by entering this command:

```
# show wgb eap dot1x credential profile
```

Deauthenticating WGB Wired Client

Deauthenticate WGB wired client by entering this command:

```
# clear wgb client {all |single mac-addr}
```

Configuring an EAP Profile

Follow these steps to configure the EAP profile:

1. Bind dot1x credential profile to EAP profile.
2. Bind EAP profile to SSID profile
3. Bind SSID profile to the radio.

Step 1 Configure the EAP profile method type by entering this command:

```
# configure eap-profile profile-name method {fast | leap | peap | tls}
```

Step 2 Attaching the CA Trustpoint for TLS by entering the following command. With the default profile, WGB uses the internal MIC certificate for authentication.

```
# configure eap-profile profile-name trustpoint {default | name trustpoint-name}
```

Step 3 Bind dot1x-credential profile by entering this command:

```
# configure eap-profile profile-name dot1x-credential profile-name
```

Step 4 [Optional] Delete an EAP profile by entering this command:

```
# configure eap-profile profile-name delete
```

Step 5 View summary of EAP and dot1x profiles by entering this command:

```
# show wgb eap profile all
```

Configuring Manual Enrollment of a Trustpoint for Terminal

Step 1 Create a Trustpoint in WGB by entering this command:

```
# configure crypto pki trustpoint ca-server-name enrollment terminal
```

Step 2 Authenticate a Trustpoint manually by entering this command:

```
# configure crypto pki trustpoint ca-server-name authenticate
```

Enter the base 64 encoded CA certificate and end the certificate by entering **quit** in a new line.

Note User has to import complete certificate chains in the trustpoint if intermediate certificate is used.

Example:

```
#configure crypto pki trustpoint demotp authenticate
```

Enter the base 64 encoded CA certificate.

....And end with the word "quit" on a line by itself....

```
-----BEGIN CERTIFICATE-----
[base64 encoded root CA certificate]
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
[base64 encoded intermediate CA certificate]
-----END CERTIFICATE-----
quit
```

Step 3 Configure a private key size by entering this command:

```
# configure crypto pki trustpoint ca-server-name key-size key-length
```

Step 4 Configure the subject-name by entering this command:

```
# configure crypto pki trustpoint ca-server-name subject-name name [Optional] 2ltr-country-code state-name
locality org-name org-unit email
```

Step 5 Generate a private key and Certificate Signing Request (CSR) by entering this command:

```
# configure crypto pki trustpoint ca-server-name enroll
```

Create the digitally signed certificate using the CSR output in the CA server.

Step 6 Import the signed certificate in WGB by entering this command:

```
# configure crypto pki trustpoint ca-server-name import certificate
```

Enter the base 64 encoded CA certificate and end the certificate by entering **quit** in a new line.

Step 7 [Optional] Delete a Trustpoint by entering this command:

```
# configure crypto pki trustpoint trustpoint-name delete
```

Step 8 View the Trustpoint summary by entering this command:

```
# show crypto pki trustpoint
```

Step 9 View the content of the certificates that are created for a Trustpoint by entering this command:

```
# show crypto pki trustpoint trustpoint-name certificate
```

Configuring Auto-Enrollment of a Trustpoint for Workgroup Bridge

Step 1 Enroll a Trustpoint in WGB using the server URL by entering this command:

```
# configure crypto pki trustpoint ca-server-name enrollment url ca-server-url
```

- Step 2** Authenticate a Trustpoint by entering this command:
- ```
configure crypto pki trustpoint ca-server-name authenticate
```
- This command will fetch the CA certificate from CA server automatically.
- Step 3** Configure a private key size by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name key-size key-length
```
- Step 4** Configure the subject-name by entering this command:
- ```
configure crypto pki trustpoint ca-server-name subject-name name [Optional] 2ltr-country-code state-name locality org-name org-unit email
```
- Step 5** Enroll the Trust point by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name enroll
```
- Request the digitally signed certificate from the CA server.
- Step 6** Enable auto-enroll by entering this command:
- ```
configure crypto pki trustpoint ca-server-name auto-enroll enable renew-percentage
```
- You can disable auto-enrolling by using the disable syntax in the command.
- Step 7** [Optional] Delete a Trustpoint by entering this command:
- ```
# configure crypto pki trustpoint trustpoint-name delete
```
- Step 8** View the Trustpoint summary by entering this command:
- ```
show crypto pki trustpoint
```
- Step 9** View the content of the certificates that are created for a Trustpoint by entering this command:
- ```
# show crypto pki trustpoint trustpoint-name certificate
```
- Step 10** View the PKI timer information by entering this command:
- ```
show crypto pki timers
```

---

## Configuring Manual Certificate Enrollment Using TFTP Server

---

- Step 1** Specify the enrollment method to retrieve the CA certificate and client certificate for a Trustpoint in WGB by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name enrollment tftp tftp-addr/file-name
```
- Step 2** Authenticate a Trustpoint manually by entering this command:
- ```
configure crypto pki trustpoint ca-server-name authenticate
```
- Retrieves the CA certificate and authenticates it from the specified TFTP server. If the file specification is included, the wgb will append the extension “.ca” to the specified filename.

- Step 3** Configure a private key size by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name key-size key-length
```
- Step 4** Configure the subject-name by entering this command:
- ```
configure crypto pki trustpoint ca-server-name subject-name name [Optional] 2ltr-country-code state-name locality org-name org-unit email
```
- Step 5** Generate a private key and Certificate Signing Request (CSR) by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name enroll
```
- Generates certificate request and writes the request out to the TFTP server. The filename to be written is appended with the extension “.req”.
- Step 6** Import the signed certificate in WGB by entering this command:
- ```
configure crypto pki trustpoint ca-server-name import certificate
```
- Imports a certificate via TFTP at the console terminal, which retrieves the granted certificate. The WGB will attempt to retrieve the granted certificate via TFTP using the same filename and the file name append with “.crt” extension.
- Step 7** View the Trustpoint summary by entering this command:
- ```
# show crypto pki trustpoint
```
- Step 8** View the content of the certificates that are created for a Trustpoint by entering this command:
- ```
show crypto pki trustpoint trustpoint-name certificate
```
- 

## SSID configuration

SSID configuration consists of the following two parts:

1. [Creating an SSID Profile, on page 31](#)
2. [Configuring Radio Interface for Workgroup Bridges, on page 32](#)

### Creating an SSID Profile

Choose one of the following authentication protocols for the SSID profile.

- [Configuring an SSID profile with Open Authentication, on page 31](#)
- [Configuring an SSID profile with PSK Authentication, on page 32](#)
- [Configuring an SSID Profile with Dot1x Authentication, on page 32](#)

#### Configuring an SSID profile with Open Authentication

Use the following command to configure an SSID profile with Open Authentication:

```
configure ssid-profile ssid-profile-name ssid radio-serv-name authentication open
```

## Configuring an SSID profile with PSK Authentication

Use the following command to configure an SSID profile with PSK WPA2 Authentication:

```
configure ssid-profile ssid-profile-name ssid SSID_name authentication psk preshared-key
key-management wpa2
```

Use the following command to configure an SSID profile with PSK Dot11r Authentication:

```
configure ssid-profile ssid-profile-name ssid SSID_name authentication psk preshared-key
key-management dot11r
```

Use the following command to configure an SSID profile with PSK Dot11w Authentication:

```
configure ssid-profile ssid-profile-name ssid SSID_name authentication psk preshared-key
key-management dot11w
```

## Configuring an SSID Profile with Dot1x Authentication

Use the following commands to configure an SSID profile with Dot1x authentication:

```
configure ssid-profile ssid-profile-name ssid radio-serv-name authentication eap profile eap-profile-name
key-management { dot11r | wpa2 | dot11w { optional | required } }
```

The following example configures an SSID profile with Dot1x EAP-PEAP authentication:

```
configure dot1x credential c1 username wgbusr password cisco123456
configure eap-profile p1 dot1x-credential c1
configure eap-profile p1 method peap
configure ssid-profile iot-peap ssid iot-peap authentication eap profile p1 key-management
wpa2
```

## Configuring Radio Interface for Workgroup Bridges

- From the available two radio interfaces, before configuring WGB mode on one radio interface, configure the other radio interface to root-ap mode.

Map a radio interface as root-ap by entering this command:

```
configure dot11radio radio-slot-id mode root-ap
```

### Example

```
configure dot11radio 0 mode root-ap
```




---

**Note** When an active SSID or EAP profile is modified, you need to reassociate the profile to the radio interface for the updated profile to be active.

---

- Map a radio interface to a WGB SSID profile by entering this command:

```
configure dot11radio radio-slot-id mode wgb ssid-profile ssid-profile-name
```

### Example

```
configure dot11radio 1 mode wgb ssid-profile psk_ssid
```

- Configure a radio interface by entering this command:

```
configure dot11radio radio-slot-id { enable | disable }
```

**Example**

```
configure dot11radio 0 disable
```




---

**Note** Only one radio or slot is allowed to operate in WGB mode.

---

## Configuring WGB/uWGB Timer

The timer configuration CLIs are common for both WGB and uWGB. Use the following commands to configure timers:

- Configure the WGB association response timeout by entering this command:

```
configure wgb association response timeout response-milliseconds
```

The default value is 100 milliseconds. The valid range is between 100 and 5000 milliseconds.

- Configure the WGB authentication response timeout by entering this command:

```
configure wgb authentication response timeout response-milliseconds
```

The default value is 100 milliseconds. The valid range is between 100 and 5000 milliseconds.

- Configure the WGB EAP timeout by entering this command:

```
configure wgb eap timeout timeout-secs
```

The default value is 3 seconds. The valid range is between 2 and 60 seconds.

- Configure the WGB bridge client response timeout by entering this command:

```
configure wgb bridge client timeout timeout-secs
```

Default timeout value is 300 seconds. The valid range is between 10 and 1000000 seconds.

## uWGB Configuration

The universal WGB is able to interoperate with non-Cisco access points using uplink radio MAC address, thus the universal workgroup bridge role supports only one wired client.

Most WGB configurations apply to uWGB. The only difference is that you configure wired client's MAC address with the following command:

```
configure dot11 <0|1> mode uwgb <uwgb_wired_client_mac_address> ssid-profile <ssid-profile>
```

The following is an example of Dot1x FAST-EAP configuration:

```
configure dot1x credential demo-cred username demouser1 password Dem0Pass!@
configure eap-profile demo-eap-profile dot1x-credential demo-cred
configure eap-profile demo-eap-profile method fast
configure ssid-profile demo-FAST ssid demo-fast authentication eap profile demo-eap-profile
 key-management wpa2
configure dot11radio 0 mode uwgb fc58.220a.0704 ssid-profile demo-FAST
configure dot11radio 0 enable
```

The following sections provide detailed information about uWGB configuration.

## Configuring IP Address

### Configuring IPv4 Address

Configure the IPv4 address of the AP by entering the following commands:

- To configure IPv4 address by DHCP, use the following command:

```
#configure ap address ipv4 dhcp
```

- To configure the static IPv4 address, use the following command. By doing so, you can manage the device via wired interface without uplink connection.

```
#configure ap address ipv4 static ipv4_addr netmask gateway
```

- To display current IP address configuration, use the following command:

```
#show ip interface brief
```

### Configuring IPv6 Address

Configure the IPv6 address of the AP by entering the following commands:

- To configure the static IPv6 address, use the following command. By doing so, you can manage the device via wired interface without uplink connection.

```
#configure ap address ipv6 static ipv6_addr prefixlen [gateway]
```

- #configure ap address ipv6 auto-config {enable|disable}



---

**Note** The `configure ap address ipv6 auto-config enable` command is designed to enable IPv6 SLAAC. However, SLAAC is not applicable for cos WGB. This CLI will configure IPv6 address with DHCPv6 instead of SLAAC.

---

- To configure IPv6 address by DHCP, use the following command:

```
#configure ap address ipv6 dhcp
```

- To display current IP address configuration, use the following command:

```
#show ipv6 interface brief
```

## Configuring a Dot1X Credential

Configure a dot1x credential by entering this command:

```
configure dot1x credential profile-name username name password pwd
```

View the WGB EAP dot1x profile summary by entering this command:

```
show wgb eap dot1x credential profile
```



## Configuring an EAP Profile

Follow these steps to configure the EAP profile:

1. Bind dot1x credential profile to EAP profile.
2. Bind EAP profile to SSID profile
3. Bind SSID profile to the radio.

- 
- Step 1** Configure the EAP profile method type by entering this command:
- ```
# configure eap-profile profile-name method { fast | leap | peap | tls }
```
- Step 2** Attaching the CA Trustpoint for TLS by entering the following command. With the default profile, WGB uses the internal MIC certificate for authentication.
- ```
configure eap-profile profile-name trustpoint { default | name trustpoint-name }
```
- Step 3** Bind dot1x-credential profile by entering this command:
- ```
# configure eap-profile profile-name dot1x-credential profile-name
```
- Step 4** [Optional] Delete an EAP profile by entering this command:
- ```
configure eap-profile profile-name delete
```
- Step 5** View summary of EAP and dot1x profiles by entering this command:
- ```
# show wgb eap profile all
```
-

Configuring Manual Enrollment of a Trustpoint for Terminal

- Step 1** Create a Trustpoint in WGB by entering this command:
- ```
configure crypto pki trustpoint ca-server-name enrollment terminal
```
- Step 2** Authenticate a Trustpoint manually by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name authenticate
```
- Enter the base 64 encoded CA certificate and end the certificate by entering **quit** in a new line.
- Note** User has to import complete certificate chains in the trustpoint if intermediate certificate is used.

