FortiWLC (SD)

Configuration Guide

Rel 8.6.0

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1 About This Guide

This guide describes the various options for configuring the Wireless LAN System.

Audience

This guide is intended for network administrators configuring and maintaining the Wireless LAN System. Familiarity with the following concepts is helpful when configuring the Forti WLAN:

- Network administration, including:
  - Internet Protocol (IP) addressing and routing
  - Dynamic Host Configuration Protocol (DHCP)
  - Configuring Layer 2 and Layer 3 switches (if required by your switch)
- IEEE 802.11 (Wi-Fi) concepts, including:
  - ESSIDs
  - WEP
- Network Security (optional)
  - WPA
  - 802.1X
  - RADIUS
  - X.509 certificates

Other Sources of Information

Additional information is available in the following Web site, Fortinet publications, and external references.

Web Resources

For the first 90 days after you buy a Forti WLC, you have access to online support. If you have a support contract, you have access for the length of the contract. See this web site for information such as:

- Knowledge Base (Q&A)
- Downloads
- Open a ticket or check an existing one
- Customer Discussion Forum

The URL is: **http://support.fortinet.com**

Fortinet Publications

- ***FortiWLC Release Notes***
- ***FortiWLC Command Reference***
- ***FortiWLC Virtual Controller Deployment Guide***

Guide to Typographic Conventions

This guide uses the following typographic conventions in paragraph text to help you identify information:

Bold text	Identifies commands and keywords in syntax descriptions that are entered literally.
Italic text	Used for new terms, emphasis, and book titles; also identifies arguments for which you supply values in syntax descriptions.
Courier font	Identifies file names, folder names, computer screen output, and text in syntax descriptions that you are required to type.
Ctrl-	Denotes that the Ctrl key should be used in conjunction with another key, for example, Ctrl-D means hold down the Ctrl and press the D key. Keys are shown in capitals, but are not case sensitive.

Provides extra information, tips, and hints regarding the topic

Identifies important information about actions that could result in damage to or loss of data, or could cause the application to behave in unexpected ways.

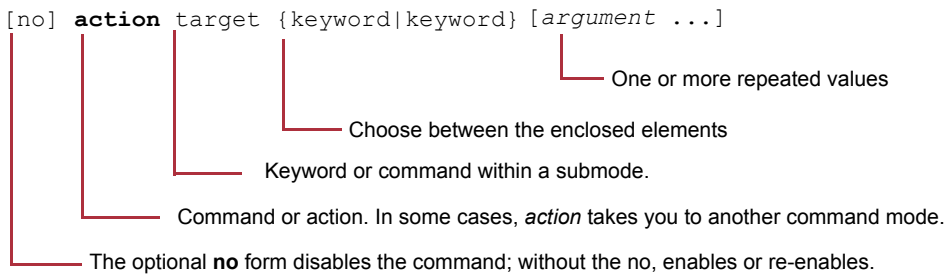
	Identifies critical information about actions that could result in equipment failure or bodily harm.

Syntax Notation

In example command syntax descriptions and examples, the following text elements and punctuation are used to denote user input and computer output for the command.

bold	Required command, keywords, and punctuation.
italic	Arguments or file names where you substitute a value.
no	The optional no form of the command disables the feature or function.
[ ]	Optional elements are enclosed by square brackets.
{ }	Braces indicates that one of the enclosed elements must be used.
|	Choices among elements are separated by vertical bars.
[{}]	A required choice within an optional element.
…	The preceding argument can be repeated.

The following figure shows a sample of syntax notation.



	Many commands have a default setting or value, listed in the Default section of the command page.

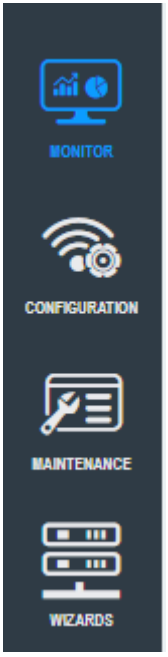
2 Web UI Concepts

Access FortiWLC (SD) by entering the IP address of the controller in a browser (see *"Browsers"* ***on page 36*** below). The Web UI interface that displays operates from four menus: Monitor, Maintenance, Configuration, and Wizards. Clicking any entry from the list expands it to display the options contained therein.

Note: With FortiWLC release 8.6, all controllers support 64-bit OS ONLY. 64-bit migration images are available to migrate the existing 32-bit FortiWLC-50D, FortiWLC-200D, and FortiWLC-500D hardware controllers to 64-bit, during upgrade to version 8.6.0. For more information, see *FortiWLC 8.6 Release Notes*. All legacy hardware MC controller models are NOT supported.

FortiWLC GUI prompts for a confirmation message before any delete operation.

Figure 1: *Menu Options in the WebUI*



How Does the GUI Relate to CLI Commands?

Most FortiWLC (SD) tasks can be accomplished using either the CLI or the GUI. Some commands can only be done with one or the other. The chart below gives some examples of this. You can refer to the illustration on the previous page or click the indicated links on the UI Interface.

I need to know...	With the CLI	With the GUI
Stations that are associated	show station show phones	Station table (Monitor > Devices > All Stations)
Stations and APs that are detectable	show ap-discovered	Station table (Monitor > Devices > All Stations)
Controller setup	show controller	System Summary (Monitor > Dashboard > System)
APs that are connected	show ap	Station table (click Monitor > Devices > All Stations)
How are APs connected	show ap-connectivity ap-id	Station table (click Monitor > Devices > All Stations)
How many stations are connected	show station or show topostation	Station table (Monitor > Devices > All Stations)
Stations connections to certain AP	show ap-assigned mac-address	Station table (Monitor > Devices > All Stations)
Add a new operating system version to a controller using FTP	copy ftp://ftpuser:ftppasswd@***off-box-ip-address***/ forti-x.x-xxx-MODEL-rpm.tar. upgrade system x.x	NA
See aggregate throughput for all APs	NA	System Dashboard (Monitor > Dashboard > System)
Syslog message summary	show syslog-table shows the entire log	SysLog Files Table (Maintenance > View Syslog) shows a segment of the log based on time

I need to know...	With the CLI	With the GUI
Alarms	show alarm	Alarms (Monitor > Fault Management > Alarms)
Rogues detected	show rogue-ap-list	Rogue AP Table (Monitor > Rogue Devices)
AP model	show ap	
Throughput bottlenecks	show statistics top10 -ap -problem (shows loss %) analyze-capture start, analyze-capture stop, analyze-capture capture	System Dashboard (Monitor > Dashboard > System)
High-volume users	show statistics top10-station-talker	Stations Dashboard (click Monitor > Dashboard > Station)
Why a user's connection failed	station-log/station add analyze-capture	Station Diagnostics (click Monitor > Diagnostics > Station)
Dead spots	show topoap	Station Diagnostics (Monitor > Diagnostics > All Station > Signal Strength Chart)
Station retries	show station	Monitor > Dashboard > Station > Retries chart
User's location	show station or show topostation	NA
Overloaded radios	show station show statistics top10-ap-problem	Monitor > Dashboard > Radio > Retries chart Radio Dashboard (Monitor > Dashboard > Radio > Throughput Chart)
High-loss radios	show station analyze-capture start, analyze-capture stop, analyze-capture snapshot	Monitor > Dashboard > Radio > Loss % chart Controller Dashboard (Monitor > Controller > High-Loss Radio chart)
Noisy radios	NA	Monitor > Diagnostics > Radio Controller Dashboard (Monitor > Controller > Noise Level chart)

I need to know...	With the CLI	With the GUI
Radio Management Overhead	show interfaces Dot11Radio statistics	Monitor > Dashboard > Radio > Management Overhead Distribution chart
Average Station data rates	show station 802.11 | “802.11a” show station 802.11 | “802.11b” show station 802.11 | “802.11g” show station 802.11 | “802.11g” show station 802.11 | “802.11ab” show station 802.11 | “802.11bg” show station 802.11 | “802.11bgn”	Monitor > Dashboard > Station > Average Rate charts

Browsers

WebUI

- Internet Explorer 9,10
- Mozilla Firefox 25+
- Google Chrome 31+

Captive Portal

- Internet Explorer 6, 7, 8,9, and 10, 11, and Edge
- Apple Safari
- Google Chrome
- Mozilla Firefox 4.x and earlier
- Mobile devices (such as Apple iPhone and BlackBerry)

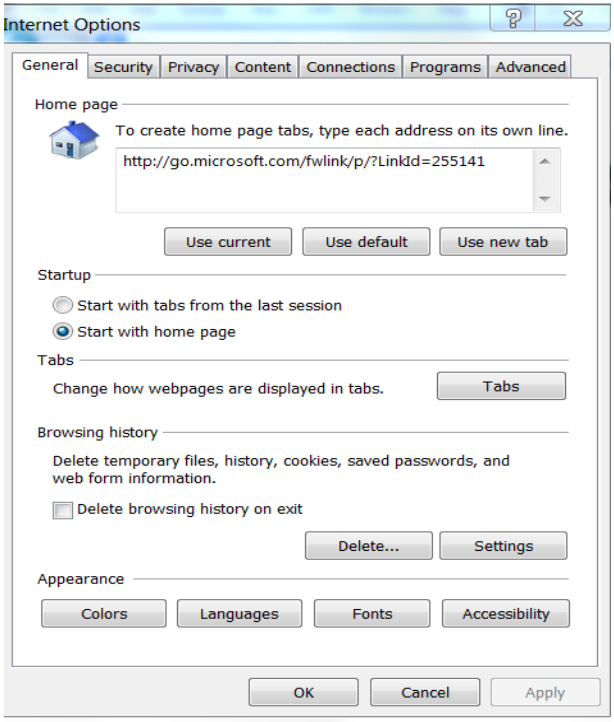
Internet Explorer Caching Settings

Be sure to turn off caching on any computer using Internet Explorer, because dashboard updates are frequently ignored with caching on. To configure Windows Internet Explorer, follow these steps:

1. Access Internet Options by opening an Internet Explorer window and then clicking Tools > Internet Options.

   A window like this one displays:

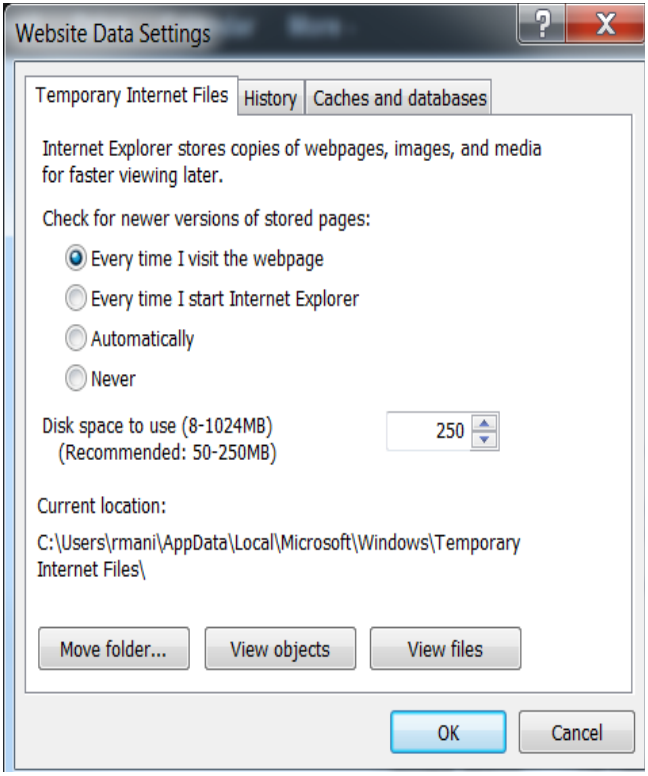
Figure 2: *Internet Options for Microsoft Windows*



2. Under Browsing history, click Settings.

   A window like this one displays:

Figure 3: *Website Data Settings*



3. Select the option Every time I visit the web page.
4. Click OK.

The dashboard will now be updated every time the statistics change.

Note that no configuration is needed for Mozilla Firefox.

What is Network Manager?

Network Manager is a Fortinet product that manages multiple controllers.

ESS, Security, VLAN, GRE and RADIUS profiles can all be configured either from Network Manager or from the controller. You can tell where a profile was configured by checking the read-only field Owner; the Owner is either NMS or controller. If a profile belongs to Network Manager, you cannot alter or delete it from a controller.

If a profile belongs to Network Manager, the recommendation is to alter/delete it from the Network Manager interface. If for some reason Network Manager is not reachable from the con-

troller, then the recommendation is to unregister the Network Manager server from the controller using the nms-server unregister CLI command.

3 Managing System Files

This chapter describes how to work with the Controller File System (CFS), which provides a single interface for managing all files available for use with Fortinet controllers. This chapter contains the following sections:

About the CFS

The CFS allows you to manage the controller operating system (FortiWLC (SD)) and its configuration files.

Files used to operate the controller are located in directories on the controller flash card. Initially, the flash contains the shipped operating system, referred to as the image, which of course is set with default settings. During the course of normal operation, you probably will want to perform some or all of the following tasks:

- Configure custom settings and save the settings to a configuration file.
- Save the configuration file to a backup directory on the controller.
- Save the configuration file to a remote location to provide a more secure backup or as input for configuring other controllers.
- Restore the settings from a known, reliable backup file.
- Restore the system to its default settings.
- Upgrade the system to a new version of the operating system.
- Downgrade the system to a previous operating system version.
- Execute scripts to automate configuration.

To accomplish these tasks you need to use the CFS to manipulate files. The CFS allows you to perform the following tasks:

- Display information about files within a directory
- The display information includes the file name, size, and date of modification.
- Navigate to different directories
- You can navigate to different directories and list the files in a directory.
- Copy files
  The CFS allows you to copy files on the controller via a pathname or to manipulate remote files. Use Uniform Resource Locators (URLs) to specify the location of a remote file. URLs are commonly used to specify files or locations on the World Wide Web. You can use the URL format to copy file to or retrieve files from a location on a remote file server.
- Delete files

Working with Local Directories

The controller flash card uses the following directories to organize its system files. You can access the following local directories:

Directory Name	Directory Contents
images	Directory where the current image resides and where you can place upgrade images that you have obtained remotely.
backup	Directory containing backup configuration files and databases.
ATS/scripts	Directory containing AP bootup scripts.
capture	Directory containing the packet capture files.

Viewing Directory and File Information

Use the pwd command to view the current directory. By default, the current working directory is images, as shown with the pwd command:

```
controller# pwd
   images
```

To view a detailed listing about the contents of a directory, use the dir command, which accepts an optional directory or filename argument:

```
dir [[directory/]filename]
```

For example, to display the contents of the images directory:

```
FortWLC# dir

total 776

-rwxrwxrwx 1 root root 108648 Jun  2 15:26 config-factory.tgz

drwxrwxrwx 9 root root   4096 Aug 30  2019 forti-8.5-1dev-75

drwxr-xr-x 9 root root   4096 Sep 19  2019 forti-8.5-2dev-3

-rwxrwxrwx 1 root root 256397 Jun  2 15:49 forti-ap-diagnostics-Sun-Jun-02-19-
  49-08-AST-2019.tar.gz

lrwxrwxrwx 1 root root     33 Jun  2 17:06 mibs.tar.gz -> forti-8.5-2dev-3/mibs/
  mibs.tar.gz

-rwxrwxrwx 1 root root 126232 Jun  2 17:06 pre-upgrade-config

-rwxrwxrwx 1 root root 127943 Jun  2 18:18 script.log

-rwxrwxrwx 1 root root 122415 Jun  2 15:27 startup-config

-rwxrwxrwx 1 root root  13653 Jun  2 16:38 upgrade.log
```

To view information about a file in different directory, use the directory arguments:

```
controller# dir ATS/scripts

total 4
   -rwxr-xr-x    1 root     root           67 Feb 21  2008 dense-.scr
   -rwxr-xr-x    1 root     root           25 Feb 21  2008 guard.scr
   -rwxr-xr-x    1 root     root           82 Feb 21  2008 non-guard.scr
   -rwxr-xr-x    1 root     root          126 Feb 21  2008 svp.scr
```

Changing to Another Directory

Use the cd command to navigate to another directory on the controller:

```
controller# cd backup
```

Use the pwd command to view the name of the current directory:

```
controller# pwd
   backup
```

Managing Files Via the WebUI

While local files can be managed via the CLI as well, the FortiWLC (SD) WebUI provides a convenient management interface from the Maintenance > File Management button. The File Management page contains separate tabs for the following types of files:

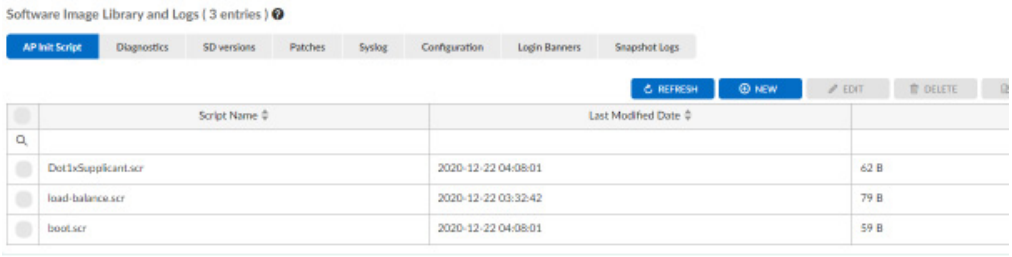
- AP Init Script—Manages AP bootup scripts
- Diagnostics—Contains diagnostic files
- SD Versions—All software image files stored on the controller
- Syslog—Stored Syslog data for the various components of the system

Refer to the sections below for additional details relating to each tab.

AP Init Script

The default tab selected when the user first navigates to the File Management system shows any scripts installed on the system designed to make small tweaks to APs upon bootup. See Figure 4 below.

Figure 4: *AP Init Script Table*



Users can perform various tasks for a given boot script by clicking the radio button alongside the desired script and clicking the necessary button from the bottom of the screen, as described in

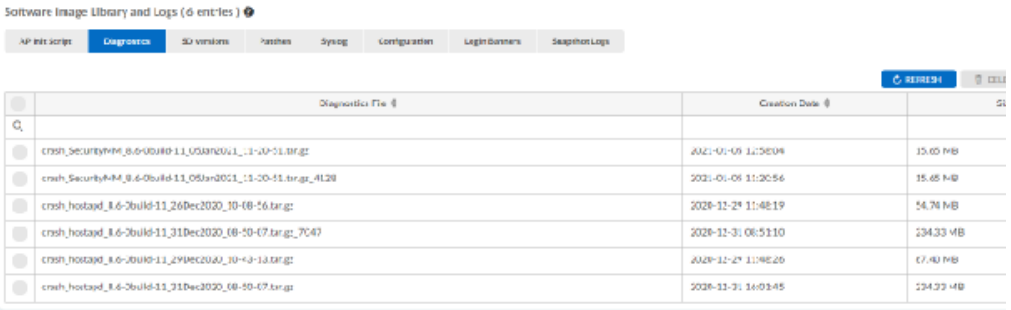
TABLE 1: *Command Buttons*

Button	Action
Refresh	Refreshes the list of scripts shown.
New	Opens the Add/Edit window, which allows a user to create a new bootscript.
View	Opens a new window that shows the content of the boot script.
Edit	Allows the user to modify the selected script, including its commands as well as the name of the script itself.
Delete	Deletes the selected script.
Import	Opens up a window from which the user can browse for a local boot script file and upload it to the controller. Note: Only files with a ".txt" extension are permitted to be uploaded.
Export	Exports the selected script to the local machine.

Diagnostics

The Diagnostics tab displays any diagnostic files that have been generated by the controller. These files are in compressed format, so once they are downloaded to the local machine, the user can decompress them and view the logs contained within.

Figure 5: *Diagnostics Tab*



Once decompressed, the diagnostic logs can be viewed using a standard text editor. To download a log file, simply click the radio button next to the desired file and click Export. The table below describes the functions performed by the buttons on the screen.

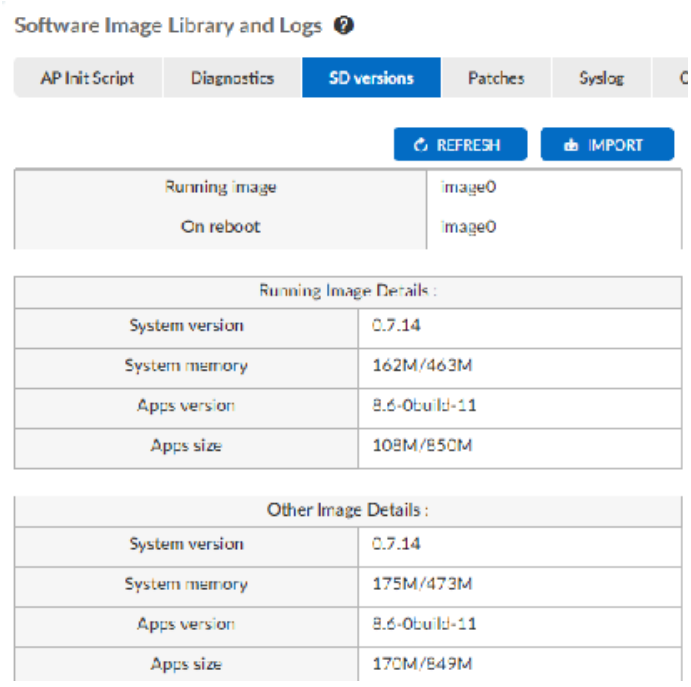
TABLE 2: *Command Buttons*

Button	Action
Refresh	Refreshes the list of files shown.
Export	Exports the selected file to the local machine.
Delete	Deletes the selected file.

Image

The Image tab allows the user to manage the FortiWLC (SD) image files stored on the controller. Since these files can be quite large, users may occasionally need to delete older images in order to perform system upgrades.

Figure 6: *Image Tab*



The following table details the buttons provided for managing system files.

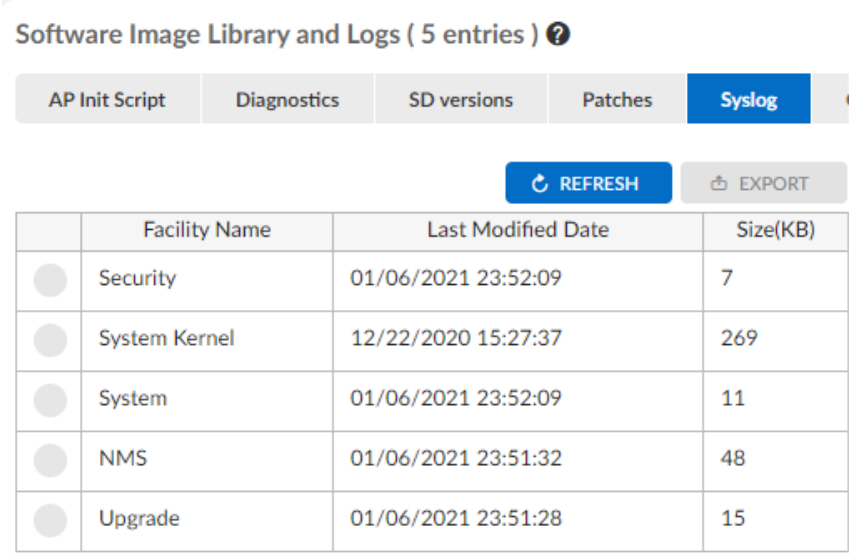
TABLE 3: *Command Buttons*

Button	Action
Refresh	Refreshes the list of files shown.
Import	Allows the user to upload an image file from the local machine onto the controller. Note: Controller image files must be in ".tar" format.
Delete	Deletes the selected file.

Syslog

The Syslog tab provides an interface to easily view and manage Syslog files that have been generated and stored on the controller. The station log can be viewed in the syslog.

Figure 7: *Syslog Tab*



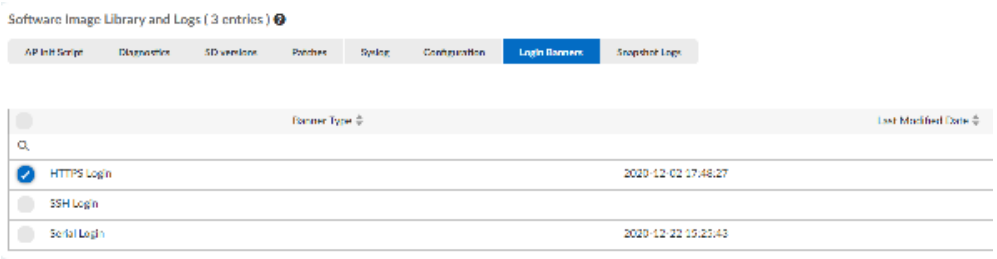
Syslog files are stored in ".log" format and can be viewed using a standard text editor. To download and view one, simply click the radio button alongside the desired file and click Export.

TABLE 4: *Command Buttons*

Button	Action
Refresh	Refreshes the list of files shown.
Export	Allows the user to download and view the selected file.

Login Banners

The login banner defines the text that is displayed when you login into the controller. The login banner applies only to the controller on which you configure it. Select the banner type, **HTTPS Login**, **SSH Login**, and **Serial** and click **Edit**, update the banner content and click **Save**.



Working with Configuration Files

Configuration files direct the functions of the controller. Commands in the configuration file are parsed by the CLI and executed when the system is booted from the database, or when you enter commands at the CLI in a configuration mode. There are two types of configuration files used by the CLI:

- The startup database file (startup-config) is executed at system startup.
- The running configuration file (running-config) contains the current (running) configuration of the software.

The startup configuration file may be different from the running configuration file. For example, you might want to change the configuration, and then for a time period evaluate your changes before saving them to the startup configuration.

In this case, you would make the configuration changes using the configure terminal commands, but not save the configuration. When you were sure you wanted to permanently incorporate the changes, you would use the copy running-config startup-config EXEC command.

Changing the Running Configuration

The configure terminal EXEC command allows you to make changes to the running configuration. Commands are executed immediately, but are not saved. To save the changes, see “Changing the Startup Configuration.”

TABLE 5: *Steps to Modify the Running Configuration*

Command	Purpose
controller# configure terminal	Enters global configuration mode.
controller(config)#	Enter the commands you want to put in your running configuration. The CLI executes these commands immediately and also inserts them to the running configuration file.
controller# copy running-config startup-config	Saves the running configuration file as the startup configuration file. You must save the running configuration to the startup configuration file for your configuration changes to persist during a reboot.
controller(config)# end or controller(config)# Ctrl-Z	Ends the configuration session and exits EXEC mode. NOTE: You need to press the Ctrl and Z keys simultaneously.
controller(config)# Ctrl-C	Cancels any changes and reverts to the previous mode.

Changing the Startup Configuration

To make your configuration changes persistent across reboots, use the copy running-config startup-config EXEC command to copy the running configuration to a startup configuration.

Manipulating System Files

To manage the system files, you might want to transfer a configuration file to a remote system to back up the file, or obtain from a remote system an update or backup file. To access the remote system, you probably need a username and password. This section provides some example commands for performing these tasks.

Manipulating Files on a Network Server

To specify a file on a network server, use one of the following forms:

- ftp://<***username>:<password>***@server/filename

- scp://<***username>:<password>***@server/filename
- sftp://<***username>:<password>***@server/filename
- tftp://server/filename

The server can either be an IP address or host name. The username, if specified, overrides a username specified by the global configuration command ip ftp username. A password also overrides a password specified by the global configuration command ip ftp password.

The specified directory and filename are relative to the directory used for file transfers, or in absolute format.

The following example uses secure FTP to access the file named forti-8.5-config on a server named ftp.fortinet.com. This example uses the username admin and the password secret to access this server:

controller# copy sftp://admin:secret@ftp.fortinet.com/forti-8.5-config<space>.

For SCP (secure copy), replace the prefix sftp with scp.

Remote File Transfer Tasks

On a remote file system located on an FTP, SFTP, TFTP or SSH server, you can perform the following tasks:

- Copy files to or from the controller using the copy command.
- List the files in a given directory using the dir command.

Copying Files to a Remote Server

For example, to copy a backup image jun01.backup.mbu from the local directory images to a remote directory /home/backup on server server1, with user user1 using FTP, with the same remote filename, type:

```
controller# cd images
   controller# dir
   total 48
   -rw-r--r-- 1 root root        15317 Jan  9 15:46 jun01.backup.mbu

controller# copy jun01.backup.mbu ftp://user1@server1/home/backup/.
   FTP Password:
   controller#
```

Type the password for user user1 at the FTP Password prompt. To use SCP instead of FTP:

```
controller# copy jun01.backup.mbu scp://user1@server1/home/backup/.
   SCP Password:
```

Displaying a Remote Server's Directory Contents

To display the contents of the remote directory /home/backup on the server server1, for the username user1 and password userpass, you can type:

```
controller# dir ftp://user1:userpass@server1/home/backup
```

If you only specify the user name but not the password, the CLI prompts you to enter the password:

```
controller# dir ftp://user1@server1/home/backup
   FTP Password:
```

Setting a Remote Username and Password

The secure remote file transfer commands require a remote username and password on each request to a server. The CLI uses the user name and password specified in the dir or copy command to authenticate with the remote file servers.

If you do not want to type the user name and password for each secure remote file transfer command, you can set these values for the duration of your session using the ip ftp, ip sftp, or ip scp commands.

For example, to set the FTP user name to user1 and the FTP password to userpass, type:

```
controller# configure terminal
   controller(config)# ip ftp username user1
   controller(config)# ip ftp password userpass
   controller(config)# ^Z
   controller#
```

Likewise, to set the SCP user name to user1 and the SCP password to userpass, type:

```
controller# configure terminal
   controller(config)# ip scp username user1
   controller(config)# ip scp password userpass
   controller(config)# ^Z
   controller#
```

If you have set the FTP username and password as in the previous example, you can now type the following:

```
controller# dir ftp://server1/home/backup
```

Upgrading System Images

The controller is shipped with a pre-installed system image, containing the complete FortiWLC (SD) software. This image is loaded when the controller boots. As new software releases become available, you may decide to upgrade the system image.

Each release is accompanied by a Release Notes file on the documentation CD, which include procedures for upgrading different types of system configurations to the current release. Be sure to use the procedure included in the Release Notes when you choose to upgrade your system, as they provide the most up-to-date procedures.

Summary of File System Commands

The following lists the available file system commands in privileged EXEC mode.

Command	Purpose
controller> cd [filesystem]	Sets the default directory on the Flash memory device. If no directory name is specified, this sets the default directory to images. Permitted directories are: images: The directory containing upgrade images ATS/scripts: The directory containing AP boot scripts backup: The directory containing database backup images.
controller> pwd	Displays the current working directory.
controller> dir [filesystem:][filename]	Displays a list of files on a file system. This can be one of the permitted directories given in the cd command or a remote directory referenced by an FTP URL.
controller# delete filename controller# delete directory:filename controller# delete flash: image	Deletes a file from the file system or deletes an upgrade image file from flash memory. The directory parameter can be used to delete a file from a different folder.
controller# show flash	Display the versions of the image files contained in the controller's flash memory.
controller# rename old new	Renames a file from old to new.
controller# show running-config	Display the contents of the running configuration file.

Command	Purpose
controller# more running-config	Display the contents of the running configuration file. Alias for show running-config, but in contrast to that command, this one prompts the user to press a key to scroll the screen once it is filled. This allows the configuration to be shown a screen at a time, instead of scrolling all the way through instantly.
controller# copy running-config ftp|sftp|scp:[[[//username:password]@location/directory]/filename]	Copies the running configuration file to an FTP, SFTP, or SCP server, for example: controller# copy running-config ftp://user1:userpass@server1/jan01-config controller# copy running-config scp://user1:userpass@server1/jan01-config
controller# copy running-config startup-config	Saves the running-configuration to the startup configuration to make it persistent. You should always do this after a set of configuration commands if you want your changes to persist across reboots.
controller# reload ap [id] | all | controller | default	Reboots the controller and/or the specified AP: If the ap keyword is specified, all APs are rebooted, or if id is included, the AP with the identifier id is rebooted. If the keyword all is specified, the Fortinet controller and all the APs are rebooted, using the current startup configuration. If the keyword controller is specified, the controller is rebooted, using the current startup configuration. If the keyword default is specified, the controller and all the APs are rebooted at the factory default startup configuration.
controller# upgrade feature ***version***	Upgrades the system with the specified feature.
controller# upgrade system ***version***	Upgrades the system image on the controller and all APs to the specified version.
controller# upgrade ap ***version*** | **same** [id | range | **all**]	Upgrades the access point image to the same version of system software that the controller is running. ***id***—Upgrades the access point with the specified ID to the same version of system software that the controller is running. range—Upgrades a range of APs, specified as a list using commas and dashes, without spaces or wildcards. AP IDs must be listed in ascending order. all—Upgrades all access point image to the same version of system software that the controller is running.

Command	Purpose
controller# downgrade system ***version***	Downgrades the system image on the controller and all APs to the specified version. Note that when this command is executed, the user will be prompted to remove all local users and groups from the system.
controller# run ***script***	Executes the named script. If the script is in the current directory, the relative path name is specified. Otherwise, the full path name must be specified. The script must be either in images, ATS/scripts, or backup.

Upgrading Patches

In addition to providing options to install and un-install patches, you can now easily view more details about the contents of a patch and also get history of patches installed in the controller. These new options are available via the controller WebUI and the CLI.

Using the WebUI

Patch management options are available in the **Maintenance** > **File Management** > **Patches** tab. If there patch build file copied in the controller, they will be listed on this page. For specific option, select a patch file and click the option at the bottom of the page.

Using CLI

1. show patches

Displays the list of patch builds copied to the controller.

```
#show patches

8.0-0dev-51-patch-bug1234 [installed]

8.0-0dev-50-patch-bug1234_bug1236

8.0-0dev-50-patch-bug1234
```

```
8.0-0dev-50-patch-2015.07.22-17h.12m.09s

8.0-0dev-50-patch-bug1234_bug1235

8.0-0dev-51-patch-bug1234_bug1235

8.0-0dev-51-patch-bug1234
```

2. show patch installed

Displays the patch currently installed in the controller.

controller(15)# show patch installed

8.0-0dev-51-patch-bug1234

3. show patch history

Displays the history of all the patches installed and uninstalled in the controller

```
controller(15)# show patch history

2015:07:24 01:51:13: uninstalled 8.0-0dev-50-patch-bug1234 on build 8.0-0dev-51

2015:07:24 01:54:13: installed 8.0-0dev-51-patch-bug1234_bug1235 on build 8.0-
  0dev-51

2015:07:24 01:56:39: uninstalled 8.0-0dev-51-patch-bug1234_bug1235 on build
  8.0-0dev-51

....<snipped>....

2015:07:24 14:54:50: uninstalled 8.0-0dev-51-patch-bug1234 on build 8.0-0dev-51
```

4. show patch details <patch-name>

Displays the list of bug fixes available in this patch.

```
controller(15)# show patch details 8.0-0dev-50-patch-bug1234

8.0-0dev-50-patch-bug1234

patch is revertable

bugs:

  37405: summary of bug 37405

controller(15)#
```

5. show patch contents <patch-name>

Displays the md5 sum of the patch build.

```
controller(15)# show patch contents 8.0-0dev-50-patch-bug1234

8.0-0dev-50-patch-bug1234

files:

  /opt/meru/etc/coord.config: 3d4c720265e21a53dfafe2a484e8bf11
```

6. patch uninstall <patch-name>

Use this command to un-install the patch build from the controller.

```
controller(15)# patch uninstall
```

7. Reverting from backup.

```
cp -f /data/.patch-backup//meru-8.0-0dev-51-patch-bug1234/coord.config /opt/
  meru/etc/coord.config

Reverting from backup done.
```

4 Managing the System

This chapter describes procedures for configuring controllers and managing the system. This chapter contains the following sections:

Configure Basic Controller Parameters During Setup

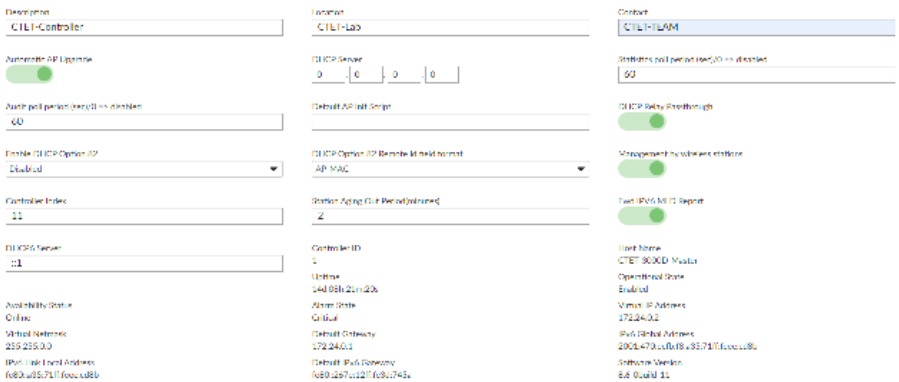
These basic controller parameters are configured by someone with Level 15 permission, using the interactive setup script that sets up every new controller:

- Country setting
- Controller location
- Hostname
- Passwords for admins and guests
- Dynamic IP address or a static IP address and netmask
- Time zone
- DNS server names
- Gateway server name
- Network Time Protocol server

Start the setup script, at the Privileged EXEC prompt, type setup.

Configure Controller Parameters From the Web UI

To reconfigure an existing controller, click Configuration > Devices > Controller > [select a controller] > Settings. The following parameters can be configured from the Web UI with Level 10 permission.

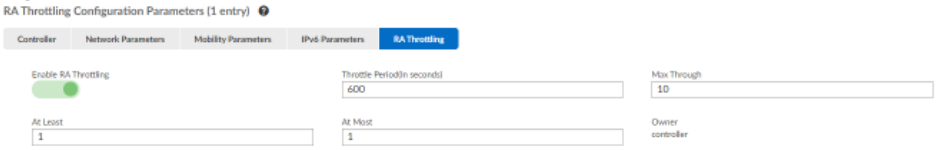


- Information for recognizing and tracking controllers such as the Description, Location, and Contact person
- Whether or not APs should be Automatically Upgraded by a controller
- DHCP Server address and DHCP Relay Passthrough (whether or not packets are actually passed to the DHCP server)
- Statistics Polling Period and Audit Polling Period, which affect how often a controller refreshes data
- Default AP Initialization Script (bootscript) that run on APs with no other script specified
- Controller Index number used for identification (Note that changing this initiates a controller reboot.)
- Whether or not the controller will interact with the AeroScout Location Engine and associated APs will interact with AeroScout Tags to provide real-time asset tracking
- Whether or not Fastpath Mode is used. Fastpath Mode accelerates the rate that packets move through the Ethernet interface based on identification of an IP packet stream. When FastPath is enabled, the beginning of the IP packet stream is processed by the controller, and all subsequent packets of the same stream are forwarded according to the disposition of the initial packets, without being processed by the controller. This offloads a significant amount of processing from the controller.
- Whether or not Dynamic Frequency Selection (DFS) is enforced. For installations within the United States, enforcing DFS means that channels 52-64 (5.25-5.35 GHz), 100-116 (5.47-5.725 GHz), and 136-140 (5.68-5.70 GHz) conform to DFS regulations, protecting radar from interference on these channels.
- The number of minutes of station inactivity that causes a client to time out is set by the Station Aging Out Period.
- **Enable DHCP Option 82** - When DHCP option 82 is enabled, the controller acts as a DHCP relay agent to avoid DHCP client requests from untrusted sources. This secures the network where DHCP is used to allocate network addresses. The controller adds the DHCP option 82 information to DHCP requests from clients before forwarding the requests to the DHCP server. By default, this option is disabled.
- **DHCP Option 82 Remote Id field format** - Select the DHCP option 82 remote ID field format as AP-MAC or AP-MAC-SSID.
  Notes:
  - DHCP relay pass-through should be disabled for the controller to act as the DHCP relay agent.
  - This feature is not supported if the data plane mode is bridged.
  - This feature is not supported for IPv6.
- In the **DHCP6 Server** field type the IPv6 address to which 802.11 client DHCP requests are forwarded.
- Enable **Fwd IPV6 MLD Report** to forward the Multicast Listener Discovery report.

RA Throttling

Router Advertisement (RA) throttling enables the controller to restrict RA packets in a wireless network. This prevents excessive bandwidth consumption by multicast IPv6 RA messages over the wireless edge of a switched network. The RA packets are reduced to a minimum without impacting IPv6 client connectivity. Roaming clients and new clients are not impacted with RA throttling.

Figure 8: *Configuring RA throttle*



- **Throttle period**: The period of time that RA throttling occurs. RA throttling takes place only after the **Max Through** limit or the **At Most** value is reached for a particular router. The valid range is 10 to 86400 seconds; default is 600 seconds..
- **Max Through**: The maximum number of RA packets on the VLAN before throttling occurs. The valid range is 0 to 256 RA packets; default is 10 RA packets. A value of 0 allows an unlimited volume of RAs packets without throttling.
- **At Least**: The minimum number of RA packets per router sent as multicast traffic before throttling begins. The valid range is 0 to 32 RA packets; default is 1.
- **At Most**: The maximum number of RA packets per router sent as multicast traffic before throttling begins. The valid range is from 0 to 256 RA packets; default is 1.

Note: The configured **At Most** value must be less than the configured **Max Through** value.

Configure UDP Broadcast with Web UI

You can enable all UDP ports at once with the WebUI commands for upstream and downstream traffic. Fortinet does not recommend that you enable this feature on a production network because it could lead to broadcast storms leading to network outages. This feature is provided for testing purposes only.

You need to assign each ESS (see the chapter “Configuring an ESS.”) to a specific VLAN (see the chapter “Configuring VLANs.”) before enabling all UDP broadcast ports. Having multiple ESS’s in the default VLAN and enabling all UDP broadcast ports does not work.

To configure UDP broadcast upstream/downstream for all ports, follow these steps:

1. Click Configuration > Devices > System Settings.
2. Click the tab UDP Broadcast Ports.
3. Determine the type of UDP Broadcast mode you wish to configure (Tunnel Mode or Bridge Mode) and click that Tab.

4. Click Add.
5. Check the type of UDP Broadcast rule you wish to configure, Upstream or Downstream.
6. Enter a UDP Port Number in the range 1-65355 and then click Save.
   The port number now appears in the UDP Broadcast Port list.

Perform the above steps for as many ports as desired.

Configure Controller Parameters From the CLI

Reset System and System Passwords from the CLI

The passwords for the system users “admin' and “guest” can be reset to their default values during a system boot. When the controller prompts “accepting reset request” displays, type pass to reset the passwords.

To reset the settings for the entire system to their default values, type reset at the reset system values prompt.

Limit Wireless Client Access to the Controller From the CLI

Administrators wishing to block access to the controller management utilities for wireless clients can do so with the no management access command. When wireless management access is blocked, all packets sent to the controller by wireless clients are dropped except for those used for Captive Portal.

To remove wireless access to the controller, enter the command:

```
controller(config)# no management wireless
```

To check the management status, use the show controller command. The line near the bottom of the output, Management by wireless stations: will show either an on or off value.

```
FortiWLC# show controller

Global Controller Parameters

Controller ID : 1

Description : controller

Host Name : default

Uptime : 18d:00h:13m:08s

Location :

Contact :
```

```
Operational State : Enabled
Availability Status : Online
Alarm State : No Alarm
Automatic AP Upgrade : on
Virtual IP Address : 10.33.96.201
Virtual Netmask : 255.255.255.0
Default Gateway : 10.33.96.1
IPv6 Global Address : 2001:470:ecfb:45f:feaa:14ff:fee7:2d4a
IPv6 Link Local Address : fe80::feaa:14ff:fee7:2d4a
Default IPv6 Gateway : fe80::d27e:28ff:fe48:96
DHCP Server : 127.0.0.1
Statistics poll period (sec)/0 => disabled : 60
Audit poll period (sec)/0 => disabled : 60
Software Version : 8.5-0dev-27
Network Device Id : fc:aa:14:e7:2d:4a
System Id : 2701C69EB576
Default AP Init Script :
DHCP Relay Passthrough : on
Controller Model : FortiWLC-200D
Region Setting : US
Country Setting : United States Of America
Manufacturing Serial # : N/A
Management by wireless stations : on
Controller Index : 0
FastPath Mode : on
Bonding Mode : single
Station Aging Out Period(minutes) : 2
Roaming Domain State : enable
```

```
Station Roaming Time Out Period(minutes) : 60

Layer3 Routing Mode : off

Force Dhcp Retries : 4

VM NIC Queues :0#
```

To re-enable access to wireless clients, use the management wireless command:

```
controller(config)# management wireless
```

Limit Wired Client Access to the Controller With QoS Rules

To control access to the controller from wired network devices, you can configure rule-based IP ACL lists using the qosrules command. This section provides qosrule examples for several types of configurations.

The following is an example that blocks management access (on TCP and UDP) to the controller (at 192.168.1.2) for all devices except the host at 192.168.1.7. Notice that match tags are enabled when srcip, dstip, srcport, dstport, netprotocol, or packet min-length is configured for a rule.

Allow the host 192.168.1.7 to access the controller with TCP/UDP:

```
controller(config)#  qosrule 20 netprotocol 6 qosprotocol none
   controller(config-qosrule)# netprotocol-match
   controller(config-qosrule)# srcip 192.168.1.7
   controller(config-qosrule)# srcip-match
   controller(config-qosrule)# srcmask 255.255.255.255
   controller(config-qosrule)# dstip 192.168.1.2
   controller(config-qosrule)# dstip-match
   controller(config-qosrule)# dstmask 255.255.255.255
   controller(config-qosrule)# action forward
   controller(config-qosrule)# end
   controller(config)# qosrule 21 netprotocol 17 qosprotocol none
   controller(config-qosrule)# netprotocol-match
   controller(config-qosrule)# srcip 192.168.1.7
   controller(config-qosrule)# srcip-match
   controller(config-qosrule)# srcmask 255.255.255.255
   controller(config-qosrule)# dstip 192.168.1.2
   controller(config-qosrule)# dstip-match
   controller(config-qosrule)# dstmask 255.255.255.255
   controller(config-qosrule)# action forward
   controller(config-qosrule)# end
```

The following qosrules allow wireless clients to access the controller on TCP ports 8080/8081 if using the Captive Portal feature.

```
controller(config)# qosrule 22 netprotocol 6 qosprotocol none
   controller(config-qosrule)# netprotocol-match
   controller(config-qosrule)# srcip <subnet of wireless clients>
   controller(config-qosrule)# srcip-match
   controller(config-qosrule)# srcmask <netmask of wireless clients>
   controller(config-qosrule)# dstport-match on
   controller(config-qosrule)# dstip 192.168.1.2
   controller(config-qosrule)# dstip-match
   controller(config-qosrule)# dstmask 255.255.255.255
   controller(config-qosrule)# dstport 8080
   controller(config-qosrule)# action forward
   controller(config-qosrule)# end
```

```
controller(config)# qosrule 23 netprotocol 6 qosprotocol none
   controller(config-qosrule)# netprotocol-match
   controller(config-qosrule)# srcip <subnet of wireless clients>
   controller(config-qosrule)# srcmask <netmask of wireless clients>
   controller(config-qosrule)# dstport-match on
   controller(config-qosrule)# dstip 192.168.1.2
   controller(config-qosrule)# dstip-match
   controller(config-qosrule)# dstmask 255.255.255.255
   controller(config-qosrule)# dstport 8081
   controller(config-qosrule)# action forward
   controller(config-qosrule)# end
```

The following qosrules block all hosts from accessing the Controller using TCP/UDP.

```
controller(config)# qosrule 24 netprotocol 6 qosprotocol none
   controller(config-qosrule)# netprotocol-match
   controller(config-qosrule)# dstip 192.168.1.2
   controller(config-qosrule)# dstip-match
   controller(config-qosrule)# dstmask 255.255.255.255
   controller(config-qosrule)# action drop
   controller(config-qosrule)# end
```

```
controller(config)# qosrule 25 netprotocol 17 qosprotocol none
   controller(config-qosrule)# dstip 192.168.1.2
   controller(config-qosrule)# dstip-match
   controller(config-qosrule)# dstmask 255.255.255.255
   controller(config-qosrule)# action drop
   controller(config-qosrule)# end
```

Configuring UDP Broadcast From the CLI

You can enable all UDP ports at once with the CLI commands for upstream and downstream traffic. Fortinet does not recommend that you enable this feature on a production network

because it could lead to broadcast storms leading to network outages. This feature is provided for testing purposes only.

You need to assign each ESS (see the chapter “Configuring an ESS.”) to a specific VLAN (see the chapter “Configuring VLANs.”) before enabling all UDP broadcast ports. Having multiple ESS’s in the default VLAN and enabling all UDP broadcast ports does not work.

To configure UDP broadcast upstream/downstream for all ports, use these two CLI commands:

```
default# configure terminal
   default(config)# ip udp-broadcast upstream all-ports selected
   default(config)# ip udp-broadcast downstream all-ports on
   default(config)# end
```

To display configured UDP broadcast upstream/downstream for all ports, use these two CLI commands:

```
default# show ip udp-broadcast upstream all-ports
   Upstream UDP Broadcast All Ports
   UDP All Ports : on
   default#
   default# show ip udp-broadcast downstream all-ports
   Downstream UDP Broadcast All Ports
   UDP All Ports : selected
   default#
```

To view the currently configured broadcast ports for either upstream or downstream, use show ip udp-broadcast [downstream/downstream-bridged/upstream/upstream-bridged].

Configure Time Services From the CLI

We recommend that you configure controllers to synchronize their system clock with a Network Time Protocol (NTP) server. This ensures the system time is accurate and standardized with other systems. Accurate and standardized system time is important for alarms, traces, syslog, and applications such as cryptography that use timestamps as a parameter for key management and lifetime control. An accurate clock is also necessary for intrusion detection, isolation and logging, as well as network monitoring, measurement, and control.

During the initial system configuration, the setup script prompts for an IP address of an NTP server. If you do not supply an IP address of an NTP server at that time, or if you wish to change an assigned server at a later time, you can use the ntp server followed by the ntp sync commands.

- To set up automatic periodic synchronizing with the configured NTP server, use the command start-ntp.

There are several NTP servers that can be designated as the time server. The site www.ntp.org provides a list of servers that can be used.

To set a server as an NTP server, use the command:

ntp server ***ip-address***

where ***ip-address*** is the IP address of the NTP server providing clock synchronization.

If you choose not to use a NTP server to synchronize the system clock, the system time can be set manually with the calendar set command.

Configure a Controller Index with the CLI

To configure a controller index from CLI, using the following commands

```
ramecntrl(0)# configure terminal
   ramecntrl(0)(config)# controller-index 22
   ramecntrl(0)(config)# exit
```

Note that changing the index causes a controller to reboot.

Licensing for Virtual Controllers

This section assumes you have already received your entitlement for the Fortinet Virtual Controller you ordered. Along with the entitlement that allows you to obtain the license for your instance, you would also have received instructions on where to download the right version of the software for the model you ordered.

Obtain the license only after completing the installation of the Virtual Controller. Contact the Forticare Support with the details entailed in the following sections to obtain the license.

For more information, see the *FortiWLC Virtual Deployment Guide*.

802.11n Video Service Module (ViSM)

Video streaming has the low latency and loss requirements of with the high-throughput requirements of data. The Fortinet Video Service Module™ (ViSM) is an optional licensed software module that delivers predictable 802.11 video performance with minimal delay, latency and jitter. Sustainable high data rates, even in mixed traffic, are supported along with synchronization of video and audio transmissions.

ViSM also introduces additional mechanisms for optimizing unicast and multicast video such as application aware scheduling, /video synchronization, and client-specific multicast group management. Features include the following:

- High throughput with low burstiness offers predictable performance and consistent user experience
- Application-aware prioritization synchronizes the and video components of a video stream, adapting the delivery of each frame based on its importance to the application.
- Multicast group management optimizes delivery to only those Virtual Ports whose clients are members of the multicast group.
- Seamless video-optimized handoff proactively reroutes the multicast delivery tree to prevent lost video frames during a transition between access points and ensures zero loss for mobile video.
- User and role based policy enforcement provides granular control over application behavior.
- Visualization reveals which clients are running which applications.

Implementing ViSM

Virtual Port already changes multicast to unicast transmissions. ViSM adds per-client IGMP Snooping to the transmission. Therefore, to implement ViSM, turn on IGMP Snooping. CLI commands control IGMP snooping (see ***FortiWLC (SD) Command Reference***). At this time, ViSM licensing is not enforced.

Using AeroScout

The AeroScout System version 3 (but not version 2) product works with Forti WLC to locate and track tagged assets to deliver direct benefits such as process automation and theft prevention. Tags are small, battery-powered devices attached to equipment or personnel. See AeroScout's web site for more detailed information about the various tags available from AeroScout.