Example:

```
#configure crypto pki trustpoint demotp authenticate
```

Enter the base 64 encoded CA certificate.

....And end with the word "quit" on a line by itself....

```
-----BEGIN CERTIFICATE-----
[base64 encoded root CA certificate]
-----END CERTIFICATE-----
```

```

-----BEGIN CERTIFICATE-----
[base64 encoded intermediate CA certificate]
-----END CERTIFICATE-----
quit

```

- Step 3** Configure a private key size by entering this command:
- ```
configure crypto pki trustpoint ca-server-name key-size key-length
```
- Step 4** Configure the subject-name by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name subject-name name [Optional] 2ltr-country-code state-name locality org-name org-unit email
```
- Step 5** Generate a private key and Certificate Signing Request (CSR) by entering this command:
- ```
configure crypto pki trustpoint ca-server-name enroll
```
- Create the digitally signed certificate using the CSR output in the CA server.
- Step 6** Import the signed certificate in WGB by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name import certificate
```
- Enter the base 64 encoded CA certificate and end the certificate by entering **quit** in a new line.
- Step 7** [Optional] Delete a Trustpoint by entering this command:
- ```
configure crypto pki trustpoint trustpoint-name delete
```
- Step 8** View the Trustpoint summary by entering this command:
- ```
# show crypto pki trustpoint
```
- Step 9** View the content of the certificates that are created for a Trustpoint by entering this command:
- ```
show crypto pki trustpoint trustpoint-name certificate
```
- 

## Configuring Auto-Enrollment of a Trustpoint for Workgroup Bridge

---

- Step 1** Enroll a Trustpoint in WGB using the server URL by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name enrollment url ca-server-url
```
- Step 2** Authenticate a Trustpoint by entering this command:
- ```
configure crypto pki trustpoint ca-server-name authenticate
```
- This command will fetch the CA certificate from CA server automatically.
- Step 3** Configure a private key size by entering this command:
- ```
# configure crypto pki trustpoint ca-server-name key-size key-length
```
- Step 4** Configure the subject-name by entering this command:

```
# configure crypto pki trustpoint ca-server-name subject-name name [Optional] 2ltr-country-code state-name  
locality org-name org-unit email
```

Step 5 Enroll the Trust point by entering this command:

```
# configure crypto pki trustpoint ca-server-name enroll
```

Request the digitally signed certificate from the CA server.

Step 6 Enable auto-enroll by entering this command:

```
# configure crypto pki trustpoint ca-server-name auto-enroll enable renew-percentage
```

You can disable auto-enrolling by using the disable syntax in the command.

Step 7 [Optional] Delete a Trustpoint by entering this command:

```
# configure crypto pki trustpoint trustpoint-name delete
```

Step 8 View the Trustpoint summary by entering this command:

```
# show crypto pki trustpoint
```

Step 9 View the content of the certificates that are created for a Trustpoint by entering this command:

```
# show crypto pki trustpoint trustpoint-name certificate
```

Step 10 View the PKI timer information by entering this command:

```
# show crypto pki timers
```

Configuring Manual Certificate Enrollment Using TFTP Server

Step 1 Specify the enrollment method to retrieve the CA certificate and client certificate for a Trustpoint in WGB by entering this command:

```
# configure crypto pki trustpoint ca-server-name enrollment tftp tftp-addr/file-name
```

Step 2 Authenticate a Trustpoint manually by entering this command:

```
# configure crypto pki trustpoint ca-server-name authenticate
```

Retrieves the CA certificate and authenticates it from the specified TFTP server. If the file specification is included, the wgb will append the extension “.ca” to the specified filename.

Step 3 Configure a private key size by entering this command:

```
# configure crypto pki trustpoint ca-server-name key-size key-length
```

Step 4 Configure the subject-name by entering this command:

```
# configure crypto pki trustpoint ca-server-name subject-name name [Optional] 2ltr-country-code state-name  
locality org-name org-unit email
```

Step 5 Generate a private key and Certificate Signing Request (CSR) by entering this command:

```
# configure crypto pki trustpoint ca-server-name enroll
```

Generates certificate request and writes the request out to the TFTP server. The filename to be written is appended with the extension “.req”.

Step 6 Import the signed certificate in WGB by entering this command:

```
# configure crypto pki trustpoint ca-server-name import certificate
```

Imports a certificate via TFTP at the console terminal, which retrieves the granted certificate. The WGB will attempt to retrieve the granted certificate via TFTP using the same filename and the file name append with “.crt” extension.

Step 7 View the Trustpoint summary by entering this command:

```
# show crypto pki trustpoint
```

Step 8 View the content of the certificates that are created for a Trustpoint by entering this command:

```
# show crypto pki trustpoint trustpoint-name certificate
```

SSID configuration

SSID configuration consists of the following two parts:

1. [Creating an SSID Profile, on page 31](#)
2. [Configuring Radio Interface for uWGB, on page 39](#)

Creating an SSID Profile

Choose one of the following authentication protocols for the SSID profile.

- [Configuring an SSID profile with Open Authentication, on page 31](#)
- [Configuring an SSID profile with PSK Authentication, on page 32](#)
- [Configuring an SSID Profile with Dot1x Authentication, on page 32](#)

Configuring an SSID profile with Open Authentication

Use the following command to configure an SSID profile with Open Authentication:

```
# configure ssid-profile ssid-profile-name ssid radio-serv-name authentication open
```

Configuring an SSID profile with PSK Authentication

Use the following command to configure an SSID profile with PSK WPA2 Authentication:

```
# configure ssid-profile ssid-profile-name ssid SSID_name authentication psk preshared-key
key-management wpa2
```

Use the following command to configure an SSID profile with PSK Dot11r Authentication:

```
# configure ssid-profile ssid-profile-name ssid SSID_name authentication psk preshared-key
key-management dot11r
```

Use the following command to configure an SSID profile with PSK Dot11w Authentication:

```
# configure ssid-profile ssid-profile-name ssid SSID_name authentication psk preshared-key
key-management dot11w
```

Configuring an SSID Profile with Dot1x Authentication

Use the following commands to configure an SSID profile with Dot1x authentication:

```
# configure ssid-profile ssid-profile-name ssid radio-serv-name authentication eap profile eap-profile-name
key-management { dot11r | wpa2 | dot11w { optional | required } }
```

The following example configures an SSID profile with Dot1x EAP-PEAP authentication:

```
configure dot1x credential c1 username wgbusr password cisco123456
configure eap-profile p1 dot1x-credential c1
configure eap-profile p1 method peap
configure ssid-profile iot-peap ssid iot-peap authentication eap profile p1 key-management
wpa2
```

Configuring Radio Interface for uWGB

- From the available two radio interfaces, before configuring WGB mode on one radio interface, configure the other radio interface to root-ap mode.

Map a radio interface as root-ap by entering this command:

```
# configure dot11radio radio-slot-id mode root-ap
```

Example

```
# configure dot11radio 0 mode root-ap
```



Note When an active SSID or EAP profile is modified, you need to reassociate the profile to the radio interface for the updated profile to be active.

- Map a radio interface to a WGB SSID profile by entering this command:

```
# configure dot11radio radio-slot-id mode uwgb uwgb-wired-client-mac-address ssid-profile
ssid-profile-name
```

- Configure a radio interface by entering this command:

```
# configure dot11radio radio-slot-id { enable | disable }
```

Example

```
# configure dot11radio 0 disable
```



Note After configuring the uplink to the SSID profile, we recommend you to disable and enable the radio for the changes to be active.



Note Only one radio or slot is allowed to operate in uWGB or WGB mode.

Converting Between WGB and uWGB

To convert from WGB to uWGB, use the following command:

```
#configure dot11radio <0|1> mode uwgb <WIRED_CLIENT_MAC> ssid-profile <SSID_PROFILE_NAME>
```

To convert from uWGB to WGB, use the following command. This conversion involves a reboot of the AP.

```
#configure Dot11Radio 1 mode wgb ssid-profile <SSID_PROFILE_NAME>
```

```
This command will reboot with downloaded configs.
Are you sure you want continue? [confirm]
```

LED Pattern

Two new LED patterns are added to IW9167EH WGB mode:

- When WGB is in disassociated state, the System LED is blinking RED.
- When WGB makes association to parent AP, System LED turns to solid GREEN.

Configuring HT Speed Limit

In WGB field moving case deployment, you can manually set a transmission rate limit with High Throughput (HT) Modulation and Coding Scheme (MCS).

The following is an example to configure WGB to transmit with 802.11n HT m4. m5. rate:

```
Config dot11radio [1|2] 802.11ax disable
```

```
Config dot11radio [1|2] 802.11ac disable
```

```
Config dot11radio [1|2] speed ht-mcs m4. m5.
```

WGB also supports to configure legacy rates.

- For 802.11b/g, the legacy rates are configured as following:

```
configure dot11radio 0 speed legacy-rate
1.0 Allow 1.0 Mb/s rate
11.0 Allow 11.0 Mb/s rate
12.0 Allow 12.0 Mb/s rate
18.0 Allow 18.0 Mb/s rate
2.0 Allow 2.0 Mb/s rate
24.0 Allow 24.0 Mb/s rate
36.0 Allow 36.0 Mb/s rate
48.0 Allow 48.0 Mb/s rate
5.5 Allow 5.5 Mb/s rate
54.0 Allow 54.0 Mb/s rate
6.0 Allow 6.0 Mb/s rate
9.0 Allow 9.0 Mb/s rate
basic-1.0 Require 1.0 Mb/s rate
basic-11.0 Require 11.0 Mb/s rate
basic-12.0 Require 12.0 Mb/s rate
basic-18.0 Require 18.0 Mb/s rate
basic-2.0 Require 2.0 Mb/s rate
basic-24.0 Require 24.0 Mb/s rate
```

```

basic-36.0 Require 36.0 Mb/s rate
basic-48.0 Require 48.0 Mb/s rate
basic-5.5 Require 5.5 Mb/s rate
basic-54.0 Require 54.0 Mb/s rate
basic-6.0 Require 6.0 Mb/s rate
basic-9.0 Require 9.0 Mb/s rate
default Set default legacy rates

```

- For 802.11a, the legacy rates are configured as following:

```

configure dot11radio [1|2] speed legacy-rate
12.0 Allow 12.0 Mb/s rate
18.0 Allow 18.0 Mb/s rate
24.0 Allow 24.0 Mb/s rate
36.0 Allow 36.0 Mb/s rate
48.0 Allow 48.0 Mb/s rate
54.0 Allow 54.0 Mb/s rate
6.0 Allow 6.0 Mb/s rate
9.0 Allow 9.0 Mb/s rate
basic-12.0 Require 12.0 Mb/s rate
basic-18.0 Require 18.0 Mb/s rate
basic-24.0 Require 24.0 Mb/s rate
basic-36.0 Require 36.0 Mb/s rate
basic-48.0 Require 48.0 Mb/s rate
basic-54.0 Require 54.0 Mb/s rate
basic-6.0 Require 6.0 Mb/s rate
basic-9.0 Require 9.0 Mb/s rate
default Set default legacy rates

```

Legacy rate is used by 802.11 management frame and control frame. WGB legacy rates should match AP's legacy rates, or at least, having overlap between these two rate sets. Otherwise, WGB association will be rejected due to mismatched rates.

To check WGB Tx MCS rate, use the **debug wgb dot11 rate** command. The following example shows the output of this command.

```

JWGB1#debug wgb dot11 rate
[*10/14/2023 03:16:08.6175]
[*10/14/2023 03:16:08.6175]          MAC      Tx-Pkts  Rx-Pkts      Tx-Rate(Mbps)      Rx-Rate(Mbps)  RSSI  Tx-Retries
JWGB1#[*10/14/2023 03:16:09.6179]  24:16:1B:F8:02:6E      0          0      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -70      0
JWGB1#[*10/14/2023 03:16:11.6187]  24:16:1B:F8:02:6E    330        330      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -71     15
[*10/14/2023 03:16:11.6187]  24:16:1B:F8:02:6E    332        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -71     25
[*10/14/2023 03:16:12.6190]  24:16:1B:F8:02:6E    327        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -71     18
[*10/14/2023 03:16:12.6190]  24:16:1B:F8:02:6E    330        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -70     13
[*10/14/2023 03:16:13.6194]  24:16:1B:F8:02:6E    333        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -71     21
[*10/14/2023 03:16:14.6198]  24:16:1B:F8:02:6E    331        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -70     16
[*10/14/2023 03:16:15.6202]  24:16:1B:F8:02:6E    328        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -70     24
[*10/14/2023 03:16:16.6206]  24:16:1B:F8:02:6E    330        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -70     21
[*10/14/2023 03:16:17.6210]  24:16:1B:F8:02:6E    332        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -70     22
[*10/14/2023 03:16:18.6214]  24:16:1B:F8:02:6E    327        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -71     22
[*10/14/2023 03:16:19.6218]  24:16:1B:F8:02:6E    333        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -71     18
[*10/14/2023 03:16:20.6221]  24:16:1B:F8:02:6E    330        2      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -71     17
[*10/14/2023 03:16:21.6258]  24:16:1B:F8:02:6E    328        3      HT-20_1SS,MCS5,(52)  HT-20_1SS,MCS5,SIGI(57)  -70     16

```

Radio Statistics Commands

To help troubleshooting radio connection issues, use the following commands:

- **#debug wgb dot11 rate**