AeroScout tags do not associate to an access point; instead they send out beacon signals in pre-configurable intervals or when an event is triggered (the tag is in motion, a button is pressed, etc.). Messages transmitted by AeroScout tags are received by access points and are forwarded with additional information, such as RSSI values or signal strength measurements, to the AeroScout Engine. The Engine calculates the accurate location of the tag.

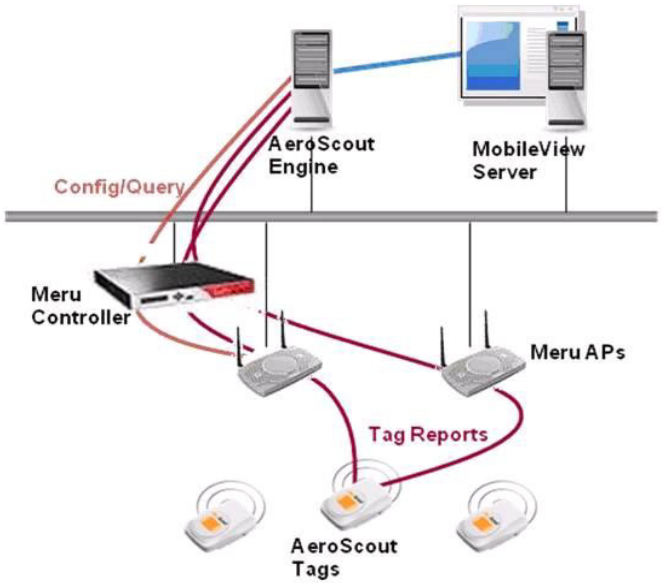
Reporting Tags do not affect the normal operation of access points; they keep performing in all of the supported modes (802.11a/b/g communication). AeroScout Tags also do not have an IP address and are unidirectional in the sense that they transmit and do not receive standard Wi-Fi messages.

For APs to process the tag signals and communicate with the AeroScout Engine, the AeroScout Engine-AP Interface protocol must be implemented on access points. In *Figure 9 on page 68*, the AeroScout solution architecture is shown. The following is the high-level process that occurs in the implementation:

- AeroScout tags send short wireless messages at a regular interval.
- The signal is received by access points that are connected to a Forti WLC running AeroScout software, and the signal is sent to the AeroScout engine along with its measured signal strength.
- The AeroScout engine uses signal strength to determine the coordinates of the reported location, and sends this data to AeroScout MobileView.
- AeroScout MobileView uses location data to display maps, enable searches, create alerts, manage assets, interface to third parties through an API.

Using Location Feed

Figure 9: *AeroScout Network Diagram*



In addition to Fortinet standard Wi-Fi infrastructure, AeroScout Location Receivers and Exciters can be deployed for time-different of arrival (TDOA) locationing and choke points respectively.

Configuring AeroScout

Tracking tags is done from the AeroScout product using a Forti WLC and APs. To configure a Forti WLC to work with AeroScout, use the command aeroscout enable as shown here:

```
controller(config)# aeroscout ?
   disable                (10) Disabling AeroScout Feature.
   enable                 (10) Enabling AeroScout Feature.
   ip-address             (10) The Aeroscout engine IP address.
   port                   (10) The Aeroscout engine port.
   controller(config)#
```

Location Accuracy

Since RSSI values are the basis of the location calculation, the access point must match its channel with the tag's transmission channel, and drop tag messages that were transmitted on a channel other than that of the access point. The matching is implemented because tag reports contain the transmission channel in each message.

For this reason, the combination of AeroScout's solution architecture with Fortinet's Virtual Cell deployments and Air Traffic ControlTM technology provide a more accurate location for tags. In other words, Fortinet's APs can all be deployed in a single channel with a virtualized BSSID, thereby providing more reference points for the tag messages and a more accurate location.

For the location of a tag to be calculated accurately, at least three access points need to report the Wi-Fi message transmitted by the tag. A message received and reported by less than three APs provides only a very general location which, in most cases, is the location of the AP closest to the tag. To see the tag locations, use AeroScout. Tags do not show up when you use the Fortinet CLI command show discovered-station or anywhere else from the Fortinet CLI.

It is important to place APs closer to the perimeter of the space that will tag and track assets, filling in coverage holes in the center of the coverage area. It is better to surround the tracking area. Aside from this, use standard Fortinet Networks deployment guidelines in placing the APs and distancing them from one another. In other words, plan for coverage and optimal data rates. When AeroScout Exciters are used for choke-point location, one AP receiving the Tag message is enough to deliver an accurate location report.

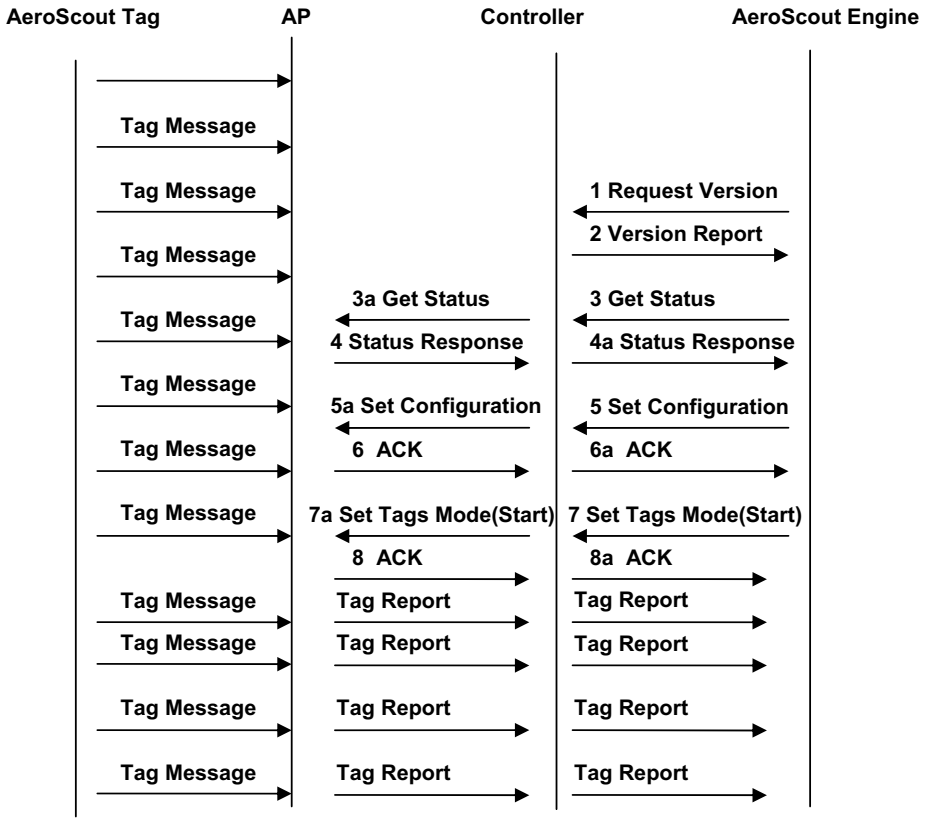
Tag Protocol Implementation

The Tag protocol operates between access points and the AeroScout engine. The Fortinet AeroScout implementation supports tag (but not laptop) messages transmitted in either in

IBSS (default) or WDS frame format, although Fortinet APs receive and process tag frames only in IBSS format.

Once the Forti WLC and access points are upgraded to the current version, the tag protocol is enabled automatically. No additional configuration steps are necessary. Management of the AeroScout Tags, Engine, and MobileView application are managed through the AeroScout platform. *Figure 10 on* ***page 70*** shows the operation and messages used in the Tag protocol:

Figure 10: *AeroScout Tag Protocol Messages*



AeroScout and Rogue Detection

If an AP interface is in dedicated scanning mode with Rogue AP enabled, tags are not forwarded for any channels. If an AP interface is in normal mode with Rogue AP enabled, tags are forwarded on the home channel only. Tags on foreign channels are not forwarded.

AeroScout Syslog Error Messages

Error Condition	Severity	Message
Cannot create a ATS AeroScout Manager mailbox	critical	AeroScoutMgr mailbox creation failed
Cannot set AeroScout mode in the driver	critical	Cannot set AeroScout mode to enable/disable
Invalid AE messages	warning	Unknown Message Code[0xXX]
		Data length error. rcvdLength[%d], expect at least [%d]
Messages from unknown or unsupported mailboxes	miscellaneous	Msg from Unknown MailboxId[xx]
Cannot allocate a mailbox buffer to send a controller message	warning	AllocBuf failed reqID[0xXXXX]
IOCTL to the AeroScout kernel module failed	warning	reqID[0xXXXX] IOCTL[xx] to AeroScout kernel module failed
Cannot get wireless channel config information	warning	Could not get wireless interface config for interface[xx]

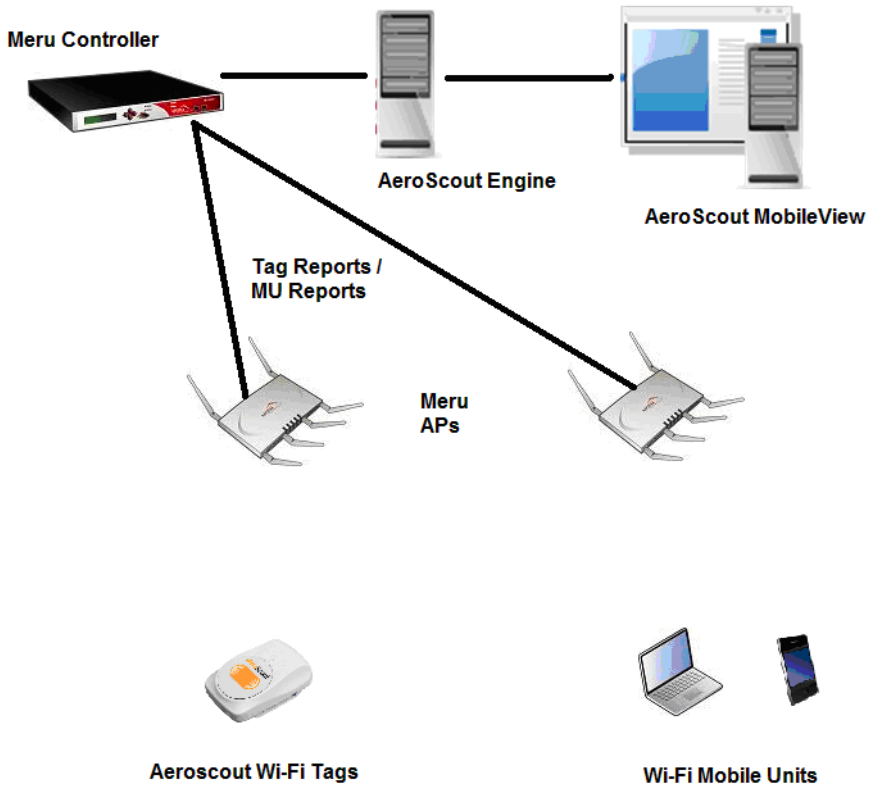
AeroScout Mobile Unit

AeroScout offers Wi-Fi-based solutions for Real Time Location Service (RTLS).

The AeroScout Mobile Unit architecture is displayed in *Figure 11 on* ***page 72***. The following is the high-level process that occurs in the implementation:

- Wi-Fi mobile units send wireless frames to one or more APs.
- The AP sends reports for each Wi-Fi mobile unit (by using a dilution mechanism to control traffic between AP and Engine) to the AeroScout Engine.
- The AeroScout Engine determines the coordinates and sends it to AeroScout MobileView.
- The AeroScout Mobile View uses location data to display maps, enable searches, create alerts, manage assets, work with third-parties, and much more.

Figure 11: *Aeroscout Mobile Unit*



Wi-Fi Mobile Units (MUs) can be located, if associated to some access point, or while transmitting broadcast or unicast messages. The messages transmitted by Wi-Fi Mobile Units are received by Access Points and are passed along with additional information (e.g., signal strength measurements) to the AeroScout Engine, which is a core component of the AeroScout visibility system. The AeroScout Engine also calculates an accurate location of the Wi-Fi device. In order to locate the Mobile Units, Access Points that receive their messages must pass the RSSI values of each message to the AeroScout Engine. The access points must also be able to collect data messages from MUs that are not associated with them and pass the RSSI values to the AeroScout Engine.

Reporting Tags and/or Wi-Fi mobile units must not affect the normal operation of the AP—that is, the AP must be performing in all its supported modes, such as normal 802.11a/b/g communication, monitoring, bridge modes, etc. Due to the high MU traffic, it is possible to dilute the MU messages that are sent to AeroScout Engine.

Configuring AeroScout

Tracking tags is preformed from the AeroScout product using a Forti WLC and APs. To configure a Forti WLC to work with AeroScout, use the command aeroscout enable, as shown below:

```
default# sh aeroscout
   Aeroscout Parameters

Enable/Disable              : enable
   Aeroscout Engine IP Address : 0.0.0.0
   Aeroscout Engine Port       : 12092

   default#
```

Configure AeroScout Mobile Unit from AeroScout Engine

Follow the steps below to configure an AeroScout Mobile Unit from the AeroScout Engine:

1. Enable Aeroscout on the controller.
2. Open the Aeroscout Engine.
3. Load the Floor Map on the Engine.
4. Add the APs on the Aeroscout Engine.
5. In the Configuration->System Parameters->Access Points, check the “Enable mobile-unit location with access Points” checkbox.
6. To start the Mobile Unit Positioning option on the AeroScout engine, select ‘Start MU positioning’ from the Actions menu.

AeroScout Compounded Report

For better performance, several MU reports can be combined within a fixed pre-defined period in Compounded Reports. Fortinet’s system combines a maximum of 18 MU reports in one Compounded Report. The number of Mobile Unit reports inside the Compounded Report varies as per the Compounded Message Timeout configured on the Aeroscout Integration Tool. The ‘Compounded Message timeout’ is configured on the Aeroscout Integration tool under ‘Set Configuration’.

Dilution Timeout

In certain scenarios, the Mobile Unit traffic may be high, and the time resolution needed for location is much lower than the data rate of most Mobile Units. If every AP starts reporting every Wi-Fi frame to the Aeroscout Engine, it will create unnecessary data overhead on the network, and provide a real-time location in a level much higher than required.

To help the AP dilute messages from each Mobile Unit, the Aeroscout protocol provides the following two parameters:

- Dilution Factor
- Dilution Timeout

Fortinet Mobile Unit reporting supports and implements only Dilution Timeout. The Dilution Timeout allows to set a limitation for the amount of time with no Mobile Unit messages from a specific Mobile Unit.

For Example: If the Dilution Timeout value is set to 60 seconds and, if the AP receives a message from an MU for which it has not reported a message to the AE for more than 60 seconds, the new message will be reported to the AE immediately regardless of the dilution factor and the dilution counter will be initialized. Commands broadcast by an MU (e.g. Probe Requests) are required to be forwarded to the AE regardless of the dilution parameters.

The Dilution Timeout can be configured on the Aeroscout Engine as follows Configuration->system parameters->Access Points->Dilution Time out.

Generic AP Notification

Generic AP notifications are autonomous messages sent to the Aeroscout Integration tool on port 12092 to report the AP connectivity state (AP comes online, offline, Aersocout parameter configuration changes).The Aeroscout Integration tool acknowledges all Generic AP notification messages sent by the controller. For Generic AP Notifications, the IP address of the Aeroscout engine must be configured on the controller.

When AeroScout mode is changed from "enabled" to "disabled", No Generic AP notification is sent. Ensure to use the AP Integration tool with version as 1.0.1.

In the Fortinet solution, Generic AP notifications are sent out from the controller to the Aeroscout Engine during the AP connectivity state change or when aeroscout configurations on the controller undergoes a change. In general a Generic AP notification is used to communicate an IP address change, a "wake up" from reboot, and or any error conditions that need to be communicated to the Aeroscout engine.

Configure AeroScout Integration tool for Receiving the Generic AP Notification

To Configure AeroScout Integration tool for receiving the Generic AP Notification, perform the following steps:

- Enable AeroScout on the controller and configure the ip-address of the AeroScout Integration tool on controller.
- Open the AeroScout Integration Tool and configure the port from the default value 1122' to '12092'.

- In the scenario where the AP's come online and go offline, change the AeroScout Configuration parameter on the controller. The Controller sends a generic AP Notification for all the AP's on the Controller and the AeroScout Integration Tool acknowledges to the controller's notification for each generic AP Notification.

Configuring Link-Layer Discovery Protocol (LLDP)

The Link-Layer Discovery Protocol (LLDP) is a layer-2 neighbor discovery protocol that allows network devices to advertise specific information about themselves to other devices on the network and receive information from them.

LLDP neighbor discovery by both controllers and access points is supported. LLDP-capable devices transmit information in type, length, and value (TLV) messages to neighboring devices. Devices advertise information such as chassis ID, port ID and description, system name and description, system capabilities, and management IP addresses.

This protocol is supported on all FortiWLC controllers and 11ac access points. This feature of FortiWLC facilitates efficient network management by being aware of its neighbors and also locating defunct access points in the network.

The controller and access points advertise information using LLDP periodically to their neighboring switches at a configured interval of time. The controller maintains a database of LLDP information received from its neighboring switches. The access points send LLDP information about the neighboring switch along with its own details to the controller periodically at a configured reporting interval of time. This information from the access points is also stored on the controller database. The Controller persists the stored information in its database for a configured period of time and then discards it.

To enable and configure the LLDP neighbor discovery feature navigate to **Configuration > Devices > LLDP Discovery**.

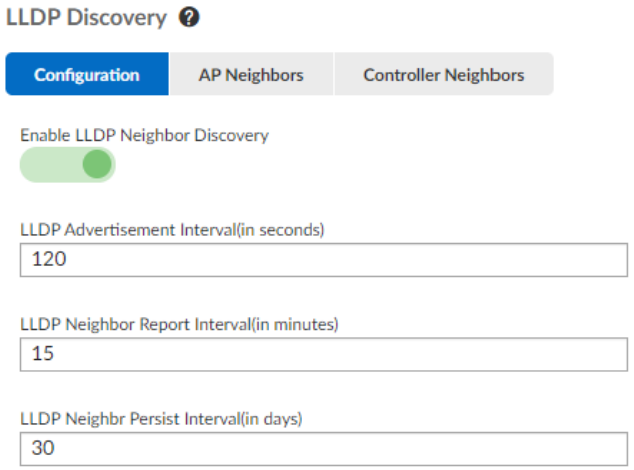
Notes:

- LLDP discovery is supported only on 11ac/11ax APs.
- LLDP discovery is NOT supported on Mesh APs.
- In an N+1 setup, the active slave controller sends/receives LLDP messages from the switch connected to it.
- Prior to enabling LLDP discovery, ensure that LLDP is enabled globally or in each port of the neighboring switches.
- LLDP discovery is not supported for the AP interface where wired station is connected.
- Static power configuration is required for the HP-2920-48G-POE+ switch.

Configuring LLDP

Enable the LLDP neighbour discovery feature to configure the controller and access points to start the neighbour discovery process.

Figure 12: *Configure LLDP discovery*

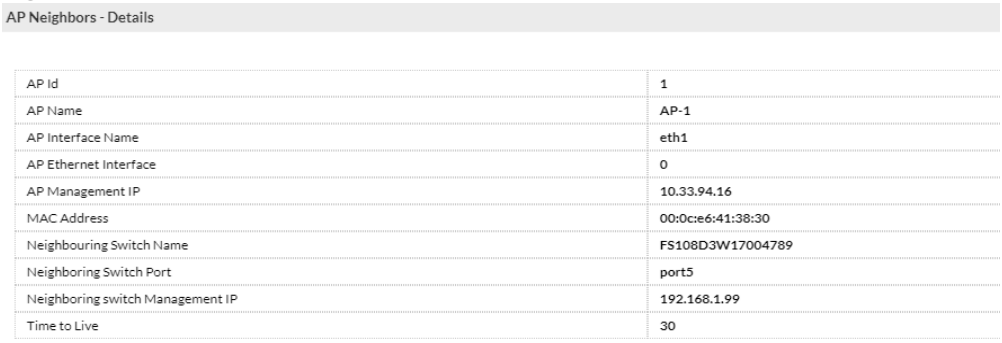


Parameter	Description
LLDP Advertisement Interval(in seconds)	Specifies the frequency at which LLDP (packets) advertisements are sent by the controller and the access points. The valid range is 30-120 seconds. The default value is 120 seconds.
LLDP Neighbor Report Interval(in minutes)	Specifies the frequency at which the access points send information about the neighboring switch to the controllers. The valid range is 10-30 minutes. The default value is 15 minutes.
LLDP Neighbor Persist Interval(in days)	Specifies the number of days the neighbor information is held in the controller database, before it is discarded. The valid range is 30-365 days. The default value is 30 days.

AP Neighbors

Displays the access point information along with their corresponding switch information that is received by the controller.

Figure 13: *Viewing AP neighbor details*



Field	Description
AP Id	The unique numeric identifier of the access point.
AP Name	The name of the access point.
AP Interface Name	The interface name of the access point that receives and sends LLDP packets to the particular switch.
AP Ethernet Interface	The interface ID of the access point that receives and sends LLDP packets to the particular switch.
AP Management IP	The MAC address of the AP.
MAC Address	The MAC address or the serial number of the access point.

Neighboring Switch Name	The neighboring switch with which the access point exchanges LLDP information.
Neighboring Switch Port	The port of the neighboring switch that is connected to the access point.
Neighboring Switch Management IP	The IP address of the management interface of the neighboring switch.
Time to Live	Displays the Time-To-Live of the LLDP packets.

Controller Neighbors

Displays the controller information along with their corresponding switch information.

Figure 14: *Viewing controller neighbor details*

Field	Description
Controller Ethernet Interface	The interface ID of the controller that receives and sends LLDP packets to the particular switch.
Controller Interface Name	The interface name of the controller that receives and sends LLDP packets to the particular switch.
MAC Address	The MAC address of the controller.
Neighboring Switch Name	The neighboring switch with which the controller exchanges LLDP information.
Neighboring Switch Port	The port of the neighboring switch that is connected to the controller.

Neighboring Switch Management IP	The IP address of the management interface of the neighboring switch.
Time to Live	Displays the Time-To-Live of the LLDP packets.

Configuring Jumbo Frames

An Ethernet frame is classified as Jumbo when its size exceeds the standard Maximum Transmission Unit (MTU) of 1500 bytes.

For wireless clients, Jumbo frames are NOT supported; aggregation is supported in the tunnel mode only. Wireless payload is aggregated into jumbo frames to improve the system throughput.

For wireless clients, Jumbo frames are NOT supported; aggregation is supported in the tunnel mode only. Wireless payload is aggregated into jumbo frames to improve the system throughput.

Note: The jumbo frames configuration applies to packets between the AP and controller only.

Field	Description
Enable Jumbo Frames	Select to configure the MTU for Jumbo frames.
Jumbo frames MTU	The MTU configures the largest size of the Ethernet frame (in bytes) that a network can transmit. Any packet larger than the configured MTU is fragmented into smaller packets for transmission. The valid range is 1500 - 9000 bytes; default is 4500 bytes for controller.

You can configure and manage Jumbo frames on the controller using the *jumbo enable/disable*, *jumbo mtu*, and *show jumbo-frames* commands. For more information see the *FortiWLC CLI Reference Guide*.

See *"Add and Configure an AP with the Web UI" on page 355.* to configure Jumbo frames for APs.

Configuring FortiPresence API

The FortiPresence API extends the wireless retail analytics solution to retailers who can use data from the analytics report to understand customer behavior, for example when they arrive, length of stay or come into the store, how long they stay, and if they are a new or repeat customer.

Supported only on 802.11ac APs.

HTTPS is supported for FortiPresence social WiFi redirection by FortiWLC.

How it Works

When the location server feature is enabled on the controller, all 11ac APs send STA reports of STA/AP in their discovered list and STA in the assigned list at configured time intervals.

The controller forwards the STA reports to the data analytics server which then analyses the data and provides user-friendly information to the user.

Configuring the Controller

The location-server feature can be enabled on the controller using the following commands. There are two report formats - Legacy and FortiPresence. The standard FortiPresence feed should be used by 3rd party partners. The information needed below can be obtained when you purchase a FortiPresence license for this feature.

1. Specify the location **server IP address**.

   (config)# location-server ip-address 1.1.1.1
2. Specify the **location server port**. The port is the port used for communication between the controller and the location server

   (config)# location-server port 300
3. Specify the **project name**. The project-name indicates to which customer project the packets belong. Maximum of 16 ASCII characters can be used

   (config)# location-server project-name FortiStore
4. Specify password. The **secret** (password) is a shared secret to sign each packet to in order to validate its authenticity and integrity. Maximum of 16 ASCII characters can be used.

   (config)# location-server secret fortisecret
5. Specify the **report format**. The standard FortiPresence feed should be used. Maximum of 16 ASCII characters can be used

   (config)# location-server report-format forti-presence
6. Specify **report interval** at which the reports are queried. The Location Report Interval (in Seconds). The default is 5 seconds.

   (config)# location-server report interval 30

We recommend that you set the interval time to 30 seconds

7. Specify the l**ocation server source**.

   (config)# location-server source wifi

   To view the configured details, use the show location- server command.

```
#show location-server

Location Server Configuration

ReportFormat                          : forti-presence

Project Name                          : FortiStore

Enable/Disable Location Server        : enable
```

```
Secret                                : *****
Location Server Source                : wifi
Location Server IP Address            : 1.1.1.1
Location Server Port                  : 300
Location Report Interval (in Seconds) : 30
```

The output indicates that all APs should send station-locate reports every 30 seconds and the controller forwards it to the server 1:1:1:1 configured on UDP port 300

8. Enable **Apply to ALL APs** to apply the configured location service to all APs. When disabled, you can select specific **AP Groups** and **Access Points** to apply the location service.

The update frequency specifies the frequency at which the updates are sent for a client and is measured in seconds. The default is 5 seconds.The client devices will be spread out across the 5 seconds based on MAC address. There will be an update every 5 seconds for each client. Increasing the frequency can have a negative impact on location data in congested wireless networks.

The traffic will be sent as UDP

FortiWLC (SD) Communication Ports

The tunnel between an AP and a controller uses the following ports for communication.

Traffic	Port
AeroScout	UDP/6091
Captive Portal (http redirection)	TCP/8080
Captive Portal (https redirection)	TCP/8081
NM Location Manager - Web UI	TCP/443
NM Location Manager - Administrative Web UI (SSL)	TCP/8003
NM Location Manager - AP Communication (Capture Packets subsystem)	UDP/9177and UDP/37008
FTP	TCP/20 and TCP/21
H.323v1 flow detection.	TCP/1720
HTTP	TCP/8080
HTTPS	TCP/443

Traffic	Port
Fortinet L3 AP COMM	UDP/5000
Licensing - for connections initiated from within the controller only for licensing purposes (e.g. wncagent -> merud)	TCP/32780
Fortinet L3 AP Data	UDP/9393
Fortinet L3 AP Discovery/Keepalive	UDP/9292
NP1 advertisements / config	UDP/9980
NTP	UDP/123
RADIUS accounting	1813 / 1646
RADIUS auth	1812 / 1645
SIP	UDP/TCP 5060
SSH	TCP/22
SNMP	UDP/161 and 162
Syslog	UDP/514
TFTP	UDP/69
UDP broadcast up to 5 upstream/downstream configurable	UPD/xxx
TACACS+	TCP/49
Telnet	TCP/23
Controller packet capture	UDP/9177
WIPS	UDP/9178
WireShark, OmniPeek, Newbury	UDP/9177
SAM (AP and server)	EtherIP 97

Feature Group

Feature group makes it easier to deploy and manage configuration for large number of APs. Traditionally, you could apply a configuration to an AP or an AP group. Using feature groups, you can instantly apply a ESS Profile, DPI Policies, Port Profile, ARRP, and Radio Interfaces to one or more APs or AP Groups. You can create a maximum of 10 feature groups.

In a deployment of 300 and more APs, it is recommended to configure *Feature Group* in FortiWLC or *AP Groups* in FortiWLM. Do not run ARRP globally (on all APs) in such a deployment as it is memory and processor intensive.

The default page, lists available feature groups with the following details about each of the feature groups:

- Feature Group ID: A unique number associated with the feature group.
- Feature Group Name: Name of the feature group.
- Feature Group Description: Descriptive text about the feature group.

- Default Feature Group: Specifies if a feature group is set as default. If set as default, all APs that join the controller will be associated with this feature group. You can have only one default group.

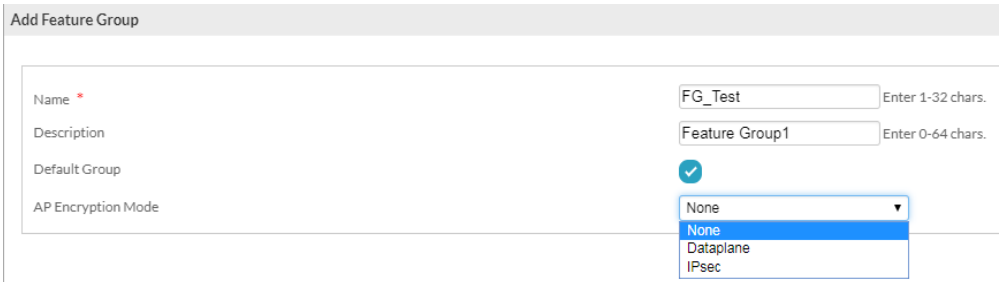
NOTE: If you have a default AP group, then this takes precedence and all APs that join the controller will be associate with the default AP group.

Creating a Feature Group

Navigate to *Configuration* > *Quick Start* > *Feature Group* and click the **Add** button and specify name (special characters and spaces cannot be used), description and also select if this group is the default feature group. Click **OK** to complete this step.

Select the **AP Encryption Mode**. The following are the supported encryption modes:

- **None**: This is the default option selected for the access point. No encryption is applied.
- **Dataplane**: This mode enables encryption only for the data path. DTLS is used to encrypt the data traffic.
- **IPsec**: This mode enables encryption of all traffic between the AP and controller (both the control and data path).



The IPsec encryption mode can be applied while adding the access points as well. If the access point being added to the feature group has a different encryption mode then, by default, it is modified to the encryption mode configured for the feature group.

After the feature group name is selected, you can now add configurations to this group. These configurations can be instantly applied to one or more APs.

- APs - Select this option to add AP Groups and individual APs to this feature group.
- ARRP - ARRP profiles are local to the group. Select this option to add ARRP configurations. For more information, See *"Automatic Radio Resource Provisioning (ARRP)" on page 384.*
- Radio - Select this option to specify the radio interface and its antenna settings.
- ESS - Select this option to select and associate ESS profiles at the interface level.
- Port Profiles - Select port profile to associate at the interface level.

- DPI - Create DPI policies for this feature group. Each feature group can contain a maximum of 25 DPI policies. DPI policies are local to group but this must be enabled at Configuration > Access Control > Application > Settings (tab)

Other options include, deleting and cloning a feature group.

Cloning a Feature Group

To clone a feature group, select the feature group and click the CLONE button. Specify a new name and description for this cloned feature group. The cloned feature group will not carry the list of mapped APs, AP groups, and DPI policies.

AP Groups

Create AP groups with list of APs associated in this controller. The AP groups can be mapped to feature groups to easily deploy configurations to the associated APs.

You can create a maximum 128 AP groups. The maximum number APs in an AP group is same as the maximum supported by the controller. An AP can be part of only one AP group or one feature group at any pont of time.

The default page, lists available AP groups with the following details about each of the AP groups:

- AP Group ID: A unique number associated with the AP group.
- AP Group Name: Name of the AP group.
- Description: Descriptive text about the AP group.
- Default AP Group: Specifies if an AP group is set as default. If set as default, all APs that join the controller will be associated with this AP group. You can have only one default group.

NOTE: The default AP group takes precedence even if you have a default feature group.

Creating an AP Group

Click the Add button and specify name (special characters and spaces cannot be used), description and also select if this group is the default AP group. Click OK to complete this step.

Configuring the Controller-Based DHCP Server

In FortiWLC (SD) release 5.1 and later, users have the ability to configure a DHCP server that can be operated directly from the controller. This configuration is ideal for relatively small deployments that do not require a separate server to handle DHCP duties. This can be particularly useful for deployments that require a DHCP sever for a separate VLAN (such as one

used for a guest network) but also would prefer not to allow that traffic to impact the corporate DHCP server.

The internal DHCP server does not support using Option 43 for multiple subnets. Use an external DHCP sever that supports Option 43 for multiple subnets.

The controller-based DHCP server requires that the DHCP Relay Passthrough option (in the Global Controller Parameters) be set to On for the controller. To verify or adjust this, access the WebUI and navigate to Configuration > Devices > Controller.

It is recommended not to use internal DHCP server/DHCP relay in production and scale deployments.

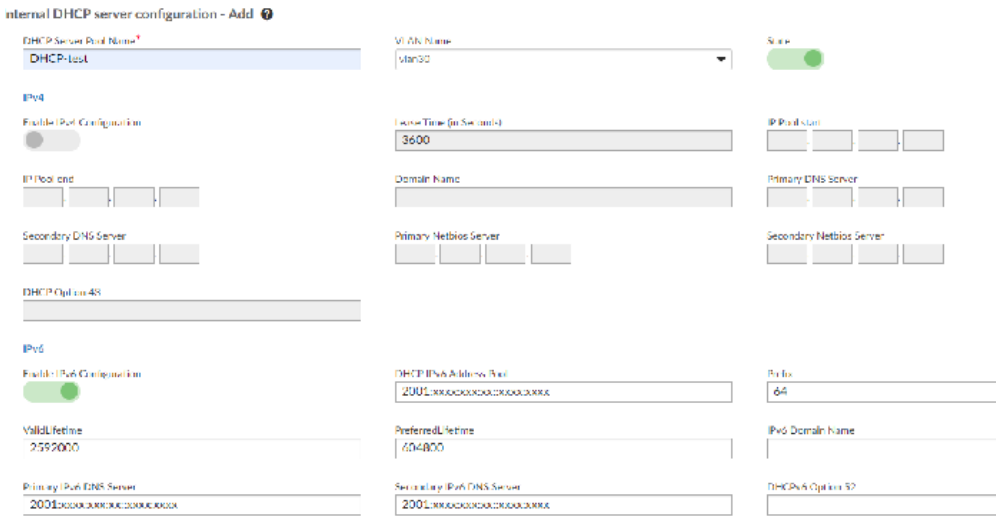
Creating a DHCP Server

The controller can have multiple different DHCP servers configured on it at any given time. A DHCP server can be associated to only one VLAN. The steps below can be repeated in order to configure different DHCP servers for separate VLANs or Virtual Interface Profiles as needed.

To create a DHCP Server:

1. From the WebUI, navigate to Configuration > Wired > DHCP and click the DHCP Server tab to view the current configured DHCP servers. Note that if no servers have been configured, the page will be blank.
2. Click Add to begin configuring the DHCP server parameters.

Figure 15: *DHCP Server Configuration*



3. Provide the necessary information as described in **Table 6**.

TABLE 6: *DHCP Options*

Option	Description
DHCP Server Pool Name	Enter a name to be ascribed to the DHCP Server.
VLAN Name	This drop-down list allows you to select a VLAN to which the server should be applied. Note that this is only available if the controller is operating in Layer 2 routing mode.
State	Set to Enabled in order to activate the DHCP server, Disabled to deactivate it.
Lease Time	The duration of IP leases that are assigned by the DHCP server. This value is displayed in seconds.
IP Pool Start/End	The start and end IP addresses of the IP pool that may be assigned by the DHCP server.
Domain Name/IPv6 Domain Name	The IPv4/IPv6 domain on which the DHCP server will be active.
Primary DNS Server/ Primary IPv6 DNS Server	The primary IPv4/IP6 DNS servers to be used by the DHCP server.
Secondary DNS Server/Secondary IPv6 DNS Server	The secondary IPv4/IP6 DNS servers to be used by the DHCP server.
Primary/Secondary Netbios Server	The primary and secondary Netbios servers to be used by the DHCP server.
DHCP Option 43	Option 43 allows you to manually specify the primary and secondary controllers to be used by the server. Enter the primary and secondary controller IP addresses (separated by a comma) in this field.
Enable IPv6 Configuration	Can be set to Enabled or Disabled--this option specifies whether the DHCP server is active.
DHCP IPv6 Address Pool	The IPv6 addresses that the DHCP server assigns.
DHCPv6 Option 52	Configure Option 52 on the DHCP server in an IPv6 deployment.

Option	Description
PreferredLifetime	The duration that a valid IP address is in the preferred state and can be used without any constraints. When the preferred-lifetime expires, the address is deprecated. The default is 604800 seconds.
ValidLifetime	The duration that an IP address remains in the valid state and can be used for new or existing communications. When the valid-lifetime expires, the address becomes invalid and can no longer be used. **Note**: The value of **PreferredLifetime** must be less than the **Valid-Lifetime** when configured together.

4. Click OK to save the server.

Viewing DHCP Leases

After the DHCP server has been configured and is active, it can begin providing IP addresses to clients. These assignments will appear in the DHCP Lease table. To view it, open the WebUI and navigate to Configuration >Wired > DHCP. The DHCP Lease table appears automatically.

Using Fortinet Service Control

Fortinet's Service Control feature is designed to allow clients in the enterprise network to access and communicate with devices that are advertising service via a protocol such as Bonjour. The limitation for Bonjour-enabled devices is that they were largely designed for small-scale use; however, they are growing increasingly prevalent in the enterprise-level environment. The nature of the service makes scaling for larger deployments challenging because the wireless traffic communications for these protocols cannot travel across various subnets; as such, users on VLAN1 will be unable to access a device operating on VLAN2 (for example).

Service Control addresses this problem by providing a framework by which Fortinet will direct traffic from clients on different subnets over to the Bonjour-capable devices (and vice versa), allowing seamless communication between the two. Additionally, users can specify which services should be available to specific users, SSIDs, or VLANs, allowing a fine control to be exercised over the deployment.

To enable Service Control:

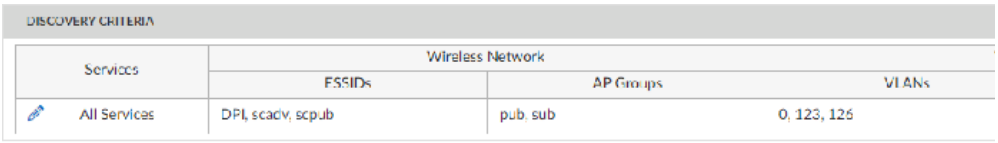
1. Navigate to Configuration > Service Control. By default, you land on the Service Control Dashboard, which currently displays no information (as the service is disabled).
2. Click the Settings tab to access the Global Settings tab
3. Check Enable Service Control. The page will automatically refresh.

Refer to the sections below for configuration instructions.

Modifying Service Control Global Configuration

Once Service Control has been enabled, the Settings tab displays two new tables: Discovery Criteria and Advanced Options. The Discovery Criteria allows the user to specify the types of services that may be discovered. By default, all AirPlay and AirPrint services configured in the system will be set for discovery across all SSIDs and APs and on Controller native VLAN by controller on the wired side. To modify this, click the pencil icon under the Services column to access the Discovery Criteria dialog.

Figure 16: *Discovery Criteria*



1. As shown above, the All Services box is checked, ensuring that all configured services will automatically be detected by the system. Uncheck this box and select the desired service(s) if you wish to restrict the types of services provided.
2. The Select Wireless Network section allows the user to customize which SSIDs/APs can access the services; by default, all of them are permitted. These options control how wireless devices access the services provided.
3. The Select Wired Network section controls how wired devices access the services; enter the VLAN(s) that should be allowed access. To add wired gateways, click the Add button and specify the desired options from the resulting list of devices.
4. Click Save to save your changes.

Wired Service Discovery using AP and Controller

Follow these steps for the wired service discovery using AP and Controller:

1. The APs and Controller wired interface is used for discovering services. Add APs and/or Controller to wired gateway list.
2. Ensure that the APs or Controller wired interface is tagged with VLAN on which services needs to be discovered and also the VLAN should be added to VLAN list.

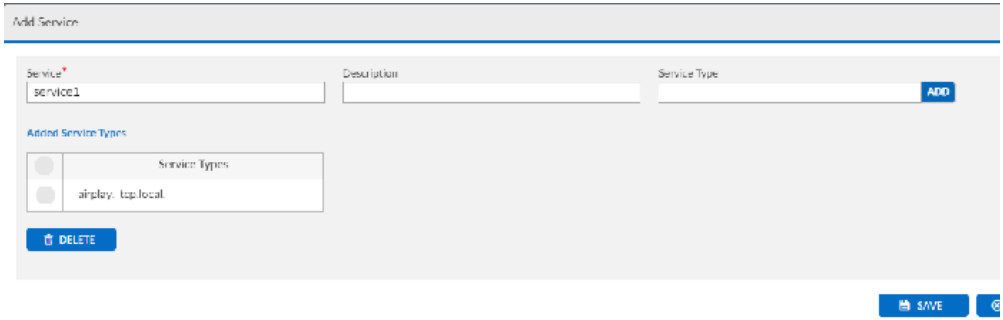
For Controller to detect services on a tagged VLAN (say VLAN XX), Controller should have a VLAN profile VLAN XX (configured VLAN). Creation of VLAN profile on the controller is not required when AP's wired interface is used for discovering services on a particular VLAN.

For AP and Controller to detect services on it own native VLAN, the VLAN list has to be updated with VLAN 0.

Adding or Removing Services

The Services tab allows the user to modify the services that may be detected via Service Control; by default, several services are pre-configured in the system. However, users can expand this list by clicking the Add button to create a new service.

Figure 17: *Adding a New Service*



Fill in the required fields as described below:

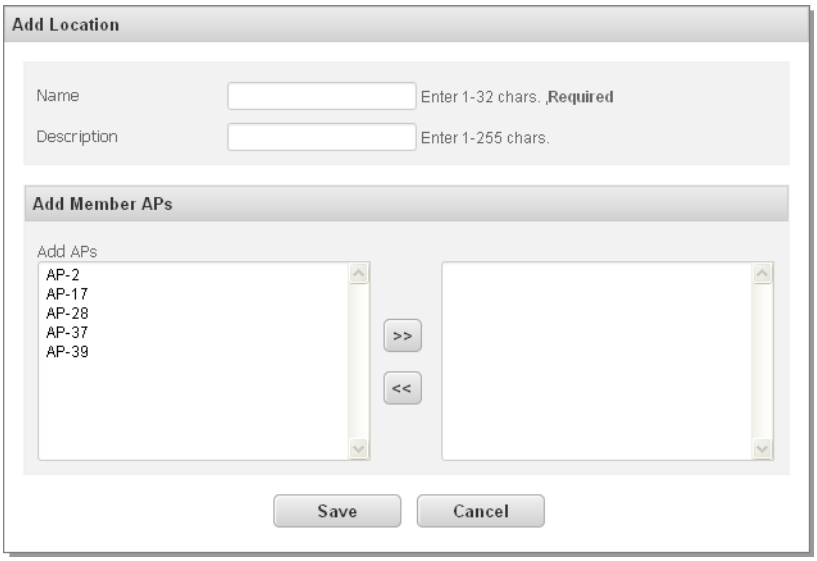
- Name—Enter a name for the service
- Description—Enter a brief description
- Service Type—Enter the service type string(s). If multiple entries are needed, enter them one at a time, clicking Add after each one. They will display in the Added Service Types table.
  Note: To remove an added service, check the box alongside it and click Delete.

Click Save to save the new service.

Configuring Locations

The Locations tab allows you to specify locations where services should be discovered and advertised; by default, no locations are configured, so click Add to create one.

Figure 18: *Adding a Location*



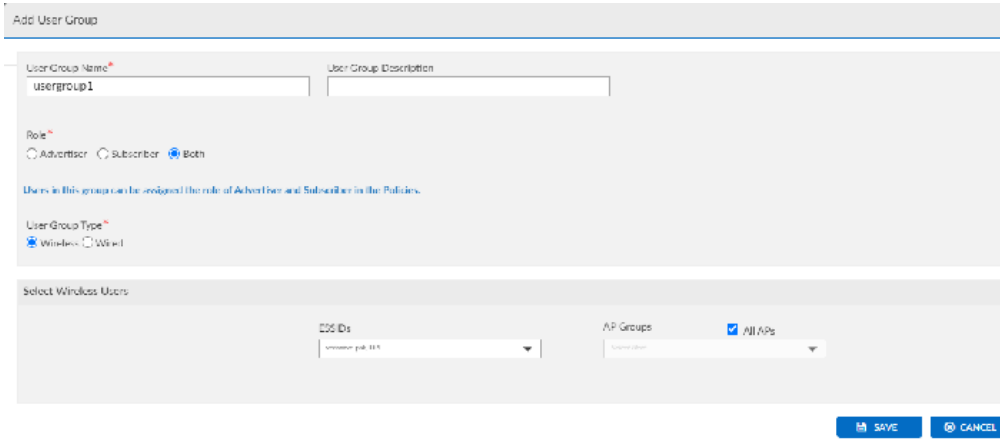
A Location consists of three main components: the location's name, description, and member APs. Enter the Name and Description in the fields provided, then select the AP(s) that belong to the desired location from the list. Click the button pointing to the right to add the selected AP(s) to the new location.

After clicking Save, the new location will appear in the Location Table. The AP(s) specified in the Location definition will now provide access to the service.

Creating User Groups

User Groups segregates Subscriber and Advertisers under a group. User Groups define which users/Advertisers (grouped by either VLAN for wired clients or SSID and Location for wireless) can access the advertised service or advertise the services. As no groups are present by default, click Add to create one.

Figure 19: *Creating a User Group*



A User Group consists of four main components: the group's name, description, Role, and wireless/wired users with wired gateway list. These fields will allow you to customize which users can access the defined services.

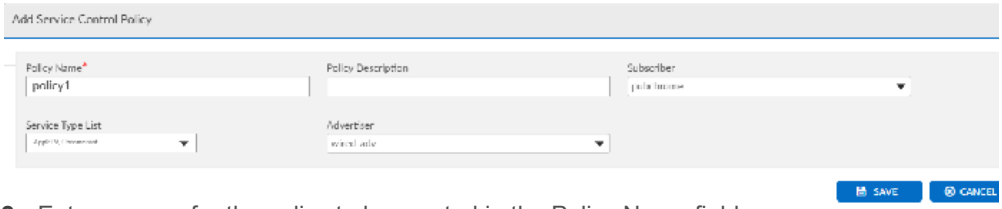
1. Enter the Name and Description in the fields provided.
2. Select one of the Role for the user group. The options are Advertiser, Subscriber, or Both.
3. Select the User Group Type. The options are Wireless or Wired.
4. If you have selected Wireless user group type, then Select Wireless Section is displayed. From the Select Wireless Users section, select the SSIDs that should be allowed access. To select multiple options, click and drag across them. Ctrl+click to select or de-select items individually.
5. If you have selected Wired user group type, then the Select Wired Users section is displayed. Enter the VLAN(s) that should be allowed to access advertised services.
6. Click Save to create the group. The devices contained within the group's parameters will now be able to access the advertised services.

Defining Service Control Policies

Service Control policies determine which user groups can access specific advertised services. Thus, the policies table allows you to define routes between the subscriber (i.e., the device that seeks the service) and the advertiser (i.e., the device that provides access to the service).

1. From the Policies tab, click Add to access the Create Service Control Policy window.

Figure 20: *Creating a Policy*



2. Enter a name for the policy to be created in the Policy Name field.
3. Enter the description of the policy.
4. Use the Select Subscriber drop-down to specify the group that should be granted access.
5. Select the desired services from the list supplied in the Choose Services section. Note that if all services should be included, simply check the All services box.
6. Finally, use the Select Advertiser drop-down to select the group that supplies access to the services.
7. Click Save to save the new policy.

IPv6 Client Support

FortiWLC supports IPv6 for both wireless and wired clients connected to Fortinet access points (APs). IPv4, dual stack (IPv4+IPv6), and native IPv6 clients co-exist in the network. FortiWLC is accessible over the SSH/telnet/SNMP from IPv6 addresses; the GUI can be accessed over the IPv6 address of the controller. To access the GUI over IPv6, enter the URL in the format*: https://[IPv6_address_of_WLC]* in the browser, for example, *https://[2001:470:ecfb:45c:428d:5cff:fe5e:c588].* The GUI can be accessed over the HTTPS protocol.

The access point can discover the controller over an IPv6 address.

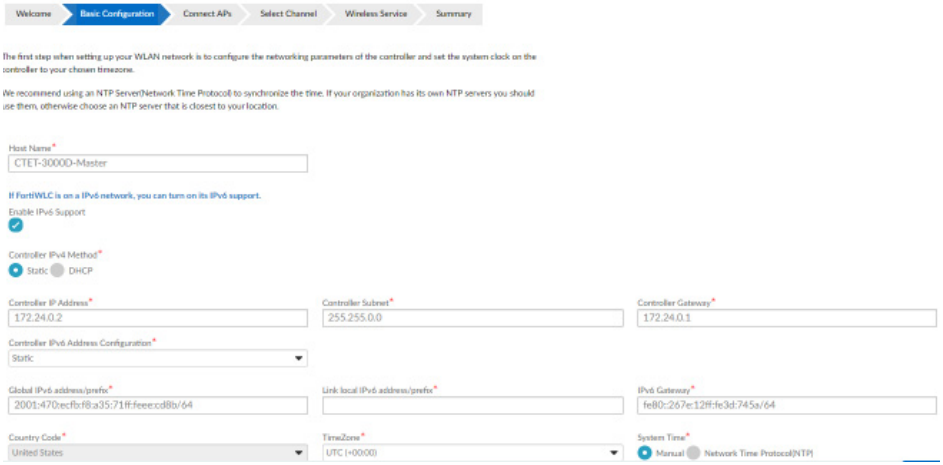
The ND proxy feature provides support for proxying the IPv6 ND protocol to allow the forwarding of ICMP messages between upstream and downstream interfaces.

ND proxy uses ICMPv6 messages such as Neighbor Solicitation (NS) and Neighbor Advertisement (NA). The ND proxy enabled interface unicasts an NS message on behalf of a host to a wireless client. The interface modifies the packet to include the wireless client MAC address only; the wireless client responds with a unicast NA message to that host.

The implementation of ND proxy is based on RFC 4389.

FortiWLC supports a maximum of 8 IPv6 addresses per client. The *show controller, show station ipv6,* or *show ip6* command on the console can be used to determine the IPv6 addresses of the controller. The *show station multiple-ip* command can be used to determine the IPv6 addresses of stations. All possible combinations of controller IPv6 address configuration are achieved using the *setup* command or using the GUI - *Wizards* > *EzSetup*.

Fortinet recommends that the infrastructure should have RA packets with prefix information support.



The following modes of IPv6 address acquisition methods are supported.

- **Static** – You can statically configure one link local and one non link local (site local, unique local or global) scope address which persists across reboots. If you configure a static non-link-local address then DHCPv6 based address acquisition is disabled.
- **DHCP** – You can configure the controller to acquire an IPv6 address based on stateless or statefull DHCPv6. Stateless DHCPv6 address acquisition is based on SLAAC.
- **Auto-config** - The FortiWLC IPv6 address acquisition is based on the flags set in the router advertisement.
- **None** – FortiWLC automatically acquires an IPV6 address using SLAAC based acquisition, always works in addition to the above existing methods.

The IPv6 client support provides the following:

- *"Basic IPv6 Forwarding"* ***on page 96***
- *"IPv6 forwarding in dynamic VLAN deployment"* ***on page 96***
- *"High Performance IPv6 Forwarding"* ***on page 97***
- *"IPv6 Security"* ***on page 98***
- *"IPv6 Multicast Optimization"* ***on page 98***
- *"IPv6 Prioritization"* ***on page 98***
- *"IPv6 Network Management Enhancements"* ***on page 98***
- *"IPv6 Configurations"* ***on page 98***

Basic IPv6 Forwarding

FortiWLC (SD) acts as an L2 switch for IPv6 clients connected in the tunnel and bridge mode. The IPv6 specification (RFC 8200) defines IPv6 router and IPv6 host subclasses of IPv6 modes. The controllers and the APs act as IPv6 hosts which forward the IPv6 packets at layer 2 and not as IPv6 router. The ESS profile supports IPv4, Dual Stack (IPv4 and IPv6) and IPv6-only clients simultaneously. The following modes of IPv6 address configuration for clients are supported:

- Stateless Address Auto Configuration (SLAAC)
- DHCPv6
- Static IPv6 Configuration (Manual)
- Link local address

The VLAN profile for wireless clients will use IPv4 address and does not require IPv6. The Allow Multicast Flag option in ESS is used to allow or block multicast traffic in ESS. If this is set to Off, then all IPv6 multicast traffic is blocked except for the Router Advertisements, Router Solicitations, Neighbor Solicitations, Neighbor Discovery Messages and DHCPv6 packets.