```

#debug wgb dot11 rate
[*03/13/2023 18:00:08.7814]          MAC      Tx-Pkts  Rx-Pkts      Rx-Rate(Mbps)      RSSI  SNR  Tx-Retries
[*03/13/2023 18:00:08.7814]  FC:58:9A:17:C2:51      0          0      HE-20,2SS,MCS6,G10.8 (154)  HE-20,3SS,MCS4,G10.8 (154)  -30     62      0

```

```
[*03/13/2023 18:00:09.7818] FC:58:9A:17:C2:51          0          0
HE-20,2SS,MCS6,GI0.8 (154)          HE-20,3SS,MCS4,GI0.8 (154)  -30      62          0
```

In this example, FC:58:9A:17:C2:51 is the parent AP radio MAC.

• **#show interfaces dot11Radio <slot-id> statistics**

#show interfaces dot11Radio 1 statistics

Dot11Radio Statistics:

DOT11 Statistics (Cumulative Total/Last 5 Seconds):

RECEIVER		TRANSMITTER	
Host Rx K Bytes:	965570/0	Host Tx K Bytes:	1611903/0
Unicasts Rx:	379274/0	Unicasts Tx:	2688665/0
Broadcasts Rx:	3166311/0	Broadcasts Tx:	0/0
Beacons Rx:	722130099/1631	Beacons Tx:	367240960/784
Probes Rx:	588627347/2224	Probes Tx:	78934926/80
Multicasts Rx:	3231513/0	Multicasts Tx:	53355/0
Mgmt Packets Rx:	764747086/1769	Mgmt Packets Tx:	446292853/864
Ctrl Frames Rx:	7316214/5	Ctrl Frames Tx:	0/0
RTS received:	0/0	RTS transmitted:	0/0
Duplicate frames:	0/0	CTS not received:	0/0
MIC errors:	0/0	WEP errors:	2279546/0
FCS errors:	0/0	Retries:	896973/0
Key Index errors:	0/0	Tx Failures:	8871/0
		Tx Drops:	0/0

Rate Statistics for Radio::

[Legacy]:

6 Mbps:			
Rx Packets:	159053/0	Tx Packets:	88650/0
		Tx Retries:	2382/0
9 Mbps:			
Rx Packets:	43/0	Tx Packets:	23/0
		Tx Retries:	71/0
12 Mbps:			
Rx Packets:	1/0	Tx Packets:	119/0
		Tx Retries:	185/0
18 Mbps:			
Rx Packets:	0/0	Tx Packets:	5/0
		Tx Retries:	134/0
24 Mbps:			
Rx Packets:	235/0	Tx Packets:	20993/0
		Tx Retries:	5048/0
36 Mbps:			
Rx Packets:	0/0	Tx Packets:	781/0
		Tx Retries:	227/0
54 Mbps:			
Rx Packets:	133/0	Tx Packets:	9347/0
		Tx Retries:	1792/0

[SU]:

M0:			
Rx Packets:	7/0	Tx Packets:	0/0
		Tx Retries:	6/0
M1:			
Rx Packets:	1615/0	Tx Packets:	35035/0
		Tx Retries:	3751/0
M2:			
Rx Packets:	15277/0	Tx Packets:	133738/0
		Tx Retries:	22654/0
M3:			
Rx Packets:	10232/0	Tx Packets:	1580/0
		Tx Retries:	21271/0
M4:			
Rx Packets:	218143/0	Tx Packets:	190408/0


```

M5:
  Rx Packets:      399283/0
  Tx Retries:      36444/0
  Tx Packets:      542491/0
  Tx Retries:      164048/0

M6:
  Rx Packets:      3136519/0
  Tx Packets:      821537/0
  Tx Retries:      329003/0

M7:
  Rx Packets:      1171128/0
  Tx Packets:      303414/0
  Tx Retries:      154014/0

```

```

Beacons missed: 0-30s 31-60s 61-90s 90s+
                  2         0         0         0

```

• **#show wgb dot11 uplink latency**

```

AP4C42.1E51.A050#show wgb dot11 uplink latency
Latency Group Total Packets Total Latency Excellent(0-8) Very Good(8-16) Good (16-32
ms) Medium (32-64ms) Poor (64-256 ms) Very Poor (256+ ms)
  AC_BK          0          0          0          0          0
  AC_BE          7        1840        4243793        1809          10
  AC_VI          0          0          0          0          0
  AC_VO          0          24          54134         24          0

```

• **#show wgb dot11 uplink**

```

AP4C42.1E51.A050#show wgb dot11 uplink

HE Rates: 1SS:M0-11 2SS:M0-11
Additional info for client 8C:84:42:92:FF:CF
RSSI: -24
PS : Legacy (Awake)
Tx Rate: 278730 Kbps
Rx Rate: 410220 Kbps
VHT_TXMAP: 65530
CCX Ver: 5
Rx Key-Index Errs: 0
      mac      intf TxData TxUC TxBytes TxFail TxDcrd TxCumRetries MultiRetries
MaxRetriesFail RxData RxBytes RxErr          TxRt (Mbps)          RxRt (Mbps)
  LER PER stats_ago
8C:84:42:92:FF:CF wbridge1  1341 1341 184032      0      0          543          96
                   0    317  33523      0 HE-40,2SS,MCS6,GI0.8 (309) HE-40,2SS,MCS9,GI0.8
(458) 27272      0 1.370000
Per TID packet statistics for client 8C:84:42:92:FF:CF
Priority Rx Pkts Tx Pkts Rx(last 5 s) Tx (last 5 s)
  0          35    1314          0          8
  1           0         0          0          0
  2           0         0          0          0
  3           0         0          0          0
  4           0         0          0          0
  5           0         0          0          0
  6        182         24          1          0
  7           3         3          0          0

Rate Statistics:
Rate-Index   Rx-Pkts   Tx-Pkts   Tx-Retries
  0           99         3         0
  4            1         1         9
  5           21        39        35
  6           31       185        64

```

7	26	124	68
8	28	293	82
9	77	401	151
10	32	140	97
11	2	156	37

Configuring Syslog

Syslog is a common protocol that the device uses to send event data logs to a central location for storing. Currently, only UDP mode is supported. Additional debug log will be collected if debug command is enabled in WGB. All collected log sent to syslog server will be in "kernel" facility and "warning" level.

- To enable WGB syslog, use the following command:

```
# logging host enable <server_ip> UDP
```

- To disable WGB syslog (default), use the following command:

```
# logging host enable 0.0.0.0 UDP
```

- To display current syslog configuration, use the following command:

```
# show running-config
```

Event Logging

For WGB field deployment, event logging will collect useful information (such as WGB state change and packets rx/tx) to analyze and provide log history to present context of problem, especially in roaming cases.

You can configure WGB trace filter for all management packet types, including probe, auth, assoc, eap, dhcp, icmp, and arp. To enable or disable WGB trace, use the following command:

```
#config wgb event trace {enable|disable}
```

Four kinds of event types are supported:

- **Basic event:** covers most WGB basic level info message
- **Detail event:** covers basic event and additional debug level message
- **Trace event:** recording wgb trace event if enabled
- **All event:** bundle trace event and detail event

The log format is `[timestamp] module:level <event log string>`.

When abnormal situations happen, the eventlog messages can be dumped manually to memory by using the following show command which also displays WGB logging:

```
#show wgb event [basic|detail|trace|all]
```

The following example shows the output of **show wgb event all**:

```
APC0F8.7FE5.F3C0#show wgb event all
[*08/16/2023 08:18:25.167578] UP_EVT:4 R1 IFC:58:9A:17:B3:E7] parent_rssi: -42 threshold:
-70
[*08/16/2023 08:18:25.329223] UP_EVT:4 R1 State CONNECTED to SCAN_START
```

```
[*08/16/2023 08:18:25.329539] UP_EVT:4 R1 State SCAN_START to STOPPED
[*08/16/2023 08:18:25.330002] UP_DRV:1 R1 WGB UPLINK mode stopped
[*08/16/2023 08:18:25.629405] UP_DRV:1 R1 Delete client FC:58:9A:17:B3:E7
[*08/16/2023 08:18:25.736718] UP_CFG:8 R1 configured for standard: 7
[*08/16/2023 08:18:25.989936] UP_CFG:4 R1 band 1 current power level: 1
[*08/16/2023 08:18:25.996692] UP_CFG:4 R1 band 1 set tx power level: 1
[*08/16/2023 08:18:26.003904] UP_DRV:1 R1 WGB uplink mode started
[*08/16/2023 08:18:26.872086] UP_EVT:4 Reset aux scan
[*08/16/2023 08:18:26.872096] UP_EVT:4 Pause aux scan on slot 2
[*08/16/2023 08:18:26.872100] SC_MST:4 R2 reset uplink scan state to idle
[*08/16/2023 08:18:26.872104] UP_EVT:4 Aux bring down vap - scan
[*08/16/2023 08:18:26.872123] UP_EVT:4 Aux bring up vap - serv
[*08/16/2023 08:18:26.872514] UP_EVT:4 R1 State STOPPED to SCAN_START
[*08/16/2023 08:18:26.8727091] SC_MST:4 R1 Uplink Scan Started.
[*08/16/2023 08:18:26.884054] UP_EVT:8 R1 CH event 149
```



Note It might take a long time to display the **show wgb event** command output in console. Using *ctrl+c* to interrupt the printing will not affect log dump to memory.

The following clear command erases WGB events in memory:

```
#clear wgb event [basic|detail|trace|all]
```

To save all event logs to WGB flash, use the following command:

```
#copy event-logging flash
```

The package file consists of four separate log files for different log levels.

You can also save event log to a remote server by using the following command:

```
#copy event-logging upload <[tftp|sftp|scp]>://A.B.C.D[/dir][/filename.tar.gz]
```

The following example saves event log to a TFTP server:

```
APC0F8.7FE5.F3C0#copy event-logging upload
tftp://192.168.100.100/tftpuser/evtlog-2023-05-31_11:45:49.tar.gz
Starting upload of WGB config
tftp://192.168.100.100/tftpuser/evtlog-2023-05-31_11:45:49.tar.gz ...
It may take a few seconds. If longer, please cancel command, check network and try again.
##### 100.0%
Config upload completed.
```

802.11v Support

802.11v is the Wireless Network Management standard for the IEEE 802.11 family of standards. One enhancement of 802.11v 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.

By adding 802.11v support to WGB, WGB can be aware of imminent disconnection before disassociation happens, and then actively starts a roam and picks up an appropriate AP from a list of neighbor APs. WGB periodically queries for latest neighbor APs and associates to the optimal AP on next roam.

Since channel information of neighbor APs is included in Basic Service Set (BSS) Transition Request frame, roaming latency can be reduced for multiple channels deployment by scanning only the channels of neighboring APs.

The wireless controller can disassociate a client based on load balance, RSSI, and data rate on AP side. This disassociation can be notified to 802.11v client before it happens. Wireless controller can disassociate the client after a period of time, if the client does not re-associate to another AP within configurable period. To enable disassociating a client by network assisted roaming, the disassociation-imminent configuration can be turned on from wireless controller, which corresponds to the optional field (disassociation imminent) within BSS Transition Management Request frame.

For detailed information of 802.11v configuration on wireless controller, see https://www.cisco.com/c/en/us/td/docs/wireless/controller/9800/17-13/config-guide/b_wl_17_13_cg/m_802_11v_ewlc.html.

To configure 802.11v support on WGB, use the following command:

- To enable or disable 802.11v support on WGB, use the following command. By enabling 802.11v support, WGB scans only the channels learned from neighbor list.

```
# configure wgb mobile station interface dot11Radio <radio_slot_id> dot11v-bss-transition [enable|disable]
```

- To configure the time interval that WGB sends BSS transition Query message to the parent AP, use the following command. Default value is 10 sec if not explicit configured. The timer is configured in seconds.