You can configure the Bridging, Allow Multicast, and Multi-To-Unicast field in the ESS profile configuration. See the chapter “Configuring an ESS.” for more details.

For the wired networks connected to the AP, configure the Allow Multicast and IPv6 bridging in Port profile, see *“Configuring Port Profiles”* ***on page 212*** for more details.

The Neighbor Discovery Optimization field of IPv6 parameter can be configured via Configuration > Devices > Controller > IPv6 Parameter.

The IPv6 related CLI commands are as follows:

- show station - this command displays the IP address type in a new column IP Mode. The valid values for this column are IPv4, IPv6, and IPv4v6.
- sh station multiple-ip - this command displays one row for each IPv4 address and one row for each IPv6 address of the station. The IPv6 address type column is added which displays one of the following values if the address is a IPv6 address – Global Unicast, Global Unicast DHCP, Link Local, Temporary.

See the Fortinet Command Reference Guide for more information on the CLI commands.

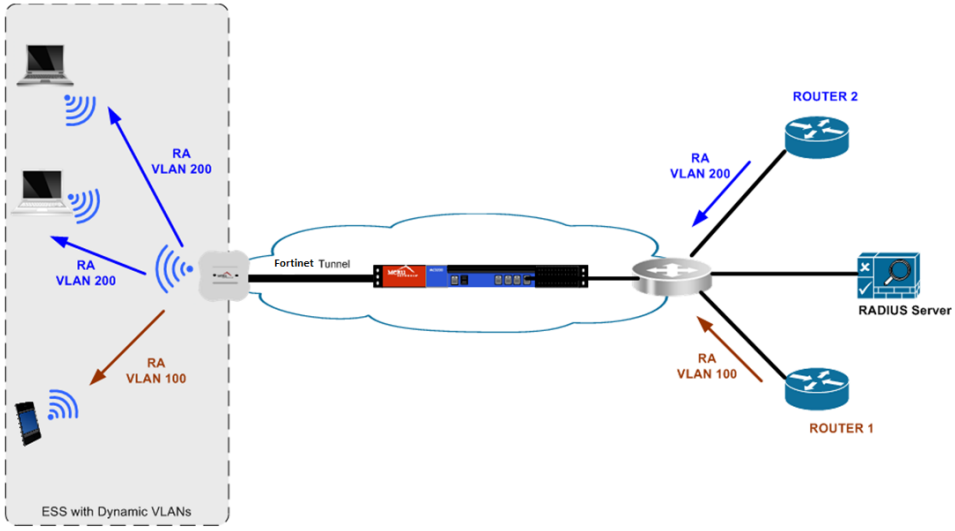
IPv6 forwarding in dynamic VLAN deployment

In the previous releases of FortiWLC (SD), for dynamic VLAN (multiple VLANs in one ESS) deployment, FortiWLC (SD) forwards multicast packets to all stations irrespective of their assigned VLAN. This was supported for IPv4 in the previous release and in FortiWLC (SD)

6.0-2-0 onwards, IPv6 is supported. Router advertisements are multicast messages that provide the router prefix information used by IPv6 stations to auto-configure their IPv6 address.

The following diagram explains the router advertisement filtering behavior:

Figure 21: *Router Advertisement Filtering*



Three wireless stations are connected to an ESS profile configured with RADIUS assigned VLANs. Two stations belong to VLAN 200 and one belongs to VLAN100. Router advertisement by the router in VLAN 100 is not sent to stations assigned to VLAN 200.

When an AP forwards router advertisements on an ESS profile configured for dynamic VLAN, RAs for one VLAN is not sent to stations in other VLANs. They are converted to unicast packets and sent only to wireless stations which are assigned to that particular VLAN. This behavior is supported for all RF virtualization modes and overrides the multicast-unicast conversion settings.

The Multicast-To-Unicast field has to be set to Only Router Advertisement (Perform Conversion only for RAs) in the ESS profile for the conversion to take place. This will ensure that the APs Multicast-To-Unicast conversion happens for RA packets to send it to only those stations which belong to that VLAN ID.

High Performance IPv6 Forwarding

FastPath feature is supported for IPv6 clients in tunnel mode. This feature is used for increasing the throughput of the controller only for UDP and TCP data flow for IPv4 and IPv6. If the FastPath field for the controller is On, then the throughput increases.

IPv6 Security

The IPv6 security is designed to secure IPv6 link operation and they are applied to both tunnel and bridge modes. The IPv6 security is supported by the following filtering methods:

- RA Guard –This is supported to block or reject the RA guard messages that arrive at the network device platform.
- DHCPv6 Guard - This is supported to block DHCP reply and advertisement messages that originate from unauthorized DHCP servers and relay agents that forward DHCP packets from servers to clients.

IPv6 Multicast Optimization

The IPv6 multicast optimization reduces the multicast traffic generated by neighbor discovery and router advertisements. This support is provided only in the tunnel mode.

IPv6 Prioritization

The IPv6 QoS support is provided by prioritizing IPv6 packets based on the traffic class field in the IPv6 header.

IPv6 Network Management Enhancements

The IPv6 client support feature provides the NMS enhancement to store multiple IPv6 addresses. The controller supports maximum of 8 addresses per client which includes:

- Global unicast addresses (DHCP and Autoconfigured)
- Link-local address
- Temporary address

IPv6 Configurations

FortiWLC supports configuring IPv6 for the following profiles/features.

Configuring a RADIUS server - When creating a RADIUS security profile, navigate to **Configuration > Security > RADIUS**, the RADIUS server IP address can be IPv4/IPv6.

Configuring Captive Portal - When configuring an external Captive Portal profile, navigate to **Configuration > Security > Captive Portal,** an IPv6 address is supported for the controller. When configuring custom Captive Portals, navigate to **Maintenance > Custom CP,** IPv6 subnets for custom captive portal are supported.

Also, the external captive portal URL now supports IPv6, for example, *https://[2001:470:ecfb:457:20c:29ff:fe3f:beff]/portal/2001:470:ecfb:45a::123fortiInitialRedirect*

Configuring an ESS profile - When configuring an ESS profile, navigate to **Configuration > Wireless > ESS**, enabling IPv6 forwarding allows ICMPv6, DHCPv6, and other IPv6 traffic to be passed through the controller in tunnel mode. If disabled, all the IPv6 packets coming into the controller are dropped. IPv6 Forwarding is disabled by default; however, on upgrade the older (pre-upgrade) configuration is retained, whether enabled or disabled.

Configuring VLAN - Navigate to **Configuration > Wired > VLAN**, the VLAN interfaces created on the controller acquire IPv6 addresses from router advertisements only.

Configuring Port - When creating port profiles, navigate to **Configuration > Wired > Port**, enabling **IPv6 forwarding** allows ICMPv6, DHCPv6, and other IPv6 traffic to be passed through the controller in tunnel mode. If disabled, all the IPv6 packets coming into the controller are dropped. IPv6 Forwarding is disabled by default; however, on upgrade the older (pre-upgrade) configuration is retained, whether enabled or disabled.

Configuring SNMP - When configuring SNMP profiles, navigate t **Configuration > Wired > SNMP**, the SNMP trap server and SNMP community client IP can be configured with IPv6 addresses.

Configuring QoS profiles - When adding firewall rules in a QoS policy, navigate to **Configuration > Policies > QoS,** IPv6 addresses can be configured for the destination and source of the QoS rule; the source and destination netmasks can be in the dotted quad format for IPv4 or in the prefix length notation for IPv6.

Configuring System Settings - When configuring the management interfaces for controller, navigate to **Configuration > Devices > System settings**, the management interface IP address assignment allows configuration of static IPv6 address (global or link local scope), DHCPv6, or auto-configuration.

Configuring User Management - When configuring access control for RADIUS and TACACS+ authentication, navigate to **Configuration > Access control > User management**, the RADIUS and TACACS+ servers can be configured with IPv6 addresses.

Configuring AP Connectivity - When configuring AP connectivity, navigate to **Configuration > Devices > APs > Connectivity** and configure the IPv6 parameters.

Configuring DHCP Server - When configuring the DHCP server, navigate to **Configuration > Wired >DHCP** and enable IPv6 configuration and set the IPv6 parameters for the DHCP server.

Configuring Controller - When configuring the global controller parameters, navigate to **Configuration > Devices > Global Controller Parameters** and configure the DHCPv6 server.

Management Interface - When configuring the management interface of the AP, navigate to **Configuration > Devices > System Settings > Management Interface** and configure an IPv6 address.

Usage Recommendations

Note the following with respect to IPv6 discovery.

- Use only one prefix in RA advertisements.
- When using DHCP, the prefix lifetime should be high to avoid IP changes.
- The DHCP and default gateway must be the same in a pure IPv6 environment.
- Use a prefix-based/stateless configuration when FortiGate is used as the IPv6 DHCP server for APs.
- IPv6, Override Default DHCP Server Flag, and DHCP IPv6 Relay Pass-Through should be enabled on the VLAN interface for IPv6 bridging (pass-through) to work.
- Enable neighbor discovery optimization (Configuration > Devices > Controller > IPv6 Parameters).

Accessing Spectrum Manager

FortiWLC (SD) versions 6.0-2-0 and later provide the ability to configure deployed APs in spectrum scanning mode, acting as a software-based spectrum monitoring device. This configuration is performed via the Configuration > Wireless > Radio table. To configure an AP for spectrum scanning mode, click the desired interface from the table and use the AP Mode drop-down to specify ScanSpectrum Mode.

The Spectrum Manager is supported on both 32-bit and 64-bit controllers.

Fortinet wireless access points use different Broadcom software for Spectrum Analyzer.

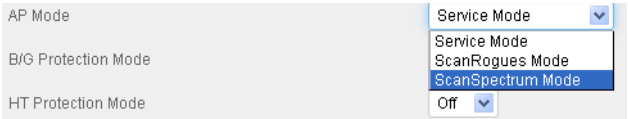
- The legacy access points such as AP832e/i and AP822V1 use the Broadcom Bandspeed software. On these access points, the channels allowed by the regulatory domain in specific countries and regions (based on the country code set on the controller) are taken as input for spectrum scanning.
- The universal access points, that is, the FAP-Us use the Broadcom AirIQ software. These access points scan all the channels (2.4 on Radio1 and 5Ghz on Radio2) irrespective of the regulatory domain channels mentioned for specific countries and regions.

Use the following CLI commands to verify the channels that are allowed in specific countries and regions.

- *#sh regulatory-domain allowed-channels*

- *#sh regulatory-domain channels-for-channel-width*
- *#sh regulatory-domain 2.4GHz-channel-band <regulatory-ap-type>*
- *# sh regulatory-domain 5GHz-channel-band <regulatory-ap-type>*

Figure 22: *AP Mode Options*



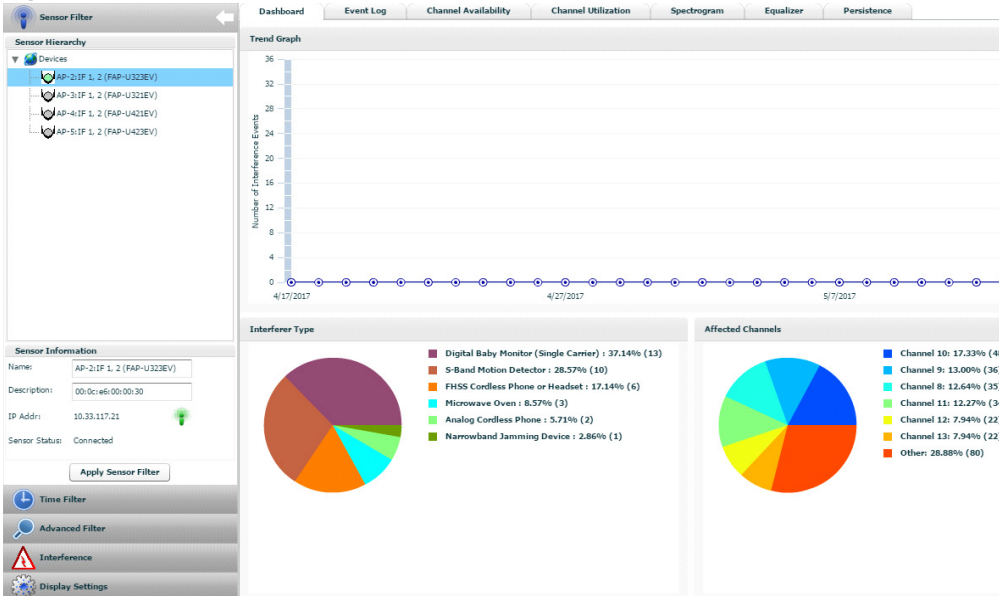
When operating in ScanSpectrum Mode, the selected interface will be unable to service clients as normal.

Once the desired AP(s) are configured, the user can access the Spectrum Manager console via Monitor > Spectrum Manager > Console.

Spectrum Manager Dashboard

The *Spectrum Manager Dashboard* screen presents the interference information gathered from various *"Sensors"* ***on page 127*** (*"Software Sensors"* ***on page 127*** and *"Hardware Sensors"* ***on page 128***). It provides a graphical representation of the Interference devices activity in the 2.4Ghz and 5Ghz spectrum.
Figure 23 on ***page 102*** illustrates the *Spectrum Manager Dashboard* screen.

Figure 23: *Spectrum Manager Dashboard*



The following table depicts the various sections displayed on the *Dashboard* screen.

Trend Graph	The *Trend Graph* plots the number of interference events observed over a period of time.
Interferer Type	The *Interferer Type Graph* is a pie chart divided by the different types of interferer observed in the set duration. The area of each sector is proportional to the percentage of the number of individual interference events from a particular type of interferer against the total number of interference events in the set duration.
Affected Channels	The *Affected Channels* Graph is a pie chart that plots the number of times, a particular channel was impacted due to an interference events. The area of each sector is proportional to the percentage of the number of events that impacted a particular channel against the total number of events. **Note**: An interference event impacts multiple channels simultaneously.

The *Dashboard* screen provides various expandable control panels to filter database and modify display settings. For further information, refer to *"Control Panels"* ***on page 117*** topic.

The *Dashboard* screen allows you to connect to the following other tabs:

1. *"Event Log"* ***on page 103***

2. *"Spectrum Manager - Channel Availability"* ***on page 105***
3. *"Spectrum Manager - Channel Utilization"* ***on page 106***
4. *"Spectrum Manager - Spectrogram"* ***on page 107***
5. *"Spectrum Manager - Equalizer"* ***on page 108***
6. *"Spectrum Manager - Persistence"* ***on page 109***

The above mentioned tabs from 3 to 7 are enabled only, by selecting the *View live data from sensor* option on the *Event Log* screen or it can be viewed through *Show Spectrum Display* of the selected sensor displayed on the Sensor's page. For further information, refer to *Spectrum Manager - Event Log* screen.

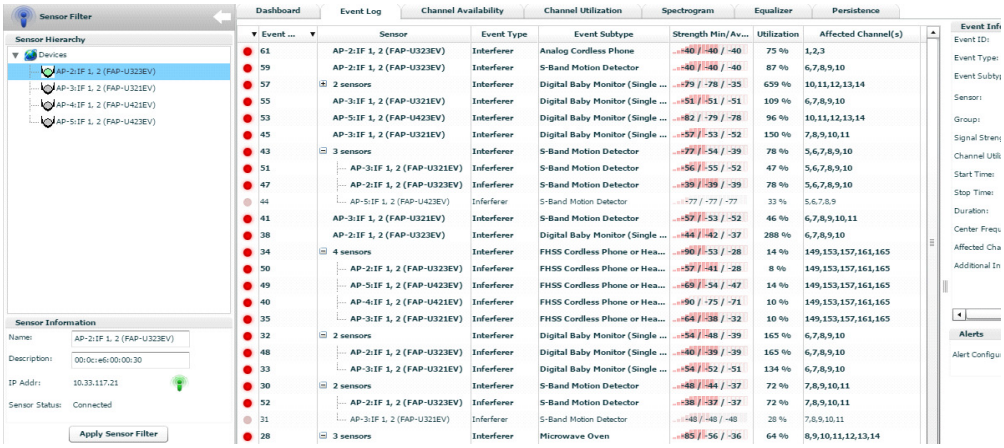
Event Log

Spectrum Manager > Monitor > Dashboard > Event Log

The *Spectrum Manager Event Log* screen provides the detailed log information of the sensors.

Figure 24 on ***page 103*** illustrates the *Spectrum Manager Event Log* screen.

Figure 24: *Spectrum Manager - Event Log*



The following table depicts the *Event Information* displayed on the *Event Log* screen:

Field	Description
Event ID	Displays the *Event ID*.
Event Type	Displays the type of Event.
Event Subtype	Displays the interference source name.

Field	Description
Sensor	Displays the name of the selected *Sensor*. The following options are available for selection: • *View live data from sensor*: This option allows you to read the *live data from the Sensor*. The below mentioned tabs are enabled by the selection of the *View live data from sensor* option. • Channel Availability • Channel Utilization • Spectrogram • Equalizer • Persistence The above mentioned tabs reveal data of the selected *Sensor* in their respective tabs. • *Show interferer on map:* Select the *icon* The *E(z)RF Map Management* screen is displayed, depicting the location of the interfering device on the Floor.
Group	Displays the sensor's group.
Signal Strength	Displays the *Signal Strength* of Interference with *Min, Max, and Avg* values in dBm.
Channel Utilization	Displays the percentage of channel utilized by the interferer.
Start Time	Displays the *Start Time* of the interference detected by the sensor.
Stop Time	Displays the *Stop Time* of the interference detected by the sensor.
Duration	Displays the *Duration* of the interference detected by the sensor.
Center Frequency	Displays the *Center Frequency* of the interference.
Affected Channel(s)	Displays the number of channels affected by the interference.
Recording Id	Displays the recording event Id.
Additional Information	Displays the interfere type for alert triggered event.
Active	Displays the number of active events highlighted with bold red dot.

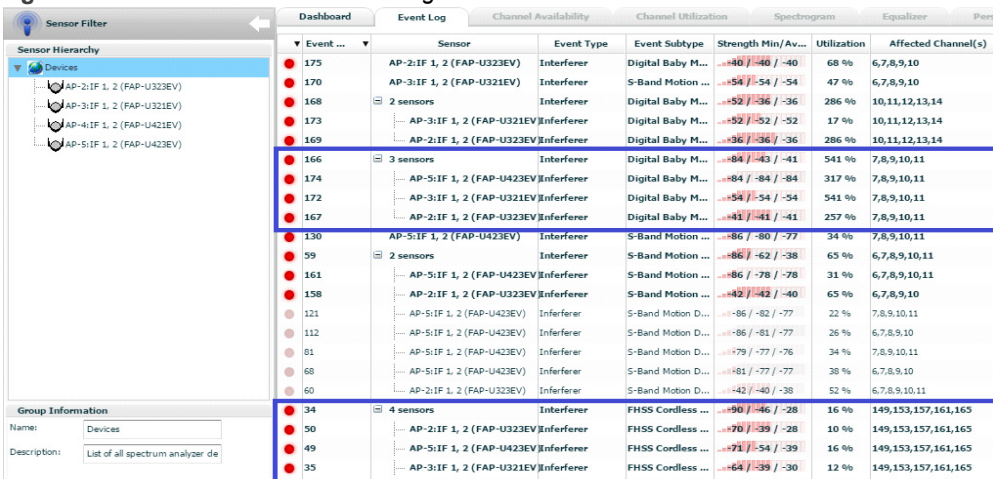
Interference Event Clustering

The *Spectrum Manager Event Log* screen displays the cluster of events. Multiple interference reports, correlated to the same interferer and interference event are assigned to the same

cluster ID. The interference event is reported as a single event, when multiple sensors reporting the same interference event.

Figure 25 on ***page 105*** illustrates the *Interference Event Clustering* screen.

Figure 25: *Interference Event Clustering*



The *Spectrum Manager Event Log* screen provides various *Control Panel* tabs. For further information, refer to *"Control Panels"* ***on page 117***.

Spectrum Manager - Channel Availability

Navigation: Spectrum Manager > Monitor > Dashboard > Channel Availability

1. Select the *Channel Availability* tab.

   The *Channel Availability* screen displays the *Channel Quality* and *Channel Utilization* graphs.

   Figure 26 on ***page 106*** illustrates the *Spectrum Manger Channel Availability* screen.

Figure 26: *Spectrum Manager - Channel Availability*

2. The *Channel Quality* and *Channel Utilization* graph, rendered in a flash application, displays a real time calculated channel quality for each of the Wi-Fi channels as well as the level of interference detected on each channel. The interference is differentiated between 802.11 interference and *Non-802.11* interference. The *Channel Utilization* graph also displays the *Channel Utilization* per Interference.
3. Each of the interference is displayed as a percentage of the channel it is utilized.

The *Channel Utilization per Interference* type is displayed on the *Channel Utilization* graph, only if the *Show Non-Wifi Interference Type* option is checked in the *Display Settings*. This option is displayed only for the *Hardware Sensors* (See *"Hardware Sensors"* ***on page 128***.)

4. The *Channel Availability* screen provides various *Control Panel* tabs. For further information, refer to *"Control Panels"* ***on page 117***.

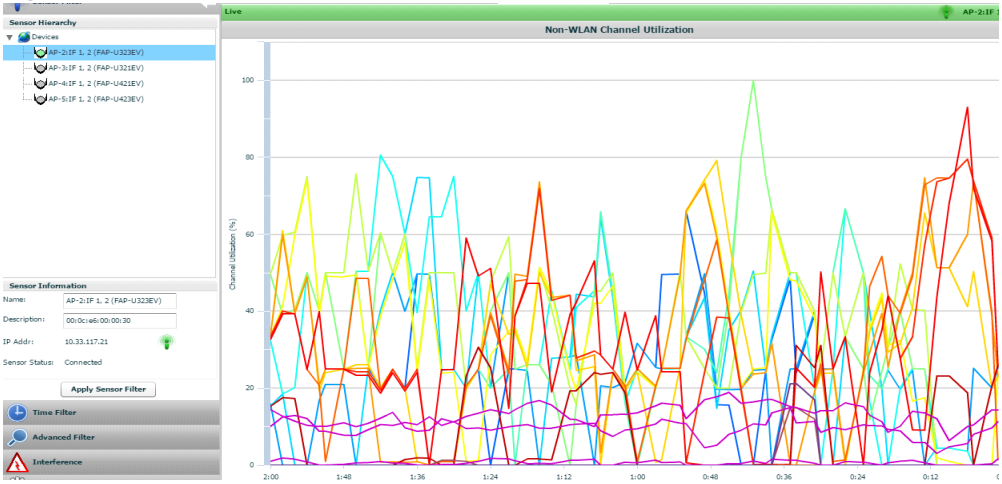
Spectrum Manager - Channel Utilization

Spectrum Manager > Monitor > Dashboard > Channel Utilization

1. Select the *Channel Utilization* tab.
   Figure 27 on ***page 107*** illustrates the *Spectrum Manager Channel Utilization* screen.

   The *Channel Utilization* screen displays the *WLAN Channel Utilization* and *Non-WLAN Channel Utilization* graphs. This option is displayed only for the *Hardware Sensors* (See *"Hardware Sensors"* ***on page 128***.)

Figure 27: *Spectrum Manager - Channel Utilization*



2. The *WLAN Channel Utilization* and *Non-WLAN Channel Utilization* graphs, rendered in a flash application, displays a real time calculated channel utilization for each of the *WLAN* and *Non-WLAN Channels*.
3. The *Channel Utilization* screen provides various *Control Panel* tabs. For further information, refer to *"Control Panels"* ***on page 117***.

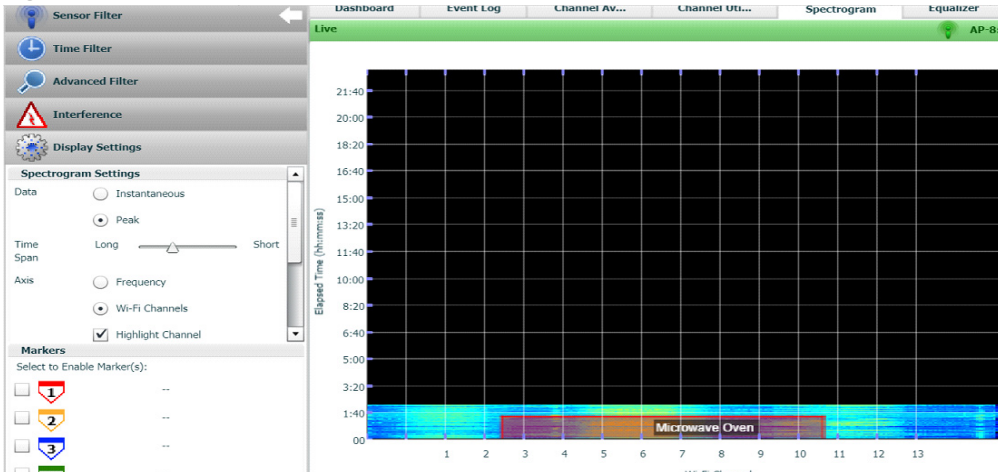
Spectrum Manager - Spectrogram

Navigation: *Spectrum > Monitor > Dashboard > Spectrogram*

1. Select the *Spectrogram* tab.
   Figure 28 on ***page 108*** illustrates the *Spectrum Manager Spectrogram* screen.

   The *Spectrogram* screen provides the spectrum activity for the Interferer devices.