```
# configure wgb neighborlist-update-interval <1-900>
```

- To check neighbor list received from associated AP, use the following command:

```
# show wgb dot11v bss-transition neighbour
```

- To check channel list from dot11v neighbor, aux radio scanned, and residual channel scanned, use the following command:

```
# show wgb dot11v bss-transition channel
```

- To clear neighbor list to provide error condition recover, use the following command:

```
# clear wgb dot11v bss-transition neighbor
```

Configuring Aux Scanning

Aux-scan mode can be configured as scanning only or handoff mode on WGB slot 2 (5G) radio to improve roaming performance.

Configuring Scanning Only Mode

When slot 2 radio is configured as scanning only mode, slot 1 (5G) radio will always be picked as uplink. Slot 2 (5G) radio will keep scanning configured SSID based on the channel list. By default, the channel list contains all supported 5G channels (based on reg domain). The scanning list can be configured manually or learned by 802.11v.

When a roaming is triggered, the algorithm looks for candidates from scanning table and skips scanning phase if the table is not empty. WGB then makes association to that candidate AP.

To configure scanning only mode, use the following command:

```
# configure dot11Radio 2 mode scan only
```

To manually configure the channel list, using the following command:

```
# configure wgb mobile station interface dot11Radio 1 scan <channel> [add|delete]
```

By default, candidate AP entries in scanning table ages out in 1200 ms. You can adjust the timer by the following command:

```
#configure wgb scan radio 2 timeout
```

```
<1-5000> Scanning ap expire time
```



Note AP selection algorithm picks candidate with best RSSI from the scanning table. In some cases, the RSSI values are out-of-date. This can lead to a failed roaming.

Check the scanning table by using the **show wgb scan** command:

```
#show wgb scan
Best AP expire time: 5000 ms

*****[ AP List ]*****
BSSID           RSSI    CHANNEL   Time
FC:58:9A:15:E2:4F  84     136       1531
FC:58:9A:15:DE:4F  37     136       41

*****[ Best AP ]*****
BSSID           RSSI    CHANNEL   Time
FC:58:9A:15:DE:4F  37     136       41
```

Configuring Aux-Scan Handoff Mode

When slot 2 radio is configured as handoff mode, both radio 1 and radio 2 are the uplink candidate. While one radio maintains wireless uplink, the other radio keeps scanning the channels. The scanning list can be configured manually or learned by 802.11v.

Radio 2 shares the same MAC address with radio 1, and supports the scanning function, association, and data serving. Both radios can work as **servicing** or **scanning** role. When a roaming is triggered, the algorithm looks for the scanning database (internal tables), selects the best candidate AP and makes connection. The radio roles and traffic will dynamically switch between slot 1 and slot 2 after each roaming. WGB always uses the radio with operating role of **scanning** to complete the roaming association to a new AP. With this configuration, the roaming interruption time can be improved to 20-50 ms.

The following table compares roaming interruption time (3 channel case) in various mechanisms:

Roaming Interruption Time	Normal Channel Setting	Aux-scan Only	Aux-scan Handoff
Scanning	$(40+20)*3=180$ ms	0+40 ms	0 ms
Association	30-80 ms	30-80 ms	20-50 ms
Total	~210 ms	70-120 ms	20-50 ms

Use the following command to configure the WGB slot2 radio to aux-scan mode:

```
# configure dot11Radio 2 mode scan handoff
```

Use the **show run** command to check your configuration:

```
#show run
...
Radio Id          : 1
  Admin state     : ENABLED
  Mode            : WGB
  Spatial Stream  : 1
  Guard Interval  : 800 ns
  Dot11 type      : 11n
  11v BSS-Neighbor : Disabled
  A-MPDU priority : 0x3f
  A-MPDU subframe number : 12
  RTS Protection  : 2347(default)
  Rx-SOP Threshold : AUTO
  Radio profile   : Default
  Encryption mode : AES128
Radio Id          : 2
  Admin state     : ENABLED
  Mode            : SCAN - Handoff
  Spatial Stream  : 1
  Guard Interval  : 800 ns
  Dot11 type      : 11n
  11v BSS-Neighbor : Disabled
  A-MPDU priority : 0x3f
  A-MPDU subframe number : 12
  RTS Protection  : 2347(default)
  Rx-SOP Threshold : AUTO
  Radio profile   : Default
```

Use the **show wgb scan** command to display the current role of each radio and the aux scanning results:

```
APFC58.9A15.C808#show wgb scan
Best AP expire time: 2500 ms

Aux Scanning Radio Results (slot 2)
*****[ AP List ]*****
BSSID          RSSI  CHANNEL  Time
FC:58:9A:15:DE:4E  54   153     57
FC:58:9A:15:E2:4E  71   153     64

*****[ Best AP ]*****
BSSID          RSSI  CHANNEL  Time
FC:58:9A:15:DE:4E  54   153     57

Aux Serving Radio Results
*****[ AP List ]*****
BSSID          RSSI  CHANNEL  Time
FC:58:9A:15:DE:4E  58   153     57
FC:58:9A:15:E2:4E  75   153     133

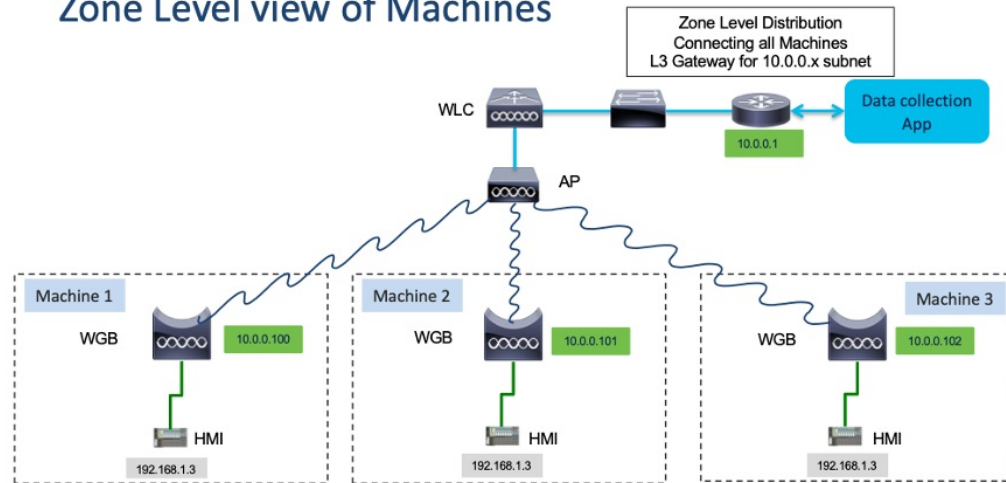
*****[ Best AP ]*****
BSSID          RSSI  CHANNEL  Time
FC:58:9A:15:DE:4E  58   153     57
```

Configuring Layer 2 NAT

One-to-one (1:1) Layer 2 NAT is a service that allows the assignment of a unique public IP address to an existing private IP address (end device), so that the end device can communicate with public network. Layer 2 NAT has two translation tables where private-to-public and public-to-private subnet translations can be defined.

In the industrial scenario where the same firmware is programmed to every HMI (customer machine, such as a Robot), firmware duplication across machines means IP address is reused across HMIs. This feature solves the problem of multiple end devices with the same duplicated IP addresses in the industrial network communicating with the public network.

Zone Level view of Machines



The following table provides the commands to configure Layer 2 NAT:

Table 4: Layer 2 NAT Configuration Commands

Command	Description
<code>#configure l2nat {enable disable}</code>	Enables or disables L2 NAT.
<code>#configure l2nat default-vlan <vlan_id></code>	Specifies the default vlan where all NAT rules will be applied. If <i>vlan_id</i> is not specified, all NAT rules will be applied to vlan 0.
<code>#configure l2nat {add delete} inside from host <original_ip_addr> to <translated_ip_addr></code>	Adds or deletes a NAT rule which translates a private IP address to a public IP address. <ul style="list-style-type: none"> <i>original_ip_addr</i>—Private IP address of the wired client connected to WGB Ethernet port. <i>translated_ip_addr</i>—Public IP address that represents the wired client at public network.
<code>#configure l2nat {add delete} outside from host <original_ip_addr> to <translated_ip_addr></code>	Adds or deletes a NAT rule which translates a public IP address to a private IP address. <ul style="list-style-type: none"> <i>original_ip_addr</i>—Public IP address of an outside network host. <i>translated_ip_addr</i>—Private IP address which represents the outside network host at private network.

Command	Description
#configure l2nat {add delete} inside from network <original_nw_prefix> to <translated_nw_prefix> <subnet_mask>	Adds or deletes a NAT rule which translates a private IP address subnet to a public IP address subnet. <ul style="list-style-type: none"> • <i>original_nw_prefix</i>—Private IP network prefix. • <i>translated_nw_prefix</i>—Public IP network prefix.
#configure l2nat {add delete} outside from network <original_nw_prefix> to <translated_nw_prefix> <subnet_mask>	Adds or deletes a NAT rule which translates a public IP address subnet to a private IP address subnet. <ul style="list-style-type: none"> • <i>original_nw_prefix</i>—Public IP network prefix. • <i>translated_nw_prefix</i>—Private IP network prefix.

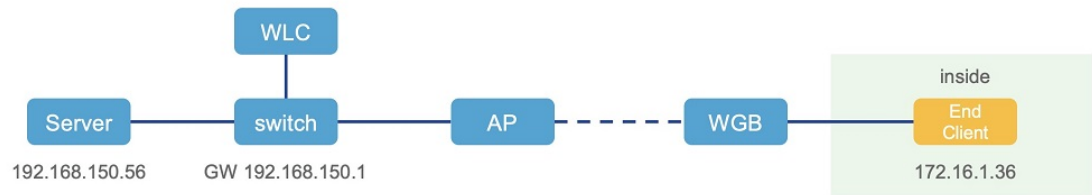
The following table provides the show and debug commands to verify and troubleshoot your Layer 2 NAT configuration:

Table 5: Layer 2 NAT Show and Debug Commands

Command	Description
#show l2nat entry	Displays the Layer 2 NAT running entries.
#show l2nat config	Displays the Layer 2 NAT configuration details.
#show l2nat stats	Displays the Layer 2 NAT packet translation statistics.
#show l2nat rules	Displays the Layer 2 NAT rules from the configuration.
#clear l2nat statistics	Clears packet translation statistics.
#clear l2nat rule	Clears Layer 2 NAT rules.
#clear l2nat config	Clears Layer 2 NAT configuration.
#debug l2nat	Enables debugging of packet translation process.
#debug l2nat all	Prints out the NAT entry match result when a packet arrives. <p>Caution This debug command may create overwhelming log print in console. Console may lose response because of this command, especially when Syslog service is enabled with a broadcast address.</p>
#undebug l2nat	Disables debugging of packet translation process.

Configuration Example of Host IP Address Translation

In this scenario, the end client (172.16.1.36) connected to WGB needs to communicate with the server (192.168.150.56) connected to the gateway. Layer 2 NAT is configured to provide an address for the end client on the outside network (192.168.150.36) and an address for the server on the inside network (172.16.1.56).



The following table shows the configuration tasks for this scenario.

Command	Purpose
<pre>#configure l2nat add inside from host 172.16.1.36 to 192.168.150.36 #configure l2nat add outside from host 192.168.150.56 to 172.16.1.56</pre>	Adds NAT rules to make inside client and outside server communicate with each other.
<pre>#configure l2nat add inside from host 172.16.1.1 to 192.168.150.1 #configure l2nat add inside from host 172.16.1.255 to 192.168.150.255</pre>	Adds NAT for gateway and broadcast address.

The following show commands display your configuration.

- The following command displays the Layer 2 NAT configuration details. In the output, I2O means "inside to outside", and O2I means "outside to inside".

```
#show l2nat config
L2NAT Configuration are:
=====
Status: enabled
Default Vlan: 0
The Number of L2nat Rules: 4
Dir      Inside      Outside      Vlan
O2I      172.16.1.56     192.168.150.56  0
I2O      172.16.1.36     192.168.150.36  0
I2O      172.16.1.255    192.168.150.255  0
I2O      172.16.1.1      192.168.150.1   0
```

- The following command displays the Layer 2 NAT rules.

```
#show l2nat rule
Dir      Inside      Outside      Vlan
O2I      172.16.1.56     192.168.150.56  0
I2O      172.16.1.36     192.168.150.36  0
I2O      172.16.1.255    192.168.150.255  0
I2O      172.16.1.1      192.168.150.1   0
```

- The following command displays Layer 2 NAT running entries.

```
#show l2nat entry
Direction      Original      Substitute      Age      Reversed
inside-to-outside  172.16.1.36@0  192.168.150. 36@0  -1      false
inside-to-outside  172.16.1.56@0  192.168.150. 56@0  -1      true
inside-to-outside  172.16.1.1@0   192.168.150. 1@0   -1      false
```

```

inside-to-outside 172.16.1.255@0 192.168.150.255@0 -1 false
outside-to-inside 192.168.150.36@0 172.16.1.36@0 -1 true
outside-to-inside 192.168.150.56@0 172.16.1.56@0 -1 false
outside-to-inside 192.168.150.1@0 172.16.1.1@0 -1 true
outside-to-inside 192.168.150.255@0 172.16.1.255@0 -1 true

```

- The following command displays the WGB wired clients over the bridge.

- Before Layer 2 NAT is enabled:

```

#show wgb bridge
***Client ip table entries***
      mac vap      port vlan_id      seen_ip  confirm_ago  fast_brg
B8:AE:ED:7E:46:EB 0  wired0      0      172.16.1.36  0.360000    true
24:16:1B:F8:05:0F 0  wbridge1    0      0.0.0.0    3420.560000 true

```

- After Layer 2 NAT is enabled:

```

#show wgb bridge
***Client ip table entries***
      mac vap      port vlan_id      seen_ip  confirm_ago  fast_brg
B8:AE:ED:7E:46:EB 0  wired0      0      192.168.150.36 0.440000    true
24:16:1B:F8:05:0F 0  wbridge1    0      0.0.0.0    3502.220000 true

```

If there are E2E traffic issues for wired client in NAT, restart the client register process by using the following command:

```
#clear wgb client single B8:AE:ED:7E:46:EB
```

- The following command displays the Layer 2 NAT packet translation statistics.