Figure 28: *Spectrum Manager - Spectrogram*



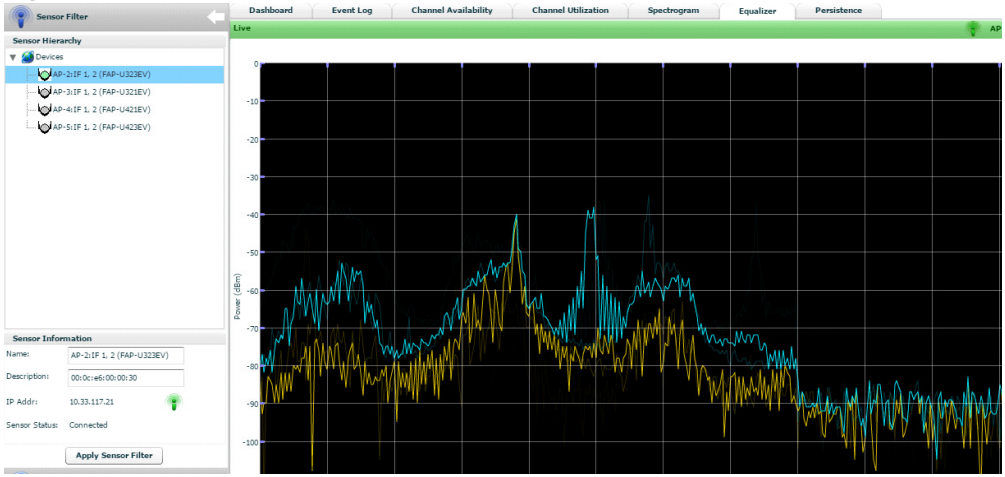
2. The scrolling *Spectrogram* displays the following details:
   - The frequency and amplitude of RF energy over time is displayed.
   - The *x-axis* displays the *Frequency (MHz)* or *Wi-Fi channel number*. The amplitude of the energy is plotted as *Instantaneous data* or the *maximum peak hold amplitude*. The amplitude is represented in blue color representing the weakest signal and red representing the strongest signal.
   - The *y-axis* displays the *Time*, with the most recent data at the bottom of the display and the plotted data scrolling upward.
3. The *Spectrogram* screen provides various *Control Panel* tabs. For further information, refer to *"Control Panels"* ***on page 117***.

Spectrum Manager - Equalizer

Spectrum > Monitor > Dashboard > Equalizer

1. Select the *Equalizer* tab.
   Figure 29 on ***page 109*** illustrates the *Spectrum Manager Equalizer* screen.

Figure 29: *Spectrum Manager - Equalizer*



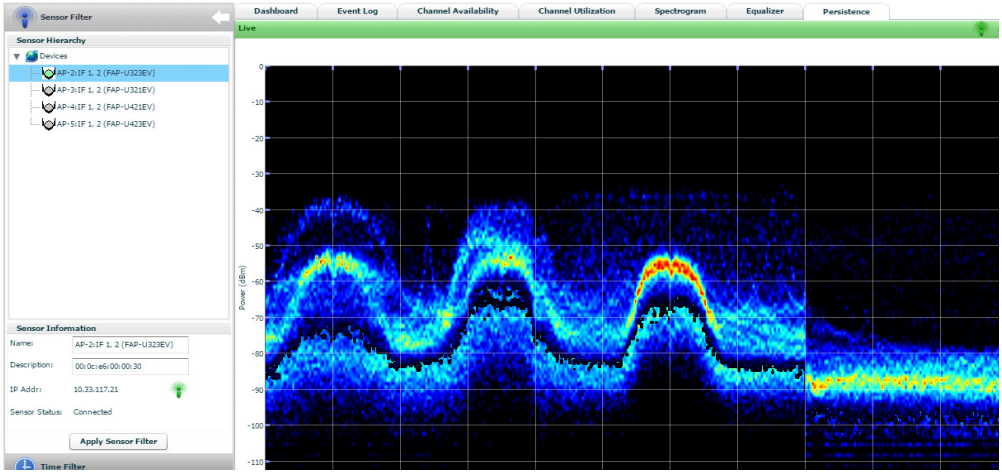
2. The *Equalizer* screen provides a flash application that starts *Sensor* to the browser. The *Equalizer* is a plot of the *amplitude* versus the *frequency* of RF (RF Energy or Signal) scanned by the *"Sensors"* ***on page 127***.
3. The *Spectrum Equalizer* plots the *amplitude* vs. *frequency* for the detected RF energy. The frequency along the x-axis can be displayed as either frequency (MHz) or Wi-Fi channels. Both the instantaneous amplitude (the last data point collected over the scan period) and the maximum peak hold amplitude (the highest data point collected over the scan period) are dynamically plotted. The instantaneous data is plotted in yellow, while the peak hold data is plotted in blue. The colors are user configurable.
4. The *Equalizer* screen provides various *Control Panel* tabs. For further information, refer to *"Control Panels"* ***on page 117***.

Spectrum Manager - Persistence

Spectrum > Monitor > Dashboard > Persistence

1. Select the *Persistence* tab.
   Figure 30 on ***page 110*** illustrates the *Spectrum Manager Persistence* screen.

Figure 30: *Spectrum Manager - Persistence*



2. The *Persistence* screen provides a flash application. The Persistence provides the spectrum activity for the Interferer devices to view the channel Persistence link to display the interference events.
3. The *Persistence* display plots the *amplitude* vs. *frequency* for the detected RF energy. Both the instantaneous amplitude (the last data point collected over the scan period) and the maximum peak hold amplitude (the highest data point collected over the scan period) are dynamically plotted. The color of a pixel on the display represents the number of times the energy was detected at that specific frequency and amplitude, with blue representing the least frequent and red representing the most frequent.

The *Persistence* screen provides various *Control Panel* tabs. For further information, refer to *"Control Panels"* ***on page 117***.

Interference Classification

The Fortinet Universal access points (FAPs) and PSM3x access points support different interference classifications in the Spectrum Manager.

This table describes the interference classifications for PSM3x and FAP-Us.

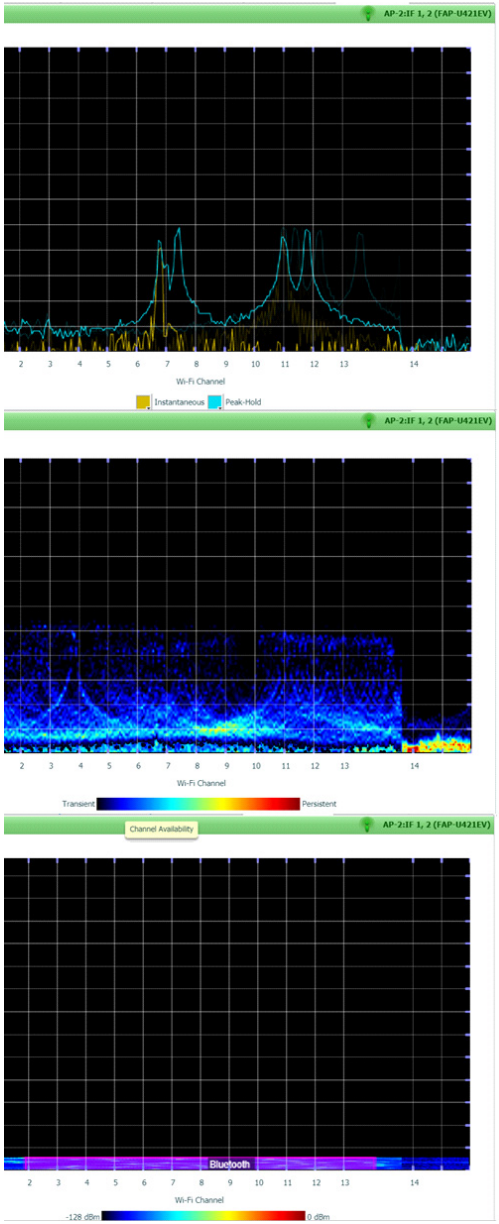
Interference Classification	PSM3x	FAPU-AIRIQ
Microwave Oven (conventional)	✓	✓
Analog Cordless Phone (2.4 GHz)	✓	✓
Analog Cordless Phone (5 GHz)	X	✓
Wireless video camera (2.4 GHz)	✓	✓

Wireless video camera (5 GHz)	✓	✓
Narrowband RF Jammer	✓	✓
Wideband RF Jammer	✓	✓
S-Band radar-based motion detector	✓	✓
Unknown Interferer	✓	X
DSSS Cordless Phone (2.4 GHz)	✓	✓
DSSS Cordless Phone (5 GHz)	✓	✓
Digital Baby Monitor – Single Carrier	✓	✓
Digital Baby Monitor – DSSS	✓	X
Microwave Oven (inverter)	✓	✓
FHSS Cordless Phone (2.4 GHz)	✓	✓
FHSS Cordless Phone (5 GHz)	✓	✓
Digital Baby Monitor – FHSS	✓	X
Xbox wireless game controller	✓	✓
Playstation2 wireless game controller	✓	X
Bluetooth Device	✓	✓
Zig bee device	✓	X
Wireless Mouse	✓	X
Air HORN Wi-Fi Signal Generator	✓	X
802.11 Frequency Hopping Device	✓	X
DFS Radar Detection	✓	X
Canopy Gear	✓	X
Non-Wi-Fi Wireless Bridge	✓	X
Possible Interferer	X	✓

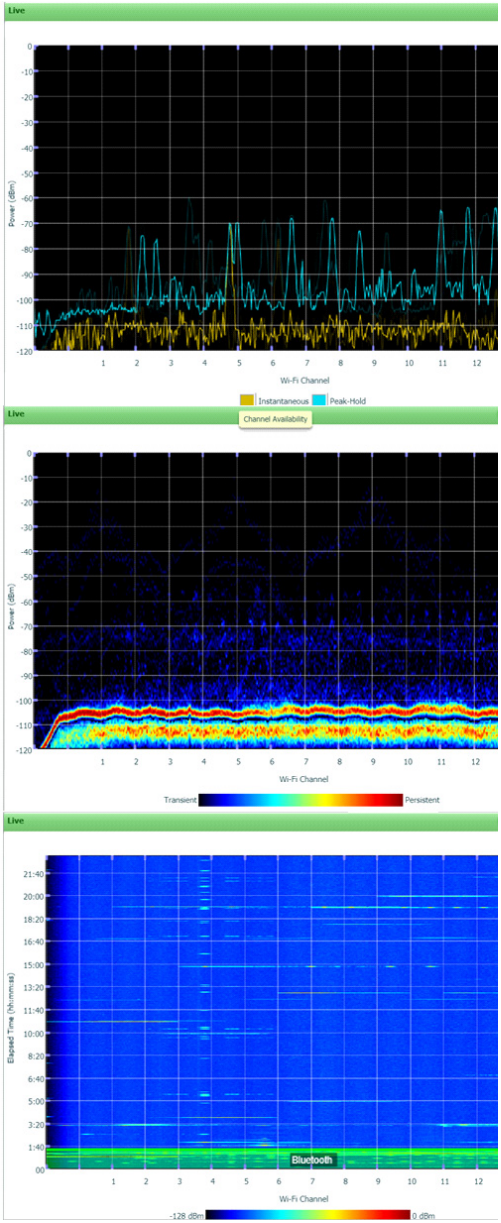
The following set of screen captures in this section depict the difference in the waveforms captured in the Equaliser, Persistence, and Spectogram, detected for interferences by FAP-Us and PSM3x.

Bluetooth Devices

FAP-U

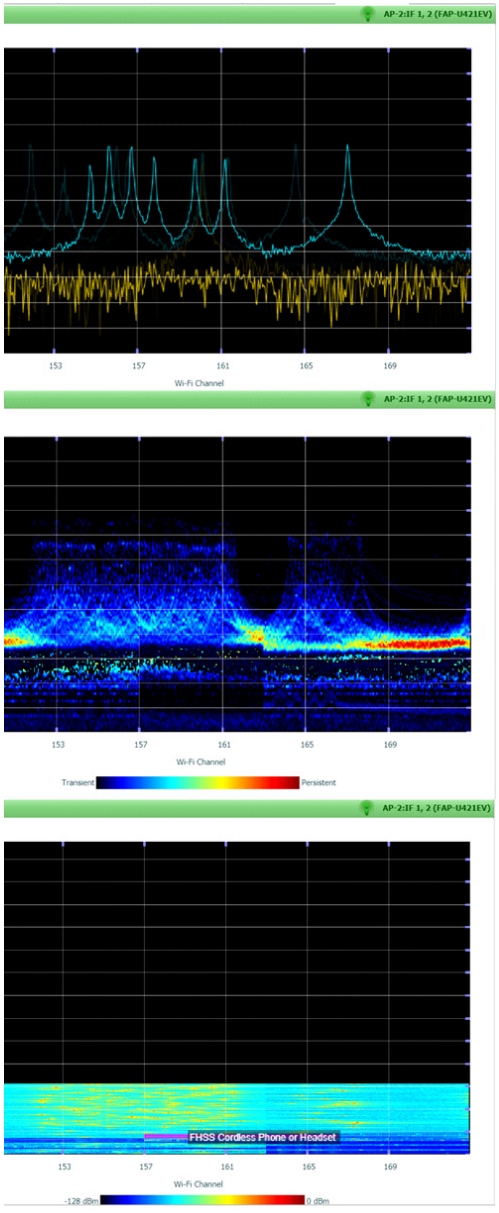


PSM3x

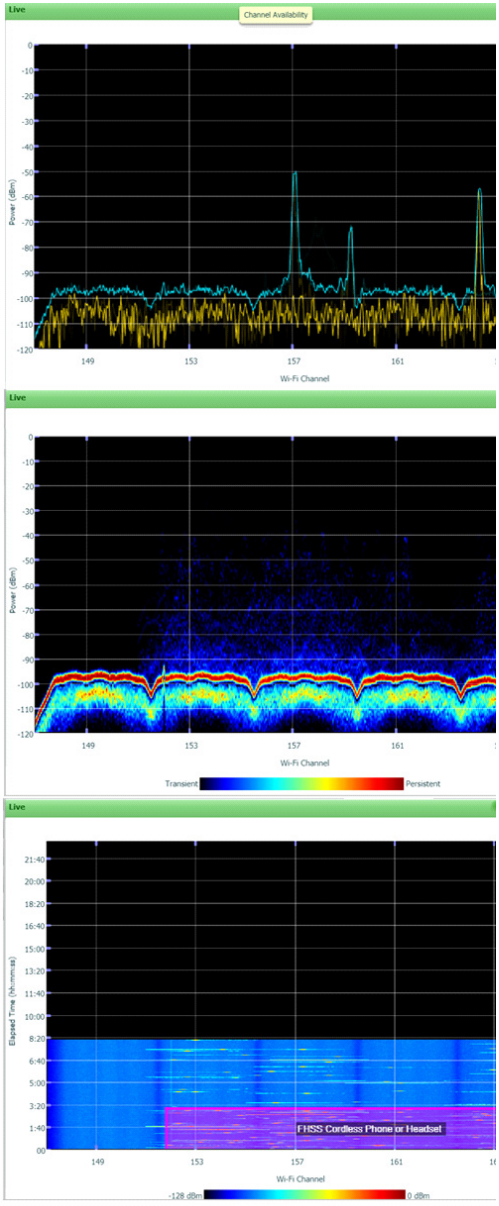


FHSS Cordless Phone (5 GHz)

FAP-U

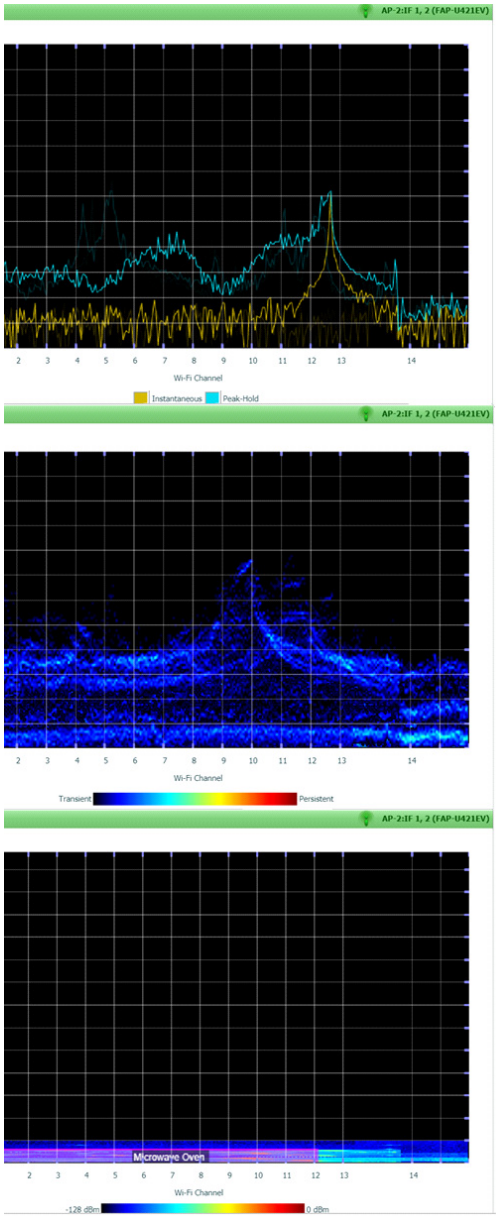


PSM3x

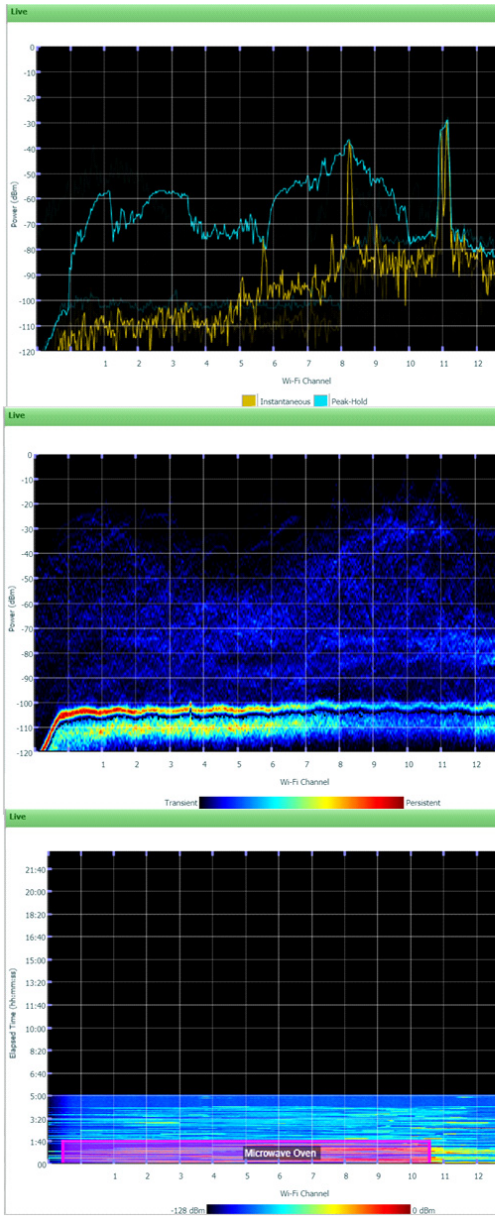


Microwave Oven (inverter)

FAP-U

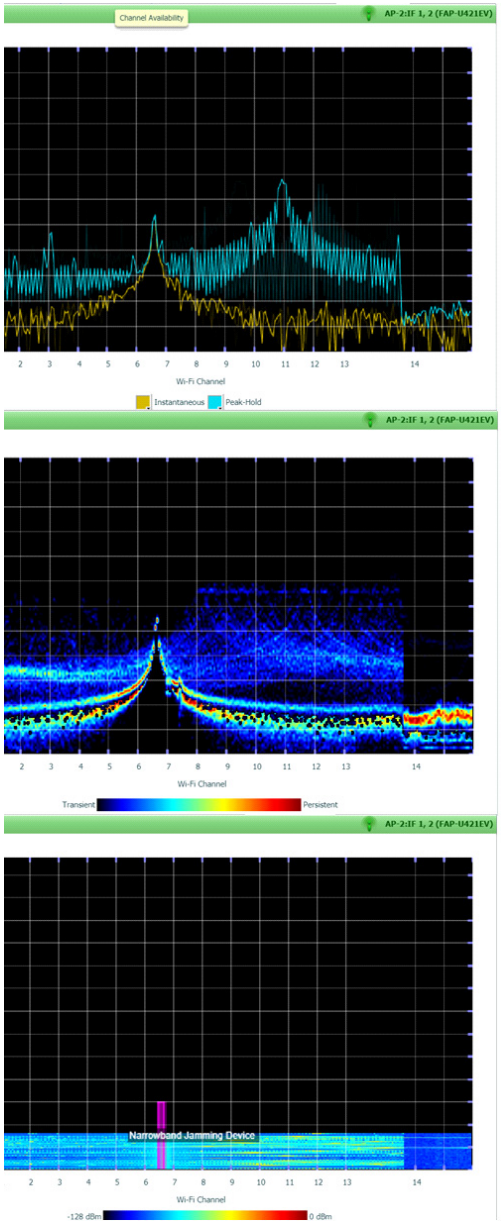


PSM3x

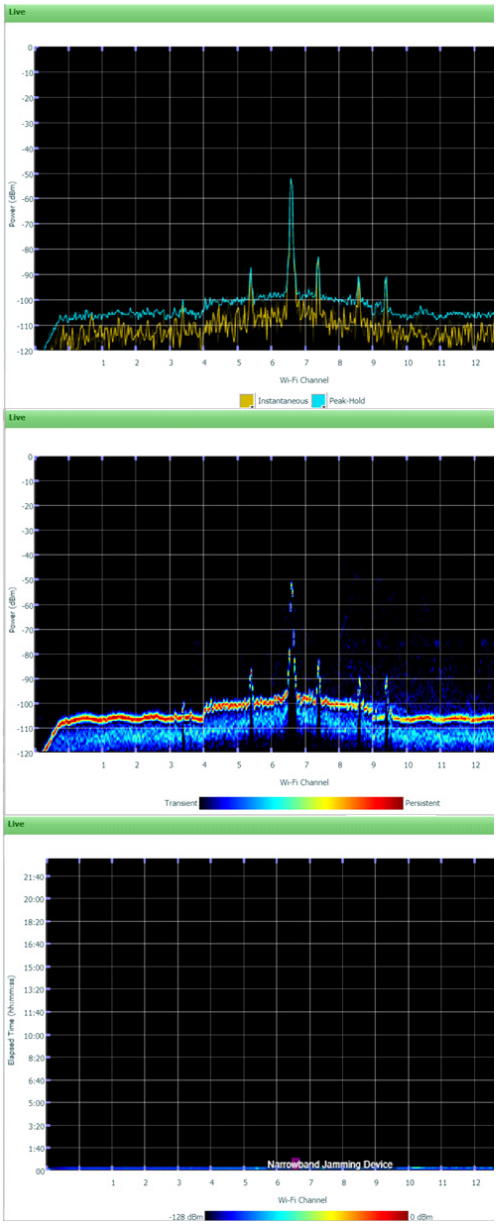


Narrowband RF Jammer

FAP-U

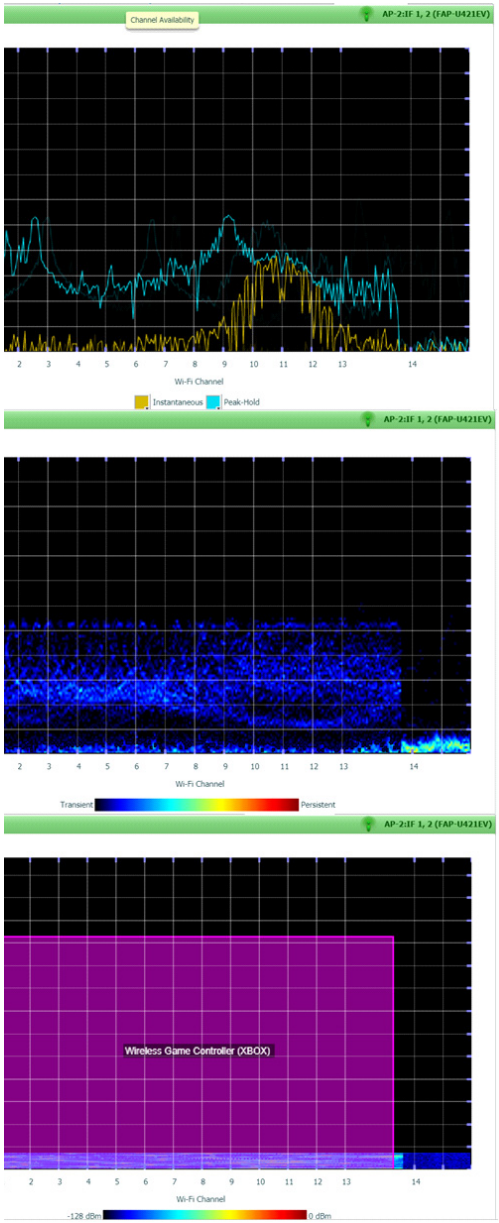


PSM3x

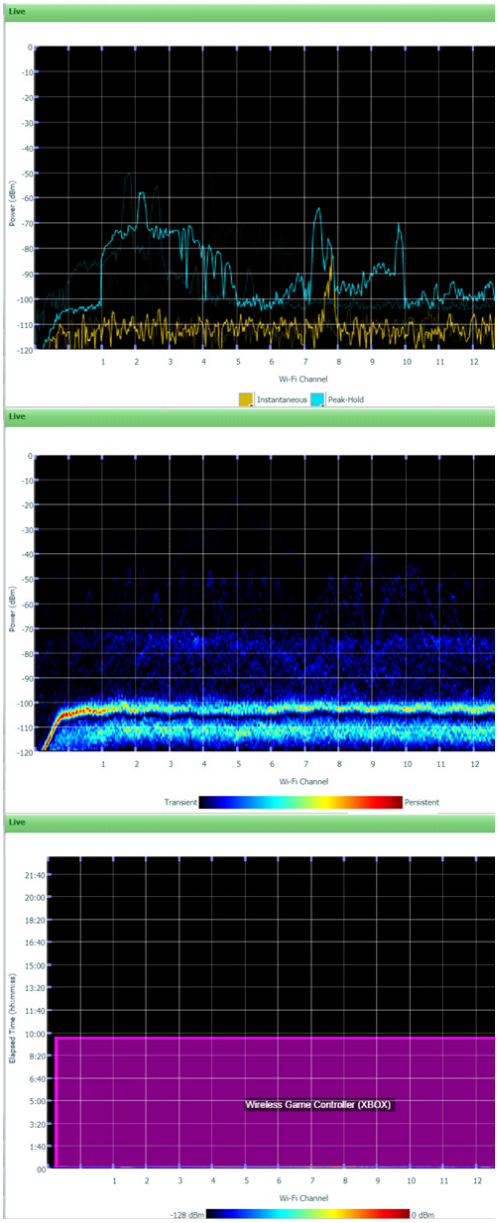


Xbox wireless game controller

FAP-U



PSM3x



Control Panels

The *Control Panels* are displayed towards the left of the *Dashboard* screen.

The following table depicts the various *Control Panel* tabs available on the *Monitor Console* screen:

- *"Sensors Filter"* ***on page 117***
- *"Advanced Filter"* ***on page 119***
- *"Interference"* ***on page 120***
- *"Display Settings"* ***on page 120***

Sensors Filter

The *Sensors Filter* enables to filter the information to be displayed on the screen by selecting a sensor under sensor hierarchy. Perform the following steps to configure the Sensors filter:

- Select the *Sensors Filter* tab. A list of sensors deployed is displayed.
- Select a sensor in *Sensor hierarchy* and click on *Filter selected Group/sensor.* The following changes also occur:
  - The selected sensor is displayed on *Trend Graph*, *Interferer Type* and *Affected Channels* sections of the *Dashboard* screen.
  - The *Event Log* details are updated with selected sensor in *Event Log* screen.
- The *Sensors Filter* tab displays the following two sections:
  - *"Sensors Hierarchy"* ***on page 117***
  - *"Group Information"* ***on page 117***

Sensors Hierarchy

The *Sensors Hierarchy* section displays the sensors hierarchically belonging to the controller.

Group Information

The *Group Information* section provides the details of the selected *Enterprise*, *Campus*, *Building*, *Floor* and *AP*.

- The following details for the selected *Enterprise*, *Campus*, *Building*, *Floor* and *AP* are displayed:
  - Name - Displays the name of the sensor.
  - Description - Displays the MAC address of the sensor.
  - IP Address - Displays the IP address of the sensor
  - Status - Displays the connection status of the sensor.

- Select an *Enterprise*, *Campus*, *Building*, *Floor* or *AP* from the above *Sensors Hierarchy* section.
- Select the *Filter Selected Group/Sensor* option.
- The graph for the selected sensor is displayed on *Trend Graph*, *Interferer Type* and *Affected Channels* sections of the *Dashboard* screen.

The *Sensors Filter* tab is enabled only in the below mentioned tabs:

- Dashboard
- Event Log

Time Filter

The *Time Filter* enables to configure the screen to display information over a period of time. This can be performed by configuring the *Start Time* and *Stop Time* parameters on the page.

Perform the below actions to configure the *Time Filter*:

- Select the *Time Filter* tab.
- The *Time Filter* tab displays the following two sections:
  - *"Start Time"* ***on page 118***
  - *"Stop Time"* ***on page 118***

Start Time

- Select the option *Earliest Time Possible*. The system fetches the data available for the earliest possible time.
- Uncheck the *Earliest Time Possible* option to select the *Start Time*.
- From the *Time* option, select the time from the drop-down list. The format followed is *hh:mm:ss* format.
- From the *Date* option, select the calendar icon to select the *Month, Date* and *Year*. The format followed is the *mm/dd/yyyy*.

Stop Time

- Select the option *Use Current Time*. The system applies the current time.
- Uncheck the *Use Current Time* option to select the *Stop Time*.
- From the Time option, select the time from the drop-down list. The format followed is *hh:mm:ss* format.
- From the Date option, select the calendar icon to select the *Month, Date* and *Year*. The format followed is the *mm/dd/yyyy*.
- Select *Apply Time Filter* option.

- The *Time Filter* is applied to the *Trend Graph*, *Interferer Type* and *Affected Channels* sections of the *Dashboard* screen.

The *Time Filter* tab is applied and enabled to the below mentioned tabs:

- Dashboard
- Event Log

Advanced Filter

The *Advanced Filter* option enables to configure the information to be displayed on the screen by choosing the following available filters:

- Channel Filter
  - This filter enables you to filter the information based on the available channels.
  - Select the desired channel from the *Channel* list.
  - Select *Apply Filter*. The *Channel Filter* is applied to the *Dashboard* screen and the *Event Log* screen.
- RSSI Filter
  - This filter depicts the signal strength of the Interferer device.
  - Select the desired *RSSI* value from the *RSSI Filter* list. The values displayed are in dBm.
  - Select *Apply Filter*. The *RSSI Filter* is applied to the *Dashboard* screen and the *Event Log* screen.
- Interferer Type
  - This filter depicts the Interferer Type.
  - A list of Interferer Type options is available for selection.
  - Select the desired *Interferer Type*.
  - Select *Apply Filter*. The *Interferer Type* filter is applied to the *Dashboard* screen.

The above mentioned Interferer type *Advanced Filter* options is enabled only on the *Dashboard* screen.

- Event Log Type
  - This filter depicts the *Event Log Type* (*Alert Event* or *Interferer Log Event*).
  - A list of *Interferer Log Events* and Alert Event options is available for selection in the *Event log* subtype.
  - Select the desired Event Log Type and select desired Event Subtype.
  - Select *Apply Filter*. The *Event Log Type/Subtype* filter is applied to the *Event Log* screen.

The above mentioned *Advanced Filter* option is enabled only on the *Event Log* screen.

The *Advanced Filter* tab is enabled only in the below mentioned tabs:

Dashboard

Event Log

Interference

The *Interference* section displays the following:

- *Start Time*: This is the *Start Time* of the interference and interference type.
- *Add Note:* The *Add Note* icon enables to add a note.

The *Interference and Notes* option is displayed on the following tabs:

- Channel Availability
- Channel Utilization
- Spectrogram
- Equalizer
- Persistence

Display Settings

The *Display Settings* option enables to configure the information to be displayed on the following screens:

The *Display Settings* tab is enabled only in the below mentioned tabs.

- Event Log
- Channel Availability
- Channel Utilization
- Spectrogram
- Equalizer
- Persistence

Event Log - Display Settings

Perform the following actions to select the columns to be displayed on the *Event Log* screen:

- Select the *Event Log* tab. The *Event Log* screen is displayed.
- Select the *Display Settings* tab.
- Select the desired columns to be displayed.
- The selected columns are displayed on the *Event Log* screen.

Select the *Apply Default Column Setting* option to display the default columns.

Channel Availability - Display Settings

Perform the following actions to modify the graphical display of the *Channel Availability* screen:

- Select the *Channel Availability* tab. The *Channel Availability* screen is displayed.
- Select the *Display Settings* tab. (*Figure 31 on* ***page 121*** illustrates the *Channel Availability* screen of the *Display Settings*.)
- The *Chart Settings* option is displayed.

Figure 31: *Display Settings - Channel Availability*

- Select the *Frequencies* from the drop-down list to view the *Channel Quality and Channel Utilization* on the respective channels. The *Display Frequency* can be set to scan the *2.4 GHz* frequency band, the *5 GHz* frequency band or *both*.
- Select the *Combine Utilization* option. This enables the *Channel Utilization* graph (which is in channel quality) to combine the *Non-Wireless LAN Interference* and *Wireless LAN Interference*.

Channel Utilization - Display Settings

Perform the following actions to modify the graphical display of the *Channel Availability* screen:

- Select the *Channel Utilization* tab. The *Channel Utilization* screen is displayed.
- Select the *Display Settings* tab.
- The following sections are displayed: (*Figure 32 on* ***page 122*** illustrates the *Channel Utilization* screen of the *Display Settings*.)
  - *"Timescale settings "* ***on page 122***
  - *"Channel selection settings"* ***on page 122***

Timescale settings

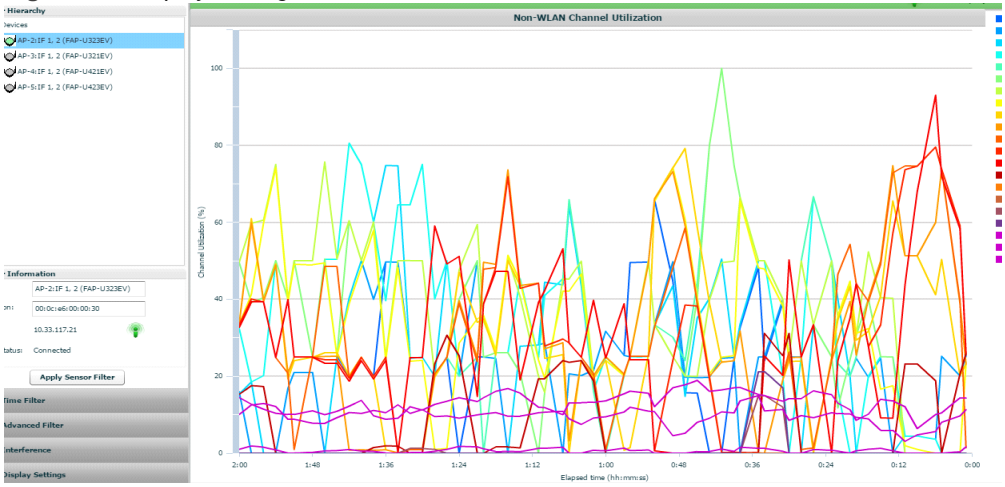
- Select the *Time Span*. The valid range is between *2 min - 120 min*.
- Select the *Time Units*. The Time Units allows you to select the *Elapsed Time* or *Actual Time*.

Channel selection settings

Select the *Frequency Band* from the drop-down list.

The *Select All* option enables to display all the *WLAN Channel Utilization*.

Figure 32: *Display Settings - Channel Utilization*



Spectrogram - Display Settings

The Spectrogram - Display Settings provides the following options:

1. *Data*

- Select the *Data* option. The *Data* option allows you to select the *Instantaneous* data or *Peak* data.

2. Time Span
   - Select the *Time Span*. The *Time Span* ranges between *Long - Short*.
3. *Axis*
   - Select the *Axis* type. The *Axis* is configured based on *Frequency* and *Wi-Fi Channels*.

   Frequency: This option displays the graph based on the frequency.

   Wi-Fi Channels: This option displays the graph based on the *Wi-Fi Channels*. Select the *Wi-Fi Channels* option, the following parameters are displayed:

   - *Highlight Channel*: Check the *Highlight Channel* option, to highlight a channel when the channel in the x-axis is being mouse-over.

   - *Wi-Fi Channel Width*: Select the *Wi-Fi Channel Width* from the drop-down list. This sets the channel width for the spectrogram to display. Select any one option from the drop-down list. The options are *20Mhz, 20Mhz+Upper 20 Mhz* and *20Mhz+Lower 20 Mhz*.

The *Wi-Fi Channel Width* option is enabled only when the *Axis* selected is *Wi-Fi Channels*.

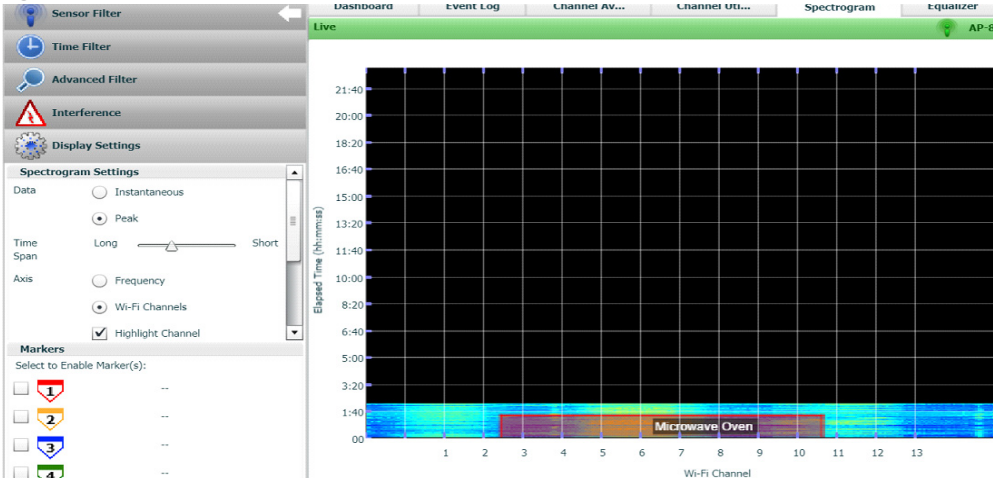
4. *Band*

- Select one option from the *Band* list.
- The Spectrogram for the respective bands can be set by selecting one of the options from the drop-down list.
- The options is *2.4GHz*, *5GHz (Lower)* and *5GHz (Upper)*.

The transient and spectrogram measure is displayed accordingly, to the color fading.

5. *Overlay Interference* - This option highlights the spectrum activity for a particular interferer.
   For Example: In the scenario where more interference events are noticed and if the particular interferer is to be viewed, then the overlay for that interferer device can be checked. (*Figure 33 on* ***page 124*** illustrates the *Spectrogram* screen of the *Display Settings.*)

Figure 33: *Display Settings - Spectrogram*



Markers

1. Select the *Spectrogram* tab. The *Spectrogram* screen is displayed.
2. Select the *Display Settings* tab.
3. Select the *Markers* section.
4. The markers can be used to visually mark a Frequency on the *Spectrogram* plot.
5. Check a marker in the Markers section, the marker appears on the *Spectrogram* graph.
6. Select the marker on the display to move it to the desired frequency to visually mark off.

Equalizer - Display Settings

The *Equalizer - Display Settings* provides the following options:

1. Persistence

- Select the *Persistence* range.
- Setting *Persistence*, allows us to study the timed trends in the graph. Increasing the persistence of the display increases the amount of time that samples are retained and displayed allowing us to study variations over time. This can be set in the bar on the display settings from *Zero* to *Infinity.*
  Figure 34 on ***page 125*** illustrates the *Equalizer* screen of the *Display Settings*.

2. *Axis*

- Select the *Axis* type. The *Axis* is configured based on *Frequency* and *Wi-Fi Channels*.
  - *Frequency*: This option displays the graph based on the frequency.
  - *Wi-Fi Channels*: This option displays the graph based on the *Wi-Fi Channels*. Select the *Wi-Fi Channels* option, the following parameters are displayed:

- *Highlight Channel*: Check the *Highlight Channel* option, to highlight a channel when the channel in the x-axis is being mouse-over.

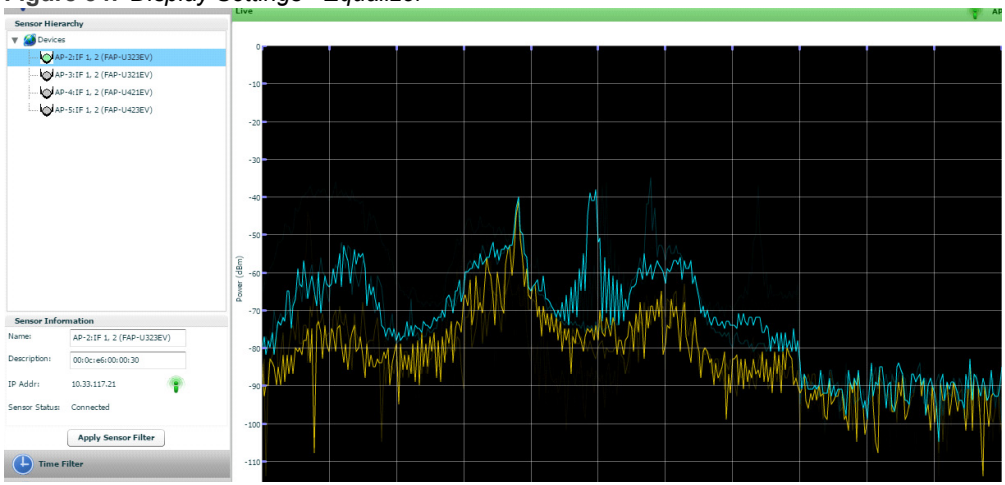
- *Wi-Fi Channel Width*: Select the *Wi-Fi Channel Width* from the drop-down list. This sets the channel width for the spectrogram to display. Select any one option from the drop-down list. The options are *20Mhz, 20Mhz+Upper 20 Mhz* and *20Mhz+Lower 20 Mhz*.

The *Wi-Fi Channel Width* option is enabled only when the *Axis* selected is *Wi-Fi Channels*.

1. Band

- Select one option from the *Band* list.
- The Equalizer for the respective bands can be set by selecting one of the options from the drop-down list.
- The options is *2.4GHz, 5GHz (Lower)* and *5GHz (Upper)*.

Figure 34: *Display Settings - Equalizer*



Markers

1. Select the *Equalizer* tab. The *Equalizer* screen is displayed.
2. Select the *Display Settings* tab.
3. Select the *Markers* section.
4. The markers can be used to visually mark a Frequency on the *Equalizer* plot.
5. Check a marker in the Markers section, the marker appears on the *Equalizer* graph.
6. Select the marker on the display to move it to the desired frequency to visually mark off.

Persistence - Display Settings

The Persistence Settings provides the following options:

1. Persistence

- Select the Persistence range.
- Setting Persistence, allows us to study the timed trends in the graph. Increasing the Persistence of the display increases the amount of time that samples are retained and displayed allowing us to study variations over time. This can be set in the bar on the display settings from *Zero* to *Infinity.*
  Figure 35 on ***page 127*** illustrates the *Persistence* screen of the *Display Settings*.

2. Axis

- Select the *Axis* type.
- The *Axis* is configured based on *Frequency* and *Wi-Fi Channels*.
  - *Frequency*: This option displays the graph based on the frequency.
  - *Wi-Fi Channels*: This option displays the graph based on the *Wi-Fi Channels*. Select the *Wi-Fi Channels* option, the following parameters are displayed:

Highlight Channel: Check the *Highlight Channel* option, to highlight a channel when the channel in the x-axis is being mouse-over.

Wi-Fi Channel Width: Select the *Wi-Fi Channel Width* from the drop-down list. This sets the channel width for the spectrogram to display. Select any one option from the drop-down list.

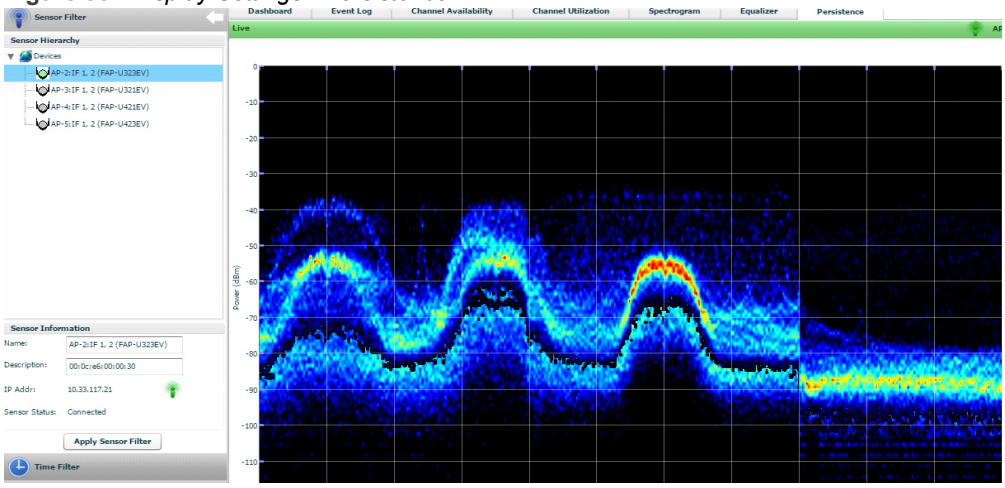
The options are *20Mhz, 20Mhz+Upper 20 Mhz* and *20Mhz+Lower 20 Mhz*.

The *Wi-Fi Channel Width* option is enabled only when the *Axis* selected is *Wi-Fi Channels*.

1. *Band*:

- Select one option from the *Band* list.
- The Equalizer for the respective bands can be set by selecting one of the options from the drop-down list.
- The options is *2.4GHz, 5GHz (Lower)* and *5GHz (Upper)*.

Figure 35: *Display Settings - Persistence*



Markers

1. Select the *Persistence* tab. The *Persistence* screen is displayed.
   Figure 35 on ***page 127*** illustrates the *Persistence* screen of the *Display Settings*.
2. Select the *Display Settings* tab.
3. Select the *Markers* section. The markers can be used to visually mark a Frequency on the *Persistence* plot.
4. Check a marker in the Markers section, the marker appears on the *Persistence* graph.
5. Select the marker on the display to move it to the desired frequency to visually mark off.

Sensors

The *Sensors* are classified as follows:

Software Sensors

The software-based sensor is a normal AP with one Radio in ScanSpectrum Mode. Here, the AP mode can be modified from Service/Normal Mode to ScanSpectrum Mode.

Note:

- The modification of AP mode from **Service/Normal Mode** to **ScanSpectrum Mode** can be performed only via the FortiWLC GUI or by pushing the AP template with Radio profile configured with the **ScanSpectrum Mode** from FortiWLM.
- You can configure both radios of FAP-U421EV, FAP-U423EV, FAP-U321EV, FAP-U323EV sensors in **ScanSpectrum Mode**, which will make the radios to scan both the Radio spectrum for interference. For all the other Sensors, only single radio can be configured in **ScanSpectrum Mode** at a time.

- No client service will be provided once Radios are configured in the **ScanSpectrum Mode.**

Hardware Sensors

The Hardware-based sensors are completely dedicated to monitor the airwaves of the time. By having a dedicated subsystem, the sensor can classify and report on the type and source of interference almost instantly and without taking CPU resources away from the wireless radio. The *Hardware Sensors* include the following *Access Points*:

- PSM3x
- AP433is

RF Interferer Classification

Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz frequency bands, where they share a medium with a variety of other devices. With the exception of Bluetooth devices, none of the other devices have any mechanisms to co-exist with Wi-Fi networks. As a result, when an interfering device is emitting energy in the WLAN channel the WLAN Access Point is used for communication, the throughput of the AP can be significantly affected.

Spectrum detects all non-802.11 interference devices, especially the devices mentioned in the below list:

- Microwave ovens (conventional)
- Microwave ovens (inverter)
- Motorola Canopy Wireless
- Non-Wifi Wireless Bridges
- Wireless video cameras (digital and analog)
- Analog cordless phones (2.4GHz and 5GHz)
- FHSS cordless phones (2.4GHz and 5GHz)
- DSSS cordless phones (2.4GHz and 5GHz)
- Bluetooth devices
- Wireless baby monitors
- Game Controllers
- RF Jammers (both narrowband and wideband)
- Wireless mice
- Zigbee devices
- Motion Detectors (S-band, radar-based)

In addition to the above mentioned devices, the RF Jamming devices also exist. The RF Jamming devices can be used to intentionally interfere with wireless communications. Although,

these devices are considered to be illegal in the US and elsewhere, they provide performance and security issues to WLANs.

Wireless LANs based on the IEEE 802.11 standards, function in the unlicensed 2.4 and 5 GHz frequency bands. Other devices emitting radio-frequency energy in these bands can interfere with WLAN transmissions. The *"Radio frequency characteristics for the interferer devices listed below"* ***on page 130*** lists some common RF interferer and their RF characteristics.

Radio frequency characteristics for the interferer devices

The Radio frequency characteristics for the interferer devices are listed below:

From the deployment perspective, the Spectrum coverage not only depends upon its sensor (receiver sensitivity), but also depends upon the interference devices transmit power (or signal strength). We cannot place the sensors far away and expect the very low signal strength interference device packets to reach the sensor.
Theoretically, lower the signal strength of the interference devices more sensors must be packed to catch those devices.

The *"Sensors"* ***on page 127*** **(***"Software Sensors"* ***on page 127*** and *"Hardware Sensors"* ***on page 128*****)** must be installed at least six feet away from a servicing AP. Having it closer affects the accuracy of interference classification.

The servicing APs must not be installed very close to PSM3x, as the false events (Analog Cordless Phones, etc.,) may be detected by PSM3x sensor due to the EMI (Electromagnetic Interference) emitted near by APs.

For Example:

Bluetooth has 2.2 dBm transmit power, for which the sensors must be placed closer in the given site, for it to be captured. So, the signal strength of interference devices is inversely proportional to the sensors coverage area.

Also the sensor coverage area is proportional to the receiver sensitivity. More the receiver sensitivity (which can be obtained with higher gain antennas) the sensors can be more sparsely distributed compared to the above example.

The conclusion is, the coverage area of the sensor depends upon the lowest signal strength of the interference device to be detected and depends upon the receiver sensitivity of the sensor. More the signal strength of the interference device and more the receiver sensitivity, the sensors will have more coverage and vice versa. Assuming the above considerable factors the predictable coverage can be identified with the following table, which has a specified interfer-

ence transmit power. So it's the administrator or the user environment the deployment for the sensors can be predicted.

TABLE 7: *Radio frequency characteristics for the interferer devices listed below*

Interferer Device	Frequency Range	Transmit Power	Modulation	# Communication Channels Supported	Width	Features
Bluetooth	2402-2480 MHz	2.2 dBm	GFSK, FHSS	79	1 MHz	Pulsed, low-power
Analog Cordless Phone	2403-2480 MHz	NA	Narrow Band FM	40	~300 kHz	Narrow Band FM
DSSS Digital Cordless Phone	2407.5-2472 MHz	20 dBm	DSSS	40	1.5 MHz	High-power, duty Factor
FHSS Digital Cordless Phone	2408.5-2472 MHz	21 dBm	FHSS	90	892 kHz	Pulsed, high-power
Conventional Microwave Oven	2.4 GHz	800W	N/A	N/A	N/A	Pulsed, broadband
Inverter Microwave	2.4 GHz	1300W	N/A	N/A	N/A	Pulsed, broadband
Wireless Video Camera	2414 – 2468 MHz	10 dBm	Frequency Modulation (FM)	4	N/A	Broadband, high-power
Digital Video Monitor	2402 – 2483 MHz	20 dBm	FHSS	27	2MHz	High-power, frequency hopping
Game Controller	2402 – 2482 MHz	N/A	FHSS	40	500kHz	Pulsed, low-power, Frequency hopping

RF Interferer Detection

With the WLANs supporting critical applications such as voice and video communications, monitoring and management of RF interference becomes a security imperative. Interference can be from an intentional, malicious interferer such as an RF jammer or from an unintentional source such as a cordless phone in a nearby location. In either case, the ability of the WLAN

to support the real-time communication required by these applications can be severely compromised by the RF interference. WLANs must be able to continuously detect the interferer in the RF environment for these security issues and trigger alerts to network administrators.

The *Sensors* which are listed in the *Event Log* page provides the interference event information.

Figure 36 on ***page 131*** illustrates the *sensors listed on the Event Log* screen.

Figure 36: *Sensors listed on the Event Log screen*

Each interferer device signal is treated as an interference event and is detected by the following parameters:

- Event Subtype (Type of interferer)
- Signal Strength (Current/ Average / Maximum) dBm
- Affected Channel(s) (Impact will be on the channels listed)
- Center frequency
- Duration (how long the inference event was seen)
- Start Time (At what time the interference event started)
- Stop Time (At what time the interference event stopped)

The active Interference event is highlighted in bold font and a red dot.