```

#show l2nat stats
Direction      Original          Substitute        ARP  IP  ICMP  UDP  TCP
inside-to-outside 172.16.1.1@2660 192.168.150.1@2660 1    4  4    0    0
inside-to-outside 172.16.1.36@2660 192.168.150.36@2660 3    129 32  90  1
inside-to-outside 172.16.1.56@2660 192.168.150.56@2660 2    114 28  85  1
inside-to-outside 172.16.1.255@2660 192.168.150.255@2660 0    0  0    0    0
outside-to-inside 192.168.150.1@2660 172.16.1.1@2660 1    4  4    0    0
outside-to-inside 192.168.150.36@2660 172.16.1.36@2660 3    39  38  0    1
outside-to-inside 192.168.150.56@2660 172.16.1.56@2660 2    35  34  0    1
outside-to-inside 192.168.150.255@2660 172.16.1.255@2660 0    0  0    0    0

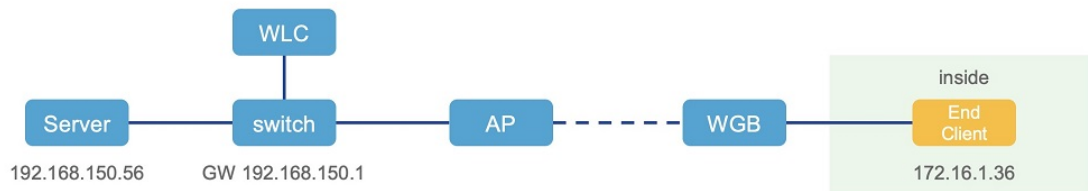
```

To reset statistics number, use the following command:

```
#clear l2nat stats
```

Configuration Example of Network Address Translation

In this scenario, Layer 2 NAT is configured to translate the inside addresses from 172.16.1.0 255.255.255.0 subnet to addresses in the 192.168.150.0 255.255.255.0 subnet. Only the network prefix will be replaced during the translation. The host bits of the IP address remain the same.



The following command is configured for this scenario:

```
#configure l2nat add inside from network 172.16.1.0 to 192.168.150.0 255.255.255.0
```

Configuring Native VLAN on Ethernet Ports

A typical deployment of WGB is that a single wired client connects directly to the WGB Ethernet port. As a result, wired client traffic must be on the same VLAN as the WGB (or WLC/AP/WGB) management VLAN. If you need the wired client traffic to be on a different VLAN other than the WGB management VLAN, you should configure native VLAN on the Ethernet port.



Note Configuring native VLAN ID per Ethernet port is not supported. Both Ethernet ports share the same native VLAN configuration.



Note When WGB broadcast tagging is enabled and a single wired passive client connects directly to the WGB Ethernet port, it may hit the issue that infrastructure DS side client fails to ping this WGB behind the passive client. The workaround is to configure the following additional commands: **configure wgb ethport native-vlan enable** and **configure wgb ethport native-vlan id X**, where X is the same VLAN as the WGB (or WLC/AP/WGB) management VLAN.

The following table provides the commands to configure native VLAN:

Table 6: Native VLAN Configuration Commands

Command	Description
#config wgb ethport native-vlan {enable disable} Example: #config wgb ethport native-vlan enable	Enables or disables native VLAN configuration.
#config wgb ethport native-vlan id <vlan-id> Example: #config wgb ethport native-vlan id 2735	Specifies native VLAN ID.

To verify your configuration, use the **show wgb ethport config** or **show running-config** command.

Low Latency Profile

IEEE 802.11 networks have a great role to play in supporting and deploying the Internet of Things (IoT) for the low latency and QoS requirement by applying the Enhanced Distributed Channel Access (EDCA), aggregated MAC protocol data unit (AMPDU), and aggregated or non-aggregated packet retry.

Enhanced Distributed Channel Access (EDCA) parameters are designed to provide preferential wireless channel access for voice, video, and other quality of service (QoS) traffic.

Configuring WGB optimized-video EDCA Profile

To configure optimized low latency profile for video use case, use the following command:

```
#configure dot11Radio <radio_slot_id> profile optimized-video {enable | disable}
```

Use the following command to verify the configuration:

```
WGB1#show controllers dot11Radio 1
EDCA profile: optimized-video
EDCA in use
=====
AC Type CwMin CwMax Aifs Txop ACM
AC_BE L 4 10 11 0 0
AC_BK L 6 10 11 0 0
AC_VI L 3 4 2 94 0
AC_VO L 2 3 1 47 0

Packet parameters in use
=====
wbridge1 A-MPDU Priority 0: Enabled
wbridge1 A-MPDU Priority 1: Enabled
wbridge1 A-MPDU Priority 2: Enabled
wbridge1 A-MPDU Priority 3: Enabled
wbridge1 A-MPDU Priority 4: Disabled
wbridge1 A-MPDU Priority 5: Disabled
wbridge1 A-MPDU Priority 6: Disabled
wbridge1 A-MPDU Priority 7: Disabled
wbridge1 A-MPDU subframe number: 3
wbridge1 Packet retries drop threshold: 16
```

Configuring WGB optimized-automation EDCA Profile

To configure optimized low latency profile for automation use case, use the following command:

```
#configure dot11Radio <radio_slot_id> profile optimized-automation {enable | disable}
```

Use the following command to verify the configuration:

```
WGB1#show controllers dot11Radio 1
EDCA profile: optimized-automation
EDCA in use
=====
AC Type CwMin CwMax Aifs Txop ACM
AC_BE L 7 10 12 0 0
AC_BK L 8 10 12 0 0
AC_VI L 7 7 3 0 0
AC_VO L 3 3 1 0 0

Packet parameters in use
=====
wbridge1 A-MPDU Priority 0: Enabled
wbridge1 A-MPDU Priority 1: Enabled
wbridge1 A-MPDU Priority 2: Enabled
wbridge1 A-MPDU Priority 3: Enabled
wbridge1 A-MPDU Priority 4: Disabled
wbridge1 A-MPDU Priority 5: Disabled
wbridge1 A-MPDU Priority 6: Disabled
wbridge1 A-MPDU Priority 7: Disabled
wbridge1 A-MPDU subframe number: 3
wbridge1 Packet retries drop threshold: 16
```

Configuring WGB customized-wmm EDCA profile

To configure customized Wi-Fi Multimedia (WMM) profile, use the following command:

```
#configure dot11Radio <radio_slot_id> profile customized-wmm {enable | disable}
```

To configure customized WMM profile parameters, use the following command:

```
#configure dot11Radio {0|1|2} wmm {be | vi | vo | bk} {cwmmin <cwmmin_num> | cwmax <cwmax_num> | aifs <aifs_num> | txoplimit <txoplimit_num>}
```

Parameter descriptions:

- be—best-effort traffic queue (CS0 and CS3)
- bk—background traffic queue (CS1 and CS2)
- vi—video traffic queue (CS4 and CS5)
- vo—voice traffic queue (CS6 and CS7)
- aifs—Arbitration Inter-Frame Spacing, <1-15> in units of slot time
- cwmmin—Contention Window min, <0-15> 2^n-1 , in units of slot time
- cwmax—Contention Window max, <0-15> 2^n-1 , in units of slot time
- txoplimit—Transmission opportunity time, <0-255> integer number, in units of 32us

Configuring Low Latency Profile on WGB

Use the following command to configure low latency profile on WGB:

```
AP# configure dot11Radio <radio_slot_id> profile low-latency [ampdu <length>] [sifs-burst {enable | disable}] [rts-cts {enable | disable}] [non-aggr <length>] [aggr <length>]
```

Use the following command to display iot-low-latency profile EDCA detailed parameters:

```
#show controllers dot11Radio 1 | beg EDCA
EDCA config
L: Local C:Cell A:Adaptive EDCA params
  AC   Type  CwMin  CwMax  Aifs  Txop  ACM
AC_BE  L      4      6     11    0     0
AC_BK  L      6     10     11    0     0
AC_VI  L      3      4      1     0     0
AC_VO  L      0      2      0     0     1
AC_BE  C      4     10     11    0     0
AC_BK  C      6     10     11    0     0
AC_VI  C      3      4      2    94     0
AC_VO  C      2      3      1    47     1
```

Configuring EDCA Parameters (Wireless Controller GUI)

- Step 1** Choose **Configuration > Radio Configurations > Parameters**. Using this page, you can configure global parameters for 6 GHz, 5 GHz, and 2.4 GHz radios.

Note You cannot configure or modify parameters, if the radio network is enabled. Disable the network status on the **Configuration > Radio Configurations > Network** page before you proceed.

Step 2 In the **EDCA Parameters** section, choose an EDCA profile from the **EDCA Profile** drop-down list. Enhanced Distributed Channel Access (EDCA) parameters are designed to provide preferential wireless channel access for voice, video, and other quality-of-service (QoS) traffic.

Configuration > Radio Configurations > Parameters

6 GHz Band **5 GHz Band** 2.4 GHz Band

⚠ 5 GHz Network is operational. Configuring EDCA Profile, DFS Channel Switch Announcement will result in loss of connectivity of clients.

EDCA Parameters

EDCA Profile

iot-low-latency ▾

Client Load Based Configuration

wmm-default

custom-voice

optimized-video-voice

optimized-voice

svp-voice

fastlane

DFS (802.11h)

⚠ DTPC Support is enabled. Please do not change Power Conservation Mode.

iot-low-latency

Step 3 Click **Apply**.

Configuring EDCA Parameters (Wireless Controller CLI)

Step 1 Enters global configuration mode.

configure terminal

Example:

```
Device# configure terminal
```

Step 2 Disables the radio network.

ap dot11 {5ghz | 24ghz | 6ghz} shutdown

Example:

```
Device(config)# ap dot11 5ghz shutdown
```

Step 3 Enables iot-low-latency EDCA profile for the 5 GHz, 2.4 GHz, or 6 GHz network.

ap dot11 {5ghz | 24ghz | 6ghz} edca-parameters iot-low-latency

Example:

```
Device(config)# ap dot11 5ghz edca-parameters iot-low-latency
```

Step 4

Enables the radio network.

```
no ap dot11 {5ghz | 24ghz | 6ghz} shutdown
```

Example:

```
Device(config)# no ap dot11 5ghz shutdown
```

Step 5

Returns to privileged EXEC mode.

```
end
```

Example:

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

Step 6

Displays the current configuration.

```
show ap dot11 {5ghz | 24ghz | 6ghz} network
```

Example:

```
Device(config)# show ap dot11 5ghz network
EDCA profile type check           : iot-low-latency
```

Configuring A-MPDU

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).

The A-MPDU parameters define the size of an aggregated packet and define the proper spacing between aggregated packets so that the receive side WLAN station can decode the packet properly.

To configure profiled based A-MPDU under 2.4G, 5G and 6G radio, use the following commands:

```
WLC(config)# ap dot11 {5ghz | 24ghz | 6ghz} rf-profile <profile-name>
```

```
WLC(config-rf-profile)# [no] dot11n a-mpdu tx block-ack window-size <1-255>
```

Global configuration is a special profile which can also be configured by using the following command:

```
WLC(config)#[no] ap dot11 {5ghz | 24ghz | 6ghz} dot11n a-mpdu tx block-ack window-size <1-255>
```

To bind different RF profiles with the radio RF tag, use the following command:

```
WLC(config)# wireless tag rf <rf-tag-name>
```

```
WLC (config-wireless-rf-tag)# 5ghz-rf-policy <rf-profile-name>
```



Note RF profile level configured **a-mpdu tx block-ack window-size** value takes preference over globally configured value.

To display configured a-mpdu length value, use the following command:

```
# show controllers dot11Radio <radio_slot_id>

AP# show controllers dot11Radio 1
Radio Aggregation Config:
=====

TX A-MPDU Priority: 0x3f
TX A-MSDU Priority: 0x3f
TX A-MPDU Window: 0x7f
```

Configuring WGB/uWGB Radio Parameters

Configuring WGB Radio Antenna

Use the following command to configure WGB radio antenna gain. The default antenna gain is 4 dBi.

```
configure dot11 <0|1|2> antenna gain <1-30>
```

Use the following command to configure WGB radio antenna. Default is abcd-antenna.

```
configure dot11 <0|1|2> antenna <a-antenna|ab-antenna|abcd-antenna>
```

802.11ax 1600ns and 3200ns Guard Interval

802.11ax supports multiple Guard Interval (GI) value: 800ns, 1600ns, and 3200ns. By default, GI is set to 800ns. But you can set it to a different value.

Longer GI is commonly used in outdoor deployment.

```
#configure dot11radio <0|1|2> guard-interval
1600 Configure 1600 ns guard interval (only in HE mode)
3200 Configure 3200 ns guard interval (only in HE mode)
800 Configure 800 ns guard interval
```

Customized Transmit Power

By default, the transmit power of the radio is set to AUTO(0) level.

To manually set the transmit power of the radio use the following command:

```
# configure Dot11Radio <0|1|2> txpower-level <0-8>
```

Assign Country Code to WGB/uWGB With -ROW PID

On day 0, you should assign proper country code to the WGB/uWGB with -ROW reg domain. WGB will load corresponding power table after rebooting.

To assign country code, use the following command:

```
#configure countrycode
Supported ROW country codes:
GB VN

WORD Select one of above ROW country codes.
```




Note After the ROW country code is configured, if you want to change the configuration to another country, you need to perform a factory reset first, and then configure the new country code.

Indoor Deployment for -E Domain and United Kingdom

IW9167EH supports indoor deployment for -E domain and GB in -ROW domain .

For outdoor mode, the IW9167EH 5G radio supports channels 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140. When indoor deployment is enabled, 5G radio supports channels 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140.

To configure indoor mode, use the **configure wireless indoor-deployment enable** command.

To disable indoor mode, use the **configure wireless indoor-deployment disable** command.

```
#configure wireless indoor-deployment
  disable  Disable indoor deployment
  enable   Enable indoor deployment
```

You can check the indoor or outdoor mode by using the **show controllers Dot11Radio [1|2]** command. In the command output, "-Ei" means the indoor mode is enabled, and "-E" means indoor mode is disabled, as shown in the following examples. The CLI output also shows the supported channels.

```
#show controllers Dot11Radio [1|2]
...
Radio Info Summary:
=====
Radio: 5.0GHz
Carrier Set: (-Ei) ( GB )
Base radio MAC: FC:58:9A:15:B7:C0
Supported Channels:
36 40 44 48 52 56 60 64 100 104 108 112 116 120 124 128 132 136 140

#show controllers Dot11Radio [1|2]
...
Radio Info Summary:
=====
Radio: 5.0GHz
Carrier Set: (-E) ( GB )
Base radio MAC: FC:58:9A:15:B7:C0
Supported Channels:
100 104 108 112 116 120 124 128 132 136 140
```

Configuring WGB Roaming Parameters

Use the following command to configure the threshold duration and signal strength to trigger reconnecting. Default value is: period 20s and threshold -70db.

```
# configure wgb mobile period <time> <rssi-threshold>
```

Use the following command to configure beacon miss count to trigger reconnecting. Default value is 10.

```
# config wgb beacon miss-count <count>
```

Use the following command to configure max packet retry to trigger reconnecting. Default value is 64.

```
# configure wgb packet retries <retry-count>
```

Use the following command to configure the static roaming channel:

```
# configure wgb mobile station interface dot11Radio <slot_id> scan <channel_id> add
```

Use the following command to delete the mobile channel:

```
# configure wgb mobile station interface dot11Radio <slot_id> scan <channel_id> delete
```

Use the following command to scan all channels:

```
# configure wgb mobile station interface Dot11Radio 1 scan all
```

Importing and Exporting WGB Configuration

You can upload the working configuration of an existing WGB to a server, and then download it to the new deployed WGBs.

To upload the configuration to a server, use the following command:

```
#copy configuration upload <sftp:|tftp://> ip-address [directory] [file-name]
```

To download a sample configuration to all WGBs in the deployment, use the following command:

```
#copy configuration download <sftp:|tftp://> ip-address [directory] [file-name]
```

The access point will reboot after the **copy configuration download** command is executed. The imported configuration will take effect after the rebooting.

Verifying the Configuration of WGB and uWGB

Use the **show run** command to check whether the AP is in WGB mode or uWGB mode.

- WGB:

```
#show run
AP Name           : APFC58.9A15.C808
AP Mode           : WorkGroupBridge
CDP State         : Enabled
Watchdog monitoring : Enabled
SSH State         : Disabled
AP Username       : admin
Session Timeout   : 300
```

```
Radio and WLAN-Profile mapping:-
```

```
=====
Radio ID      Radio Mode   SSID-Profile           SSID
      Authentication
-----
1             WGB           myssid                 demo
      OPEN
```

```
Radio configurations:-
```

```
=====
Radio Id      : NA
Admin state   : NA
Mode          : NA
```

```

Radio Id      : 1
  Admin state : DISABLED
  Mode        : WGB
  Dot11 type  : 11ax
Radio Id      : NA
  Admin state : NA
  Mode        : NA

```

- uWGB:

```

#show run
AP Name      : APFC58.9A15.C808
AP Mode      : WorkGroupBridge
CDP State    : Enabled
Watchdog monitoring : Enabled
SSH State    : Disabled
AP Username  : admin
Session Timeout : 300

```

Radio and WLAN-Profile mapping:-

```

=====
Radio ID      Radio Mode  SSID-Profile          SSID
      Authentication
-----
1             UWGB       myssid                demo
      OPEN

```

Radio configurations:-

```

=====
Radio Id      : NA
  Admin state : NA
  Mode        : NA
Radio Id      : 1
  Admin state : DISABLED
  Mode        : UWGB
  Uclient mac : 0009.0001.0001
  Current state : WGB
  Uclient timeout : 0 Sec
  Dot11 type  : 11ax
Radio Id      : NA
  Admin state : NA
  Mode        : NA

```

Use the **show wgb dot11 associations** command to verify the configuration of WGB and uWGB.

- WGB:

```

#show wgb dot11 associations
Uplink Radio ID : 1
Uplink Radio MAC : 00:99:9A:15:B4:91
SSID Name : roam-m44-open
Parent AP Name : APFC58.9A15.C964
Parent AP MAC : 00:99:9A:15:DE:4C
Uplink State : CONNECTED
Auth Type : OPEN
Dot11 type : 11ax
Channel : 100
Bandwidth : 20 MHz
Current Datarate (Tx/Rx) : 86/86 Mbps
Max Datarate : 143 Mbps
RSSI : 53

```

```

IP : 192.168.1.101/24
Default Gateway : 192.168.1.1
IPV6 : ::/128
Assoc timeout : 100 Msec
Auth timeout : 100 Msec
Dhcp timeout : 60 Sec

```

- **uWGB:**

```

#show wgb dot11 associations
Uplink Radio ID : 1
Uplink Radio MAC : 00:09:00:01:00:01
SSID Name : roam-m44-open
Parent AP MAC : FC:58:9A:15:DE:4C
Uplink State : CONNECTED
Auth Type : OPEN
Uclient mac : 00:09:00:01:00:01
Current state : UWGB
Uclient timeout : 60 Sec
Dot11 type : 11ax
Channel : 36
Bandwidth : 20 MHz
Current Datarate (Tx/Rx) : 77/0 Mbps
Max Datarate : 143 Mbps
RSSI : 60
IP : 0.0.0.0
IPV6 : ::/128
Assoc timeout : 100 Msec
Auth timeout : 100 Msec
Dhcp timeout : 60 Sec

```

Configuring and Validating SNMP With WGB

Simple Network Management Protocol (SNMP) is an application-layer protocol that provides a message format for communication between SNMP managers and agents. SNMP provides a standardized framework and a common language that is used for monitoring and managing devices in a network.

WGBs provide network administrators with an SNMP interface, allowing them to poll various states and counters. This enables administrators to easily monitor the health of their WGBs in the field.

By default, SNMP is disabled.

The SNMP framework has the following components, which are as follows.

- **SNMP Manager :** The Simple Network Management Protocol (SNMP) manager is a system that controls and monitors the activities of network hosts using SNMP. The most common managing system is a network management system (NMS). The term NMS can be applied either to a dedicated device used for network management or to the applications used on such a device.
- **SNMP Agent:** The Simple Network Management Protocol (SNMP) agent is the software component within a managed device that maintains the data for the device and reports this data, as needed, to managing systems.
- **SNMP MIB:** An SNMP agent contains MIB variables, whose values the SNMP manager can request or change through Get or Set operations. A manager can get a value from an agent or store a value in that agent. The agent gathers data from the SNMP MIB, the repository for information about device parameters and network data. The agent can also respond to manager requests to get or set data.

The following illustration shows the SNMP process. SNMP agent receives a request from SNMP client, and it passes the request to the subagent. The subagent then returns a response to the SNMP agent and the agent creates an SNMP response packet and sends the response to the remote network management station that initiated the request.

Figure 4: SNMP Process



SNMP Versions

Cisco IOS software supports the following versions of SNMP:

- **SNMPv2c**—The community-string-based administrative framework for SNMPv2. SNMPv2c is an update of the protocol operations and data types of SNMPv2p (SNMPv2 classic), and uses the community-based security model of SNMPv1.
- **SNMPv3**—Version 3 of SNMP. SNMPv3 uses the following security features to provide secure access to devices:
 - **Message integrity**—Ensuring that a packet has not been tampered with in transit.
 - **Authentication**—Determining that the message is from a valid source.
 - **Encryption**—Scrambling the contents of a packet to prevent it from being learned by an unauthorized source.

Supported SNMP MIB File

The Management Information Base (MIB) is a database of the objects that can be managed on a device. The managed objects, or variables, can be set or read to provide information on the network devices and interfaces and are organized hierarchically. The MIB consists of collections of managed objects identified by object identifiers. MIBs are accessed using a network management protocol such as SNMP.

The MIB module provides network management information on IEEE 802.11 wireless device association management and data packet forwarding configuration and statistics.

An Object Identifier (OID) uniquely identifies a MIB object on a managed network device. The OID identifies the MIB object's location in the MIB hierarchy, and provides a means of accessing the MIB object in a network of managed devices

Given below is a list of objects that are supported by the SNMP Management and Information Base (MIB): CISCO-DOT11-ASSOCIATION-MIB.

Table 7: Supported OIDs

OID Object Name	OID	OID Type	OID Description
cDot11ParentAddress	1.3.6.1.4.1.9.9.273.1.1.1	String	Provides the MAC address of the parent access point.

OID Object Name	OID	OID Type	OID Description
cDot11ActiveWirelessClients	1.3.6.1.4.1.99.273.1.1.2.1.1	Gauge	The device on this interface is currently associating with the number of wireless clients.
cDot11ActiveBridges	1.3.6.1.4.1.99.273.1.1.2.1.2	Gauge	The device on this interface is currently associating with the number of bridges.
cDot11ActiveRepeaters	1.3.6.1.4.1.99.273.1.1.2.1.3	Gauge	The device on the interface is currently associating with the number of repeaters.
cDot11AssStatsAssociated	1.3.6.1.4.1.99.273.1.1.3.1.1	Counter	When device restarts, the object counts the number of stations associated with the device on the interface.
cDot11AssStatsAuthenticated	1.3.6.1.4.1.99.273.1.1.3.1.2	Counter	When the device restarted, it currently counts the number of stations authenticated with the device on the interface.
cDot11AssStatsRoamedIn	1.3.6.1.4.1.99.273.1.1.3.1.3	Counter	When the device restarted, the object counts the number of stations roamed from another device to the device on the interface.
cDot11AssStatsRoamedAway	1.3.6.1.4.1.99.273.1.1.3.1.4	Counter	This object counts the number of stations roamed away from the device on the interface since device re-started.

OID Object Name	OID	OID Type	OID Description
cDot11AssStatsDeauthenticated	1.3.6.1.4.1.99.273.1.1.3.1.5	Counter	This object counts the number of stations deauthenticated with this device on the interface since device re-started
cDot11AssStatsDisassociated	1.3.6.1.4.1.99.273.1.1.3.1.6	Counter	This object counts the number of stations disassociated with this device on the interface since device re-started
cd11IfCipherMicFailClientAddress	1.3.6.1.4.1.99.273.1.1.4.1.1	String	This is MAC address of the client attached to the radio interface that caused the most recent MIC failure
cd11IfCipherTkipLocalMicFailures	1.3.6.1.4.1.99.273.1.1.4.1.2	Counter	When the device restarted, the object counts the number of MIC failures encountered on the radio interface.
cd11IfCipherTkipRemotMicFailures	1.3.6.1.4.1.99.273.1.1.4.1.3	Counter	When the device restarted, the object counts the number of MIC failures reported by clients on the radio interface.
cd11IfCipherTkipCounterMeasInvok	1.3.6.1.4.1.99.273.1.1.4.1.4	Counter	When the device restarted, the object counts the number of TKIP Counter Measures invoked on the interface.

OID Object Name	OID	OID Type	OID Description
cd11IfCipherCompReplaysDiscarded	1.3.6.1.4.1.99.273.1.1.4.1.5	Counter	When the device restarted, the object counts the number of received unicast fragments discarded by replay mechanism on the interface.
cd11IfCipherTkipReplaysDetected	1.3.6.1.4.1.99.273.1.1.4.1.6		When the device restarted, the object counts the number of TKIP replay errors detected on this interface.
cDot11ClientRoleClassType	1.3.6.1.4.1.99.273.1.2.1.1.3	Counter	The role classification of the client
cDot11ClientDevType	1.3.6.1.4.1.99.273.1.2.1.1.4	EnumVal	The device type of the client.
cDot11ClientRadioType	1.3.6.1.4.1.99.273.1.2.1.1.5	EnumVal	The radio classification of the client.
cDot11ClientWepEnabled	1.3.6.1.4.1.99.273.1.2.1.1.6	EnumVal	Whether WEP key mechanism is used for transmitting frames of data for the client
cDot11ClientWepKeyMixEnabled	1.3.6.1.4.1.99.273.1.2.1.1.7	EnumVal	Whether this client is using WEP key mixing
cDot11ClientMicEnabled	1.3.6.1.4.1.99.273.1.2.1.1.8	EnumVal	Whether the MIC is enabled for the client
cDot11ClientPowerSaveMode	1.3.6.1.4.1.99.273.1.2.1.1.9	EnumVal	The power management mode of the client.

OID Object Name	OID	OID Type	OID Description
cDot11ClientAid	1.3.6.1.4.1.99.273.1.2.1.1.10	Gauge	This is the association identification number of clients or multicast addresses associating with the device.
cDot11ClientDataRateSet	1.3.6.1.4.1.99.273.1.2.1.1.11	String	Is a set of data rates at which this client can transmit and receive data
cDot11ClientSoftwareVersion	1.3.6.1.4.1.99.273.1.2.1.1.12	String	Cisco IOS software version
cDot11ClientName	1.3.6.1.4.1.99.273.1.2.1.1.13	String	Cisco IOS device hostname
cDot11ClientAssociationState	1.3.6.1.4.1.99.273.1.2.1.1.14	EnumVal	The object indicates the state of the authentication and association process
cDot11ClientVlanId	1.3.6.1.4.1.99.273.1.2.1.1.17	Gauge	The VLAN which the wireless client is assigned to when it is successfully associated to the wireless station.
cDot11ClientSubIfIndex	1.3.6.1.4.1.99.273.1.2.1.1.18	Integer	This is the ifIndex of the sub-interface which this wireless client is assigned to when it is successfully associated to the wireless station.
cDot11ClientAuthenAlgorithm	1.3.6.1.4.1.99.273.1.2.1.1.19	EnumVal	The IEEE 802.1x authentication methods performed between the wireless station and this client during association

OID Object Name	OID	OID Type	OID Description
cDot11ClientDot1xAuthenAlgorithm	1.3.6.1.4.1.99.273.1.2.1.1.21	Octet String	The IEEE 802.1x authentication methods performed between the wireless client and the authentication server.
cDot11ClientUpTime	1.3.6.1.4.1.99.273.1.3.1.1.2	Gauge	The time in seconds that this client has been associated with this device
cDot11ClientSignalStrength	1.3.6.1.4.1.99.273.1.3.1.1.3	Integer	The device-dependent measure the signal strength of the most recently received packet from the client.
cDot11ClientSigQuality	1.3.6.1.4.1.99.273.1.3.1.1.4	Gauge	The device-dependent measure the signal quality of the most recently received packet from the client.
cDot11ClientPacketsReceived	1.3.6.1.4.1.99.273.1.3.1.1.6	Counter	The number of packets received from this client.
cDot11ClientBytesReceived	1.3.6.1.4.1.99.273.1.3.1.1.7	Counter	The number of bytes received from the client.
cDot11ClientPacketsSent	1.3.6.1.4.1.99.273.1.3.1.1.8	Counter	The number of packets sent to the client.
cDot11ClientBytesSent	1.3.6.1.4.1.99.273.1.3.1.1.9	Counter	The number of bytes sent to the client.
cDot11ClientMsduRetries	1.3.6.1.4.1.99.273.1.3.1.1.11	Counter	The counter increases when it successfully transmits an MSDU after one or more retransmissions.

OID Object Name	OID	OID Type	OID Description
cDot11ClientMsduFails	1.3.6.1.4.1.9.9.273.1.3.1.1.12	Counter	The counter increments when the client fails to transmit an MSDU successfully because the number of transmit attempts exceeds a certain limit.

Configuring SNMP from the WGB CLI

The following CLI commands are used for SNMP configuration.



Note

- SNMP CLI logic modified for SNMP configuration, all parameters of SNMP are required to be configured before enable SNMP feature by CLI: `configure snmp enabled`.
- All the related configurations of SNMP will be removed automatically when disable SNMP feature.

Step 1 Enter the **SNMP v2c community ID** number (SNMP v2c only).

```
Device#configure snmp v2c community-id <length 1-64>
```

Step 2 Specify the **SNMP protocol version**.

```
Device#configure snmp version {v2c | v3}
```

Step 3 Specify the **SNMP v3 authentication** protocol (SNMP v3 only).

```
Device#configure snmp auth-method <md5 | sha>
```

Step 4 Enter the **SNMP v3 username** (SNMP v3 only).

```
Device#configure snmp v3 username <length 32>
```

Step 5 Enter the **SNMP v3 user password** (SNMP v3 only).

```
Device#configure snmp v3 password <length 8-64>
```

Step 6 Specify the **SNMP v3 encryption protocol** (SNMP v3 only).

```
Device#configure snmp encryption {des | aes | none}
```

Note Possible encryption values are des or aes. Alternatively, enter none if a v3 encryption protocol is not needed.

Step 7 Enter the **SNMP v3 encryption passphrase** (SNMP v3 only).

```
Device#configure snmp secret <length 8-64>
```

Step 8 **Enable SNMP** functionality in WGB.

Device#**configure snmp enabled**

To configure SNMP v2c, repeat Step 1 through Step 2 and Step 8.

To configure SNMP v3, repeat Step 2 through Step 8.

Step 9 Disable SNMP configuration.

Device#**configure snmp disabled**

When SNMP is disabled, all related configuration is removed.

Example

Example of SNMP configuration.

- CLI for configuring SNMP v2c:

```
Device#configure snmp v2 community-id <length 1-64>
Device#configure snmp version v2c
Device#configure snmp enabled
```

- CLI for configuring SNMP v3 (security level AuthPriv):

```
Device#configure snmp auth-method <md5|sha>
Device#configure snmp v3 username <length 32>
Device#configure snmp v3 password <length 8-64>
Device#configure snmp secret <length 8-64>
Device#configure snmp encryption <aes|des>
Device#configure snmp version v3
Device#configure snmp enabled
```

- CLI for configuring SNMP v3 (security level AuthNoPriv):

```
Device#configure snmp auth-method <md5|sha>
Device#configure snmp v3 username <length 32>
Device#configure snmp v3 password <length 8-64>
Device#configure snmp encryption none
Device#configure snmp version v3
Device#configure snmp enabled
```

Verifying SNMP from WGB CLI

Use the following show command to verify the SNMP configuration.

- Show output of SNMP version v3:

```
Device# show snmp
SNMP: enabled
Version: v3
Community ID: test
Username: username
Password: password
Authentication method: SHA
Encryption: AES
Encryption Passphrase: passphrase
Engine ID: 0x8000000903c0f87fe5f314
```

- Show output of SNMP version v2c:

```
Device# show snmp
SNMP: enabled
Version: v2c
Community ID: test
Username: username
Password: password
Authentication method: SHA
Encryption: AES
Encryption Passphrase: passphrase
Engine ID: 0x8000000903c0f87fe5f314
```

Support for QoS ACL Classification and Marking

Starting from Cisco Unified Industrial Wireless Software Release 17.14.1, WGB allows you to classify different packets from two wired ports and mark them to the different access control driver queues according to the user configuration.

In addition to TCP or UDP, WGB also supports ethertype-based and DSCP-based classification. To meet the jitter and latency requirement, the WGB must classify packets and assign them to different access control queues based on the field environment.

Overview

WGB allows you to create custom rules to map incoming packets from an Ethernet port to specific priority queues on the wireless side. WGB offers the functionality to map upstream data traffic based on either IEEE 802.1p (dot1p) or Differentiated Services Code Point (DSCP).

You can configure the rules based on Ethernet type (for example, Profinet), transport layer port numbers or port range, and DSCP. It ensures forwarding packets to the different access control queues on the wireless network, facilitating efficient QoS enforcement.

As incoming packets arrive at the Ethernet port, it directs them to a specific access control queue on the wireless side using a customized rule-based mapping.

The customized rule dictates the classification and assignment of packets to different access control queues based on predetermined criteria such as source/destination IP addresses, port numbers, or protocol types. Once defined, the rules identify critical services or traffic within the incoming packets. Matching these critical services using the defined rules enables mapping them to higher priority queues within the network infrastructure.

Using rule-based traffic classification and mapping on the WGB, you can effectively manage and prioritize network traffic to meet the specific demands of critical applications and services. This approach enables you to enforce QoS policies effectively within your network to maintain optimal network performance, minimizes latency for critical services, and enhances overall user experience.

Traffic Classification Based on QoS and ACL

Classification is the process of distinguishing one traffic from another by examining the fields in the packet. The device enables classification only when QoS is enabled.

During classification, the device performs a lookup and assigns a QoS label to the packet. The QoS label indicates all QoS actions to perform on the packet and identifies the queue from which the packet is sent.

Layer 2 ethernet frames use the Ethertype field to carry classification information. The ethertype field, typically 2 bytes in size, normally indicates the type of data encapsulated in the frames

Layer 3 IP packets carry the classification information in the type of service (ToS) field that has 8 bits. The ToS field carries either an IP precedence value or a Differentiated Services Code Point (DSCP) value. IP precedence values range 0–7. DSCP values range 0–63.

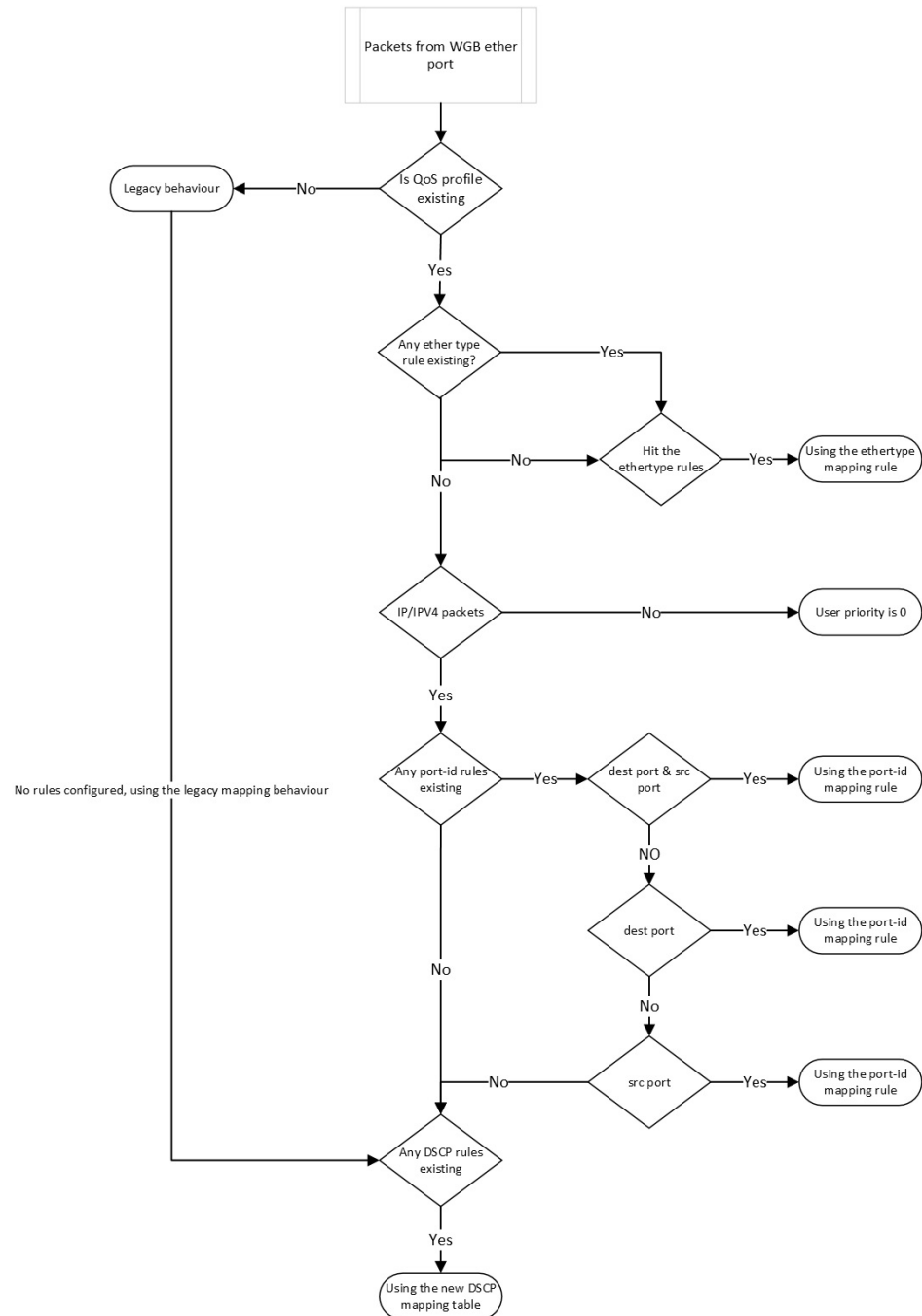
Layer 4 TCP segments or UDP datagrams carry the classification information in the source or destination port field. These port fields specify the port numbers associated with the sender and receiver of the data, enabling networking devices to classify traffic based on predetermined criteria.

The system assigns traffic to a specific service class based on ether type, DSCP, or UDP/TCP port (or port range), treating packets within the service class consistently. The WGB help to classify different packets from the two wired ports and map them to the different driver queues according to the user config.

The data plane statistics provide counts of how many times each rule hit by network traffic. These counters are essential for network administrators to analyse the effectiveness of their rules and policies, and optimize network performance.

The control plane is a part of a network architecture responsible for managing and configuring how data is forwarded through the network.

Figure 5: Flowchart of traffic flows from WGB ethernet port



When QoS is disabled, access points follows the legacy mapping behaviour and perform the following:

1. Retrieve the Tag Control Information (TCI) priority from the VLAN element for the specified ethertype 0x8100.
2. For ethertype 0x8892 (profinet) QoS mapping, assigns the TCI priority as 6.

- For ethertype 0x0800 (IP) and 0x86DD (IPv6), the DSCP priority is set according to the default dscp2dot1p mapping table.

```

===== dscp mapping =====
Default dscp2dot1p Table Value:
[0]->0 [1]->0 [2]->0 [3]->0 [4]->0 [5]->0 [6]->0 [7]->0
[8]->1 [9]->1 [10]->1 [11]->1 [12]->1 [13]->1 [14]->1 [15]->1
[16]->2 [17]->2 [18]->2 [19]->2 [20]->2 [21]->2 [22]->2 [23]->2
[24]->3 [25]->3 [26]->3 [27]->3 [28]->3 [29]->3 [30]->3 [31]->3
[32]->4 [33]->4 [34]->4 [35]->4 [36]->4 [37]->4 [38]->4 [39]->4
[40]->5 [41]->5 [42]->5 [43]->5 [44]->5 [45]->5 [46]->5 [47]->5
[48]->6 [49]->6 [50]->6 [51]->6 [52]->6 [53]->6 [54]->6 [55]->6
[56]->7 [57]->7 [58]->7 [59]->7 [60]->7 [61]->7 [62]->7 [63]->7

```

When QoS is enabled, access points perform the following:

- The priority for an ethertype QoS mapping 0x8892 (profinet) is based on the configuration setting.
- For ethertype 0x0800 (IP) and 0x86DD (IPv6), the priority is based on mapping rules that consider port or DSCP.
 - Check the UDP/TCP port (or port range) rule.
 - Check the DSCP rule.
- Assigns the user priority value 0 to non-IPv4/IPv6 packets.
- If there is no rule configuration, the QoS profile follows the legacy mapping behavior.



Note if 802.1p priority exists, it overrides any customised rule.

Configuring Quality of Service Mapping Profile

The following commands allow users to define the different classification rules for configuring WGB QoS mapping.

Step 1 Enable the QoS mapping profile.

```
Device#config wgb qos-mapping <profile-name> enable
```

Example:

```
Device#configure wgb qos-mapping demo-profile enable
```

Step 2 WGB QoS mapping profile rules based on **ethernet type**.

The below command is used to set the rules based on ethernet frame type.

- Add rules based on ethernet type.

```
Device#config wgb qos-mapping <profile-name> add ethtype hex <number> priority <0-7>
```

Example:

```
Device#configure wgb qos-mapping demo-profile add ethtype hex 8892 priority 5
```


If the command specify a profile that does not exist, the command will create a new empty profile and then add mapping rule to it.

- Delete rules based on ethernet type

```
Device#config wgb qos-mapping <profile-name> delete ethtype hex <number>
```

Example:

```
Device#configure wgb qos-mapping demo-profile delete ethtype hex 8892
```

The command will issue a warning message if it specifies a profile that does not exist. Furthermore, if deleting the specified mapping rule leaves the profile empty, it will be automatically removed.

Step 3

Rules based on **port-id/range**.

The below command is used to set the rules based on L4 port id/range.

- Add rules based on port-id/range.

```
Device#config wgb qos-mapping <profile-name> add srcport <number> | <range <start-number> <end-number>> [dstport <number> | <range <start-number> <end-number>>] priority <0-7>
```

Example:

```
Device#configure wgb qos-mapping demo-profile add srcport range 5050 5070 dstport 8000 priority 3
```

If the command specify a profile that does not exist, the command will create a new empty profile and then add mapping rule to it.

- Delete rules based on port-id/range.

```
Device#config wgb qos-mapping <profile-name> delete [srcport <number> | <range <start-number> <end-number>>] [dstport <number> | <range <start-number> <end-number>>]]
```

Example:

```
Device#configure wgb qos-mapping demo-profile delete srcport range 5050 5070 dstport 8000
```

The command will issue a warning message if it specifies a profile that does not exist. Furthermore, if deleting the specified mapping rule leaves the profile empty, it will be automatically removed.

Step 4

Rules based on **DSCP**.

The below command is used to set the rules based on IPv4/IPv6 packet DSCP value.

- Add

```
Device#config wgb qos-mapping <profile-name> add dscp <number> priority <0-7>
```

Example:

```
Device#configure wgb qos-mapping demo-profile add dscp 63 priority 4
```

If the command specify a profile that does not exist, the command will create a new empty profile and then add mapping rule to it.

- Delete

```
Device#config wgb qos-mapping <profile-name> delete dscp <number> priority <0-7>
```

Example:

```
Device#configure wgb qos-mapping demo-profile delete dscp 63
```

The command will issue a warning message if it specifies a profile that does not exist. Furthermore, if deleting the specified mapping rule leaves the profile empty, it will be automatically removed.

Note After deleting the DSCP mapping rule, the rules are reset to the default values of the DSCP mapping.

Step 5 Disable the QoS mapping profile.

```
Device#config wgb qos-mapping <profile-name> disable
```

Example:

```
Device#configure wgb qos-mapping demo-profile disable
```

When disabled, the command clear the profile from the datapath and retain it in the WGB configuration file. If the specified profile does not exist, the command issue a warning message and will not create a new empty profile.

Step 6 Delete the QoS mapping profile.

```
Device#config wgb qos-mapping <profile-name> delete
```

Example:

```
Device#configure wgb qos-mapping demo-profile delete
```

When deleted, the profile is removed from data path and WGB configuration.

Verifying WGB Quality of Service Mapping

To verify the WGB QoS mapping configuration on the Control Plane, run the **show wgb qos-mapping**.

```
Device# show wgb qos-mapping
```

```
Number of QoS Mapping Profiles: 2
=====
Profile name : qos1
Profile status : active
Number of Rules: 8
Rules:
L4 srcport : 31000-31100, dstport : 6666-7777, priority : 7
L4 srcport : 23000, dstport : N/A, priority : 3
L4 srcport : N/A, dstport : 20000-20100, priority : 5
L4 srcport : N/A, dstport : 2222, priority : 2
L4 srcport : 12300-12500, dstport : N/A, priority : 6
IPv4/IPv6 dscp: 43, priority : 1
Ethernet type : 0x8892, priority : 0
L4 srcport : 8888, dstport : 9999, priority : 4

Profile name : qos2
Profile status : inactive
Number of Rules: 8
Rules:
L4 srcport : 31000-31100, dstport : 6666-7777, priority : 2
L4 srcport : 23000, dstport : N/A, priority : 6
L4 srcport : N/A, dstport : 20000-20100, priority : 4
L4 srcport : N/A, dstport : 2222, priority : 7
L4 srcport : 12300-12500, dstport : N/A, priority : 3
IPv4/IPv6 dscp: 43, priority : 0
Ethernet type : 0x8892, priority : 1
L4 srcport : 8888, dstport : 9999, priority : 5
```

To verify the WGB QoS mapping configuration on the Data Plane, run the **show datapath qos-mapping rule**.

```
Device# show datapath qos-mapping rule

Status: active
QoS Mapping entries
===== dscp mapping =====
Default dscp2dot1p Table Value:
[0]->0 [1]->0 [2]->0 [3]->0 [4]->0 [5]->0 [6]->0 [7]->0
[8]->1 [9]->1 [10]->1 [11]->1 [12]->1 [13]->1 [14]->1 [15]->1
[16]->2 [17]->2 [18]->2 [19]->2 [20]->2 [21]->2 [22]->2 [23]->2
[24]->3 [25]->3 [26]->3 [27]->3 [28]->3 [29]->3 [30]->3 [31]->3
[32]->4 [33]->4 [34]->4 [35]->4 [36]->4 [37]->4 [38]->4 [39]->4
[40]->5 [41]->5 [42]->5 [43]->5 [44]->5 [45]->5 [46]->5 [47]->5
[48]->6 [49]->6 [50]->6 [51]->6 [52]->6 [53]->6 [54]->6 [55]->6
[56]->7 [57]->7 [58]->7 [59]->7 [60]->7 [61]->7 [62]->7 [63]->7

active dscp2dot1p Table Value:
[0]->0 [1]->0 [2]->0 [3]->0 [4]->0 [5]->0 [6]->0 [7]->0
[8]->1 [9]->1 [10]->1 [11]->1 [12]->1 [13]->1 [14]->1 [15]->1
[16]->7 [17]->2 [18]->2 [19]->2 [20]->2 [21]->2 [22]->2 [23]->2
[24]->3 [25]->3 [26]->3 [27]->3 [28]->3 [29]->3 [30]->3 [31]->3
[32]->4 [33]->4 [34]->4 [35]->4 [36]->4 [37]->4 [38]->4 [39]->4
[40]->5 [41]->5 [42]->5 [43]->5 [44]->5 [45]->5 [46]->5 [47]->5
[48]->6 [49]->6 [50]->6 [51]->6 [52]->6 [53]->6 [54]->6 [55]->6
[56]->7 [57]->7 [58]->7 [59]->7 [60]->7 [61]->7 [62]->7 [63]->7
```

To verify the WGB QoS mapping statistics on Data Plane, run the **show datapath qos-mapping statistics** command.

```
Device# show datapath qos-mapping statistics

===== pkt stats per dscp-mapping rule =====
dscp up  pkt_cnt
16 7 0
```

To clear the WGB QoS mapping statistics on Data Plane, run the **clear datapath qos-mapping statistics** command.



Note The command clears packet count statistics per rule on data-plane.



CHAPTER 4

Automated Frequency Coordination

- [AFC Support for 6 GHz Standard Power Mode](#) , on page 79
- [Verifying AFC Status on AP](#), on page 80

AFC Support for 6 GHz Standard Power Mode

The Cisco Catalyst IW9167E access point has eight N-type female connectors to support multiple antenna options, such as the Self-Identifying Antennas (SIA) on designated three SIA ports, dual-band antennas, and single-band antennas. The IW9167E is compatible with SIA antennas for the 6 GHz band.

The IW9167E supports the Automated Frequency Coordination (AFC) 6 GHz Standard Power mode. A standard power AP joins the system. Before enabling standard power, the AP must get the available frequencies and the power in each frequency range from the AFC system.

The AFC system computes the available frequencies and maximum allowable power based on the information provided by the regulatory body (FCC for United States). The response is sent back to controller, which may assign a standard power channel to the AP based on the allowed channel list returned by the AFC system.

Standard Power AP coordinate through an AFC service. The AFC accesses information and, along with the AP's geographical location and antenna characteristics, creates a topographical propagation map modeling the AP's interference radius. This map allows you to assign maximum transmission power and coordinate/configure the channel settings to avoid interference.



Note A power cycle is mandatory after the first installation of the SIA antenna.

Table 8: Radio 6 GHz power mode support

Deployment Mode	Low Power Indoor Support	Standard Power Support
Outdoor	No	Yes

The transmission power is limited to a maximum of 36 dB Effective Isotropic Radiated Power (EIRP), and APs must be coordinated through an AFC service. These APs are allowed to operate in the UNII-5 (5.925-6.425 GHz) and UNII-7 (6.525-7.125 GHz) in the -B (U.S) domain.

Table 9: 6 GHz Target Power

Conductor Per Path Power		Antenna Gain	Tx x Rx Chains	Max EIRP	Max EIRP (SP/AFC)
20-80Mhz	160Mhz				
17 dBm	16 dBm	7 dBi*	4x4	30 dBm*	36 dBm

Verifying AFC Status on AP

To verify the AFC request and response data on AP, run the **show rrm afc** command.

```
Device#show rrm afc
Location Type: 1
Deployment Type: 2
Height: 129
Uncertainty: 5
Height Type: 0
Request Status: 5
Request Status Timestamp: 2023-08-31T06:20:17Z
Request Id Sent: 5546388983266789933
Ellipse 1: longitude: -121.935066 latitude: 37.512830 major axis: 43 minor axis:
 9 orientation: 36.818100
AFC Response Request ID: 5546388983266789933
AFC Response Ruleset ID: US_47_CFR_PART_15_SUBPART_E
```

To verify the current operating power mode, run the **show controllers dot11Radio 2 | i Radio** command.

```
Device#show controllers dot11Radio 2 | i Radio
Dot11Radio2      Link encap:Ethernet  HWaddr 24:16:1B:F8:06:C0
Radio Info Summary:
Radio: 6.0GHz (SP)
```

THE SPECIFICATIONS AND INFORMATION REGARDING THE PRODUCTS IN THIS MANUAL ARE SUBJECT TO CHANGE WITHOUT NOTICE. ALL STATEMENTS, INFORMATION, AND RECOMMENDATIONS IN THIS MANUAL ARE BELIEVED TO BE ACCURATE BUT ARE PRESENTED WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. USERS MUST TAKE FULL RESPONSIBILITY FOR THEIR APPLICATION OF ANY PRODUCTS.

THE SOFTWARE LICENSE AND LIMITED WARRANTY FOR THE ACCOMPANYING PRODUCT ARE SET FORTH IN THE INFORMATION PACKET THAT SHIPPED WITH THE PRODUCT AND ARE INCORPORATED HEREIN BY THIS REFERENCE. IF YOU ARE UNABLE TO LOCATE THE SOFTWARE LICENSE OR LIMITED WARRANTY, CONTACT YOUR CISCO REPRESENTATIVE FOR A COPY.

The Cisco implementation of TCP header compression is an adaptation of a program developed by the University of California, Berkeley (UCB) as part of UCB's public domain version of the UNIX operating system. All rights reserved. Copyright © 1981, Regents of the University of California.

NOTWITHSTANDING ANY OTHER WARRANTY HEREIN, ALL DOCUMENT FILES AND SOFTWARE OF THESE SUPPLIERS ARE PROVIDED "AS IS" WITH ALL FAULTS. CISCO AND THE ABOVE-NAMED SUPPLIERS DISCLAIM ALL WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, WITHOUT LIMITATION, THOSE OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NON-INFRINGEMENT OR ARISING FROM A COURSE OF DEALING, USAGE, OR TRADE PRACTICE.

IN NO EVENT SHALL CISCO OR ITS SUPPLIERS BE LIABLE FOR ANY INDIRECT, SPECIAL, CONSEQUENTIAL, OR INCIDENTAL DAMAGES, INCLUDING, WITHOUT LIMITATION, LOST PROFITS OR LOSS OR DAMAGE TO DATA ARISING OUT OF THE USE OR INABILITY TO USE THIS MANUAL, EVEN IF CISCO OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Any Internet Protocol (IP) addresses and phone numbers used in this document are not intended to be actual addresses and phone numbers. Any examples, command display output, network topology diagrams, and other figures included in the document are shown for illustrative purposes only. Any use of actual IP addresses or phone numbers in illustrative content is unintentional and coincidental.

All printed copies and duplicate soft copies of this document are considered uncontrolled. See the current online version for the latest version.

Cisco has more than 200 offices worldwide. Addresses and phone numbers are listed on the Cisco website at www.cisco.com/go/offices.

Cisco and the Cisco logo are trademarks or registered trademarks of Cisco and/or its affiliates in the U.S. and other countries. To view a list of Cisco trademarks, go to this URL: <https://www.cisco.com/c/en/us/about/legal/trademarks.html>. Third-party trademarks mentioned are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (1721R)

© 2024 Cisco Systems, Inc. All rights reserved.