The event which is not alive at the moment will be grayed out as shown in the

The RF Interferer classification is detected by the following parameters

- Channel
- Signal Strength

- Interferer.

  Interferer can be detected,

  - By opting to filter, for only on that channel.
  - Interferer fading into the 2.4GHz and the 5GHz spectrum by varying its signal strength which is detected by opting to filter the signal strength ranging from >=- 10 dBm to >=-110 dBm
  - By Specific interferer devices.
    Interferer on all channels, in the range of signal strength and also on all types of Interferer devices can also be filtered by opting "*All*".

Historical Spectrum dashboard Analysis

Spectrum Manager provides historical spectrum data for analysis. The impact on the interferer devices can be determined with the data available from the past with the tentative date and time. Interference events caused by the interferer devices are stored in the *Spectrum Manager* database for future analysis. A history of interference events for one year is maintained.

Event logs

The triggered events from the particular sensor are consolidated, captured and displayed in the Event Log screen as displayed in *Figure 146 on* ***page 351***.

Time-based Analysis

The *Spectrum* events are the time-based triggered events, for which the "Start and Stop time" is not provided. It must display the dashboard for the current interference activity. Ensure the "Earliest Time possible in Start time and Use current time in Stop time" check box is checked, to view the dashboard for real time display.

Proactive Spectrum Manager

Proactive Spectrum Manager, designed for single channel deployment, takes a top-level view into the channel spectrum, then recommends the best channels) for network operation. The PSM dashboard presents a goodness value for all channels and recommended channels of operation for the network using a chart with green (good) and red (don't use) bars.

Configure Proactive Dashboard Manager Using the Web UI

Use the dashboard to see the channel goodness over the spectrum and best available channels for 20MHz or channel-bonded (40MHz) operation on the 2.4 and 5GHz bands. The spectrum shows bar chart goodness values for all 20MHz and 40MHz channels. The higher the bar, the better the channel is. If the color of the bar is grey, no observation on that channel has taken place.

You have two PSM options, View and Evaluate.

- View is enabled on all channels by default. View mode monitors interference, such as rogues, and displays recommendations for channel use. If you see solid green bands on every channel in the charts, either only View is enabled or Evaluate is also enabled and there are no rogues on any channels.
- Evaluate is disabled on all channels by default. If you enable Evaluate mode on the channels, then PSM will manage the use of those channels by moving devices away from channels with a specified amount of rogue activity. To enable Evaluate:

1. Click Monitor > Spectrum Manager > PSM.
2. Click Evaluate at the top of the screen.

   Optionally, select one of the options from the Evaluate drop-down list:

   View turns on rogue detection, does an immediate scan, turns off rogue detection, and then displays the results.

   One Time Adapt turns on rogue detection, does a scan, turns off rogue detection, and then moves stations to recommended channels immediately

   Periodic Adapt repeats at the interval you set in the minutes value. Every x minutes, it turns on rogue detection, does a scan, turns off rogue detection, and then moves stations to recommended channels immediately.
3. Optionally change the Evaluation Time from 120 seconds to a value of 5 - 300 seconds. Evaluation affects rogue scanning (turns it on for Evaluation Time seconds) and optionally changes channels.
4. Optionally change the Threshold from 25 to a value of 1 - 100 rogues. Threshold indicates a delta in goodness value between current and recommended channel that triggers a change of channel. Non-zero threshold applies to periodic adaptation.
5. Optionally change the Adaption Interval from 30 to a value of either zero or 5 - 10080 seconds. (The values 1-4 seconds are not supported.) The adaptation interval determines how often channels can be automatically changed for this controller.
6. Click Start Wizard.
7. Confirm by clicking OK twice.

Click Graph Help to see what the chart colors mean. Click Details on either chart to see numeric values for the green bars in the charts. A summary of rogue scanning parameters is presented at the bottom of the screen. Also, the adaptation period of a periodic adaptation is shown if one is running. The view automatically refreshes every minute.

If rogue detection is not enabled on the network, PSM turns it on when needed for evaluate mode, then turns it back off. For example, if you use the option One Time Adapt, PSM turns on rogue detection, does a scan and then moves stations to recommended channels immediately. This overwrites the running config and reboots the APs (save it to make it permanent).

Blacklisted channels are never recommended. RS4000 and mesh radios are not supported. The more non-Fortinet equipment on a channel, the lower the recommendation will be to use that channel. Do not use this feature with a multichannel configuration.

Configure Proactive Dashboard Manager Using the CLI

The CLI command for Proactive Dashboard Manager is proactive-spectrum-manager evaluate. This is an example:

```
mg-mc2# proactive-spectrum-manager evaluate
   ** Attention: Stations may be disconnected in this evaluation **
   Are you absolutely sure [yes/No]? yes
   Evaluation time [120s]? 10
   View or Adapt [View/adapt]? adapt
   Adaptation period [0] min (5-10080)? 0
```

Device Fingerprinting

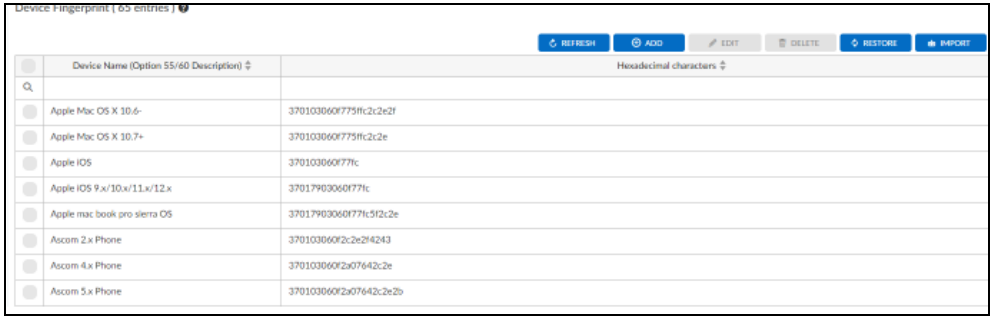
Device fingerprinting allows collection of various attributes about a device connecting to your network. The collected attributes can fully or partially identify individual devices, including the client's OS, device type, and browser being used.

Device Fingerprinting can provide more information for the station and allows system administrators to be more aware of the types of devices in use and take necessary actions. You can view the details of the devices via **Monitor** > **Dashboard**. You can import, export, add, delete, or restore the devices using the fingerprint command and the **`show fingerprints`** command displays the device fingerprints stored in the system. See *Command Reference Guide* for more information on the CLI commands.

Configuration Using WebUI

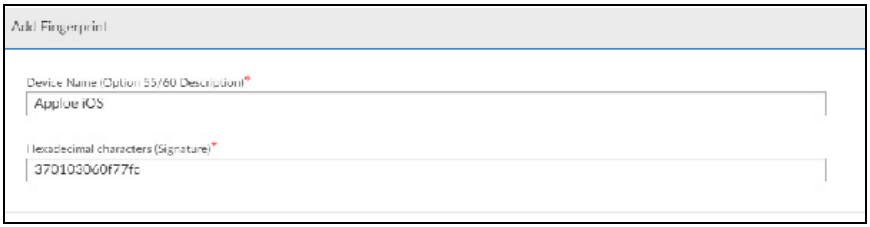
Configuration > Devices > Device Fingerprint

By default, this page lists the configured device OS types that can be monitored.



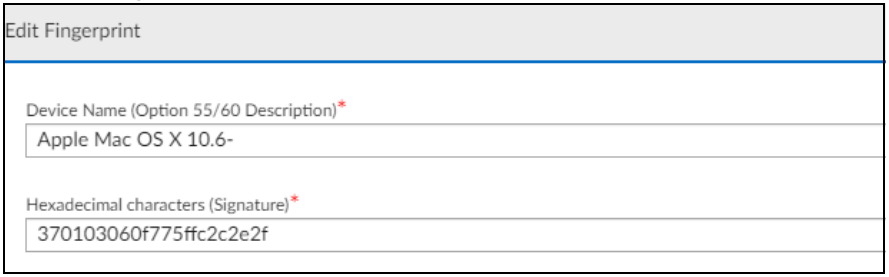
Adding a New Device OS

To add a new device OS type, click the ADD button and enter the device name and the associated hexadecimal characters (starting with 37 or 3c) and then click SAVE to add this device to the list.



Modifying an Existing Device OS

To modify an existing entry, select the checkbox for that entry and click the EDIT button. Make the required changes in the pop up box and click the SAVE button.



Export Device OS Details

To export the existing list of devices to another controller, click the checkbox in the column header to select all entries. Then click the EXPORT button to create a text file with the entries.

Import New Device OS Details

To import new entries, click the IMPORT button and browse the location with the text file. Then click the SAVE button to add the new list.

Configuration Using CLI

The CLI command fingerprint has the following options:

```
default(15)(config)# fingerprint ?

add                    (10) Adds description and hexadecimal characters.

delete                 (10) Deletes description and hexadecimal characters.

export                 (10) Adds description and hexadecimal characters.
```

```
import                (10) Adds description and hexadecimal characters.

restore               (10) Restores configuration file.
```

- add - To add new device OS type
- delete - Remove an existing device OS type
- import - Specify the filename to import device OS types. The file must be available in /opt/meru/images folder.
- export - To export the current list of device OS types. The exported file is stored as a .txt file in /opt/meru/images directory

Beacon Services

Fortinet Beacon Services use iBeacon to allow mobile application (iOS and Android devices) to receive signals from beacons in the physical world to deliver hyper-contextual content to users based on location. Bluetooth Low Energy (BLE) is the wireless personal area network technology used for transmitting data over short distances. Broadly, the Beacon Service requires a Bluetooth based iBeacon device to broadcast signals and a mobile application to receive these signals once it comes in the configured proximity. You can now create multiple Beacon Service profiles and map APs to a specific profile.

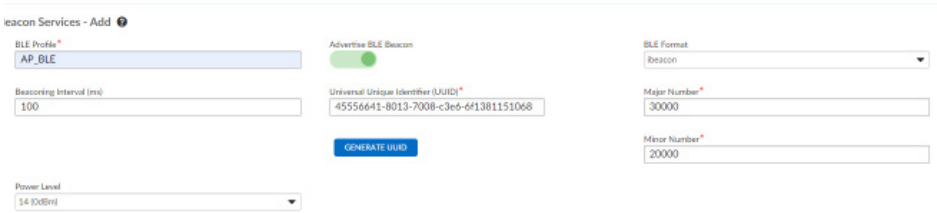
The Beacon services are available by default in FAP-U42xEV, FAP-U32xEV, FAP-U22xEV, and FAP-24JEV. For other non-wave2 APs, you will need Bluetooth adapters (For example: Broadcom USB Class 2 Bluetooth 4.0 Dongle, CSR Bluetooth 4.0 Dongle, and Iogear Bluetooth 4.0 USB Micro Adapter GBU521). Ensure that Bluetooth adapters support Bluetooth version 4.0 or above.

Note:
Wave 1 APs must be connected to 802.3at power supply.

You can perform the following operations to manage the Beacon Services. Navigate to **Configuration > Devices > Beacon Services**.

Adding Beacon Services Profiles

This option allows you to add a **Beacon Service**. You can create multiple Beacon Service profiles and also map APs to a specific profile.
APs part of a profile send iBeacons that will help advertise hyperlocal content to users in context to their location.



Update the following fields.

BLE Profile – Unique name for this **Beacon Service** profile. The supported range is 1-64 alphanumeric characters.

Advertise BLE Beacon – Enables the BLE beacons to advertise packets received by devices. These packets determine the location of the device with respect to the Beacon.

BLE Format - BLE Format - Select ibeacon as a BLE Format.

Beaconing Interval (ms) – Select the time interval at which the Beacons transmit signals to associated devices, that is, this sets the rate at which beacons advertise packets. Setting the beacon interval to a higher value decreases the frequency of unicasts and broadcasts sent by the AP. The supported range is 100-1000 milliseconds.

Universal Unique Identifier (UUID) – Click **Generate UUID**, to receive a UUID that is specific to the beacon. The purpose of the ID is to distinguish iBeacons in your network from all other beacons in other networks not monitored by you.

Major Number – This number is assigned to some beacons in a network and is used to distinguish this subset of beacons within a larger group of beacons. For example, beacons within a particular geographic area can have the same major number. The supported range is 0 to 65535.

Minor Number – This number is assigned to identify individual beacons. For example, each beacon in a group of beacons with the same major number, will have a unique minor number. The supported range is 0 to 65535.

Power Level – Select a power level for the beacon's transmit signal. The higher the power the greater will be the range of your signal. This is measured in dBM (Decibel-Milliwatts). The supported range is 0(-29 dBm) to 15(4dBm).

Exporting Beacon Services Profiles

You can export the existing Beacon profiles into your local drive.

Importing Beacon Services Profiles

You can load Beacon Services profiles by importing files (*.csv) from your local drive.

Click **Import** and browse to the saved *.csv template file.

Adding APs to the Beacon Service Profile

Click the edit icon to view the service profile details. **Beacon Services – Update** page is displayed to make changes to the service profile.

Click the **Add** option to start adding APs to the service profile. By default this page shows the list of APs added to the service profile.

- You can add multiple APs to a service profile.
- An AP can be mapped to only one service profile at a time.

Editing Beacon Services Profiles

Select the Beacon Services profile and click **Edit** to edit the values for an existing profile.

Deleting Beacon Services Profiles

Select the **Beacon Services** profile and click **Delete** in the **Action** column to delete the profile.

REST APIs

REST (**RE**presentational **S**tate **T**ransfer) is a modern, scalable (but not high performance) client-server based RPC technique using existing HTTP protocol methods (such as GET, POST, PUT, DELETE) on server resources (identified by URLs) and transferring the resources in either XML / JSON / HTML representation. The REST module currently offers Basic authentication, here, the user supplies credentials (request header ***Authorization*: *Basic***) in each request. That is, this type of authentication is *stateless*! Thus, no *login* and *logout* calls are used here, enabling one to execute HTTP methods on resources requiring credentials but without overhead of logging in. For more information see the *FortiWLC REST API Guide*.

5 Configuring an ESS

A basic service set (BSS) is the basic building block of an IEEE 802.11 wireless LAN; one access point together with all associated clients is called a BSS. An AP acquires its clients by broadcasting its name (SSID) which is picked up by clients within range. Clients can then respond, establishing a connection. It is legitimate for multiple access points to share the same SSID if they provide access to the same network as part of an Extended Service Set (ESS). You can establish different kinds of ESS for different situations such as:

- a VLAN that supports multiple access points per ESS.
- several different ESS on one physical access point.
- a VLAN for each ESS to separate network traffic. You can also specify that a VLAN be shared between multiple ESS.
- an ESS that supports just one person.
- an ESS for a remote AP, such as in a branch office. That AP can additionally support ESSs for local traffic.

The Wireless LAN System also allows you to customize a beacon per ESS to support different access point settings, such as base or supported transmit rates, different BSSs, different beacon intervals, and different DTIM periods. This beacon customization allows service customization for each ESS, as well as more flexibility in supporting different clients and services.

ESS profiles for a controller can also be configured from E(z)RF Network Manager. You can tell where an ESS was configured by checking the read-only field Owner. The Owner is either nms-server or controller.

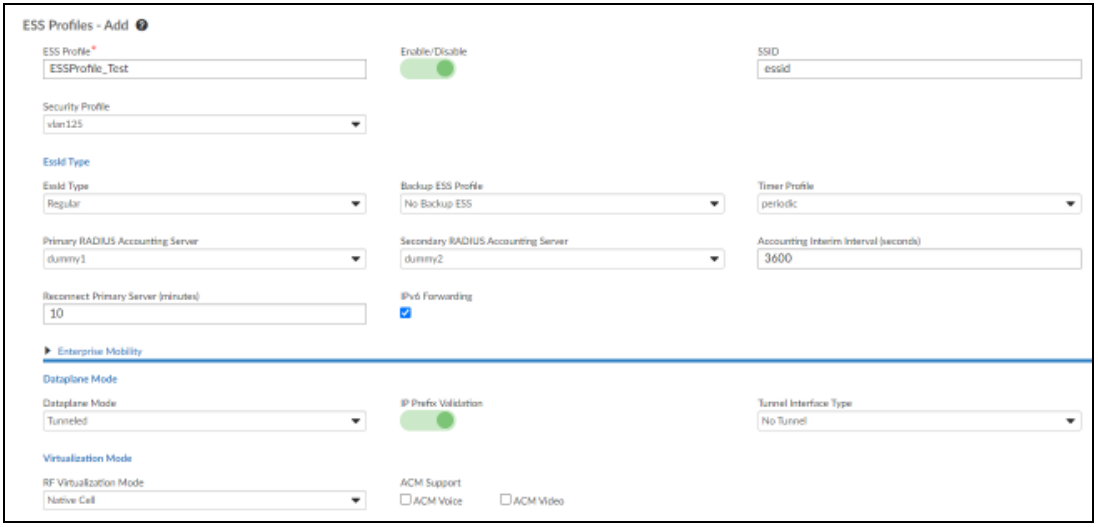
Add an ESS with the Web UI

ESS profiles can be configured either from E(z)RF Network Manager or from the controller. You can tell where an ESS profile was configured by checking the read-only field Owner; the Owner is either nms-server or controller. To add an ESS from the controller's Web UI, follow these steps:

1. Click Configuration > Wireless > ESS > Add.

The ESS Profile Add screen displays - see below.

Figure 37: *Adding an ESS Profile*



2. In the ESS Profile Name field, type the name (ID) of the extended service set. The name can be up to 32 alphanumeric characters long with no spaces.
3. In the Enable/Disable list, select one of the following:
   - Enable: ESS Profile created is enabled.
   - Disable: ESS Profile created is Disabled.
4. In the SSID field, type a name up to 32 characters for the SSID for this ESS. (Note that when you are creating either Virtual Cell overflow or a non-Virtual Cell ESS, you will be creating two ESS Profiles with the same ESSID. See *"Configure Virtual Cell Overflow with the Web UI"* ***on page 160*** for details.)
5. In the Security Profile Name list, select an existing Security Profile to associate with the ESS profile. By default, an ESS profile is associated with the Security Profile named default. For more explanation, see *"Security Profiles for an ESS"* ***on page 150***.
6. In the Primary RADIUS Accounting Server list, select either the name of a previously configured RADIUS accounting server profile or the No RADIUS option. Selecting the No RADIUS option means that no RADIUS accounting messages will be sent for clients connecting to this ESSID profile. For more information, see the authentication chapter **RADIUS Accounting for Clients**.
7. In the Secondary RADIUS Accounting Server list, select the name of a previously configured RADIUS accounting server profile or the No RADIUS option. If No RADIUS is selected, then no RADIUS accounting messages will be sent for clients connecting to this ESSID profile. For more information, see the security chapter **RADIUS Accounting for Clients**.
8. In the Accounting Interim Interval (seconds) field, type the time (in seconds) that elapses between accounting information updates for RADIUS authentication. If a RADIUS

accounting server is enabled, the controller sends an interim accounting record to the RADIUS server at the interval specified. Accounting records are only sent to the RADIUS server for clients that authenticate using 802.1x. The interval can be from 60 through 36,000 seconds (10 minutes through 10 hours). The default value is 3,600 seconds (1 hour). You can disable this field by configuring a value of 0. For more information, see the security chapter **RADIUS Accounting for Clients**.

9. Enable **IPv6 forwarding** to allow ICMPv6, DHCPv6, and other IPv6 traffic to be passed through the controller in tunnel mode. If disabled, all the IPv6 packets coming into the controller are dropped. IPv6 Forwarding is disabled by default; however, on upgrade the older (pre-upgrade) configuration is retained, whether enabled or disabled**.**
10. Enable 802.11r and specify the 802.11r Group (an integer value) to allow fast roaming for 802.11r clients between best available access points. Fast roaming is supported on AP122, AP822, AP832, OAP832, and FAP-U models. Fast roaming does not support inter-controller roaming.
11. Enable 802.11k to allow APs to discover the best available access point neighbours.
12. Enable 802.11v standards for wireless networks, which provide several enhancements for network management such as network assisted roaming and power saving.
    Network assisted roaming allows the wireless network to send requests to associated clients, recommending better APs to associate with while roaming. This is beneficial for both load balancing and in guiding clients with poor connectivity.
    Network assisted power saving allows configuring an idle period for devices ensures that they remain connected to APs without receiving any frames from them. This helps in reduced power consumption and improved battery life. The following fields, **BSS Transition**, **Max Idle Period**, **Client Idle Timeout**, and **Direct Mcast Service**, are defined by the 802.11v standard.
    Note: 802.11k and ARRP must be enabled to use 802.11v capabilities.
    - Enable **BSS Transition** to allow the roaming client to initiate a BSS transition query to the associated AP for a candidate list of other APs it can re-associate with, the associated AP responds with a BSS transition request containing the requested AP list. The AP can also send an unsolicited BSS transition request to the client. The client can accept the request and re-associate with the suggested APs or it can reject the request and continue its association with the current AP.
    - Enable the **Max Idle Period** to configure the amount of time that an AP keeps a connected client associated without receiving any frames from it, that is, this value configures the maximum time a client remains idle without transmitting any frames to the AP. When the idle period is configured, the clients are not required to send repeated keep-alive messages to the AP and remain in the sleep mode for a longer duration, thereby saving battery power.
      After this period the AP disassociates with the client.
    - Specify the **Client Idle Timeout** duration for the enabled **Max Idle Period**. The valid range is 60 - 3600 seconds and the default is 400 seconds.
    - Enable the **Direct Mcast Service** to allow the AP to transmit the requested multicast traffic as unicast frames. This enables the client to receive the multicast packets ignored

while in the sleep mode. Also, the client receives the packets faster by enabling the radio for a shorter duration as the unicast frames are transmitted at a greater wireless link rate. This saves battery power.

13. By default, access points that join the ESS profile and have the same channel form a Virtual Cell. In the New APs Join ESS profile list, select one of the following:
    - On: (default) Access points automatically join an ESS profile and are configured with its parameters.
    - Off: Prevents access points from automatically joining an ESS profile. The user is now allowed to add multiple interfaces on the ESS Profile screen. Perform the following steps to add multiple interfaces:
        - On the ESS Profile - Update screen select the New APs Join ESS profile as Off. This option prevents the APs from automatically joining an ESS profile.
        - Select the checkbox for an ESS profile and click the Settings button.
        - The ESS Profile - Update screen is displayed.
        - On the ESS Profile - Update screen, select the ESS-AP Table tab.
        - The ESS-AP Configuration screen is displayed. No information is displayed on the ESS-AP Configuration screen.
        - On the ESS-AP Configuration screen, click the Add button.
        - The ESS-AP Configuration - Add screen is displayed. Here, the user is now allowed to add multiple interfaces on the ESS Profile screen.
        - Click OK.
        - The selected interfaces are now displayed on the ESS-AP Configuration screen.
14. In the Tunnel Interface Type, select one of the following:
    - No Tunnel: No tunnel is associated with this ESS profile.
    - Configured VLAN Only: Only a configured VLAN listed in the following VLAN Name list is associated with this ESS profile. If you select this option, go to Step 13.
    - RADIUS VLAN Only: The VLAN is assigned by the RADIUS server via the RADIUS attribute Tunnel Id. Use RADIUS VLAN Only when clients authenticate via 802.1x/WPA/WPA2 or MAC Filtering.
    - RADIUS and Configured VLAN: Both a configured VLAN and RADIUS VLAN are associated with this ESS profile. If you select this option, proceed to Step 15.
    - GRE: Specifies a GRE Tunnel configuration If you select this option, go to Step 14. For details, see the security chapter **Configure GRE Tunnels**.
15. If you selected Configured VLAN Only in Step 12, select a VLAN from the list to associate with this ESS profile.
16. If you selected GRE for Tunnel Interface Type, select the name of a GRE Tunnel profile previously configured in the Configuration > Wired > GRE area. For GRE to work, DHCP relay must be enabled either locally or globally.

17. In the Allow Multicast Flag list, optionally enable multicasting (on). Only enable multicasting if you need to use a multicast application. Enabling multicasting causes all multicast packets on the air side to appear on the wired side, and all multicast packets on the wired side to appear on the air side. Also see *"Multicast"* ***on page 164*** in this chapter.
    - On: Enables multicasting. Enable multicasting only if you need to use a multicast application. Enabling multicasting causes all multicast packets on the air side to appear on the wired side, and all multicast packets on the wired side to appear on the air side.
    - Off: Disables multicasting.
18. In the Multicast-to-Unicast Conversion, select one of the following:
    - On: Enables multicast-to-unicast conversion. Enabling this conversion allows multicast packets to be converted to unicast packets and deliver it all the clients.
    - Off: Disables multicast-to-unicast conversion.The multicast packets will be delivered as multicast packets to the clients.
19. The RF Virtualization Mode drop-down in the ESS Configuration page allows the user to specify the type of virtualization used by the specified ESS profile. The option for selections are as follows:
    - Virtual Cell:
    - Virtual Port: This option is not supported on Wave 1 and Wave 2 AP models.
    - Native Cell: This option disables virtualization on the ESS and is the default setting for all APs.

All APs on the same channel in a Virtual Cell must have the same setting for these values:

- RF-Mode
- Channel Width
- N-only Mode
- Channel and MIMO mode

ACM Support: This is available in **Native Cell** and **Virtual Cell** mode. Enable this option to support Ascom and Spectralink certificate complaint phones.

The **ACM Voice** and **ACM Video** determine the bandwidth that is allocated to the voice calls. Of the maximum calls configured per radio, 70% of the bandwidth is allocated to the voice and video mediums. The control messages before the initiation of the call uses the video medium and once the call is established the voice medium is used.

SSID Broadcast Preference: Available in the **Virtual Port** mode. This is specific to address the Cisco phone connectivity issues. It consists of three options as follows:

- **Disable**: Configuring the parameter to "Disable" makes the AP not to advertise the SSID string in the beacon.

- **Always**: Configuring the parameter to "Always" enables the AP to advertise the SSID on the beacons always. This must not be configured unless recommended.
- **Till-Association**: This is the default option. Configuring the parameter to "Till Association" enables the AP to advertise the SSID in the beacons till the association stage of the client and disable the SSID broadcast in the later part of connectivity. This parameter is preferable to configure for certain versions of phones which resolve connectivity issues in the Virtual Port mode. Once the station is associated, AP stops broadcasting SSID string and the users are allowed to configure SSID broadcast, per ESS, from the FortiWLC GUI or CLI. For configuration, see *"SSID Broadcast for Vport"* ***on page 172*** in this chapter. By default, this option is selected.

20. You can make this ESS an "overflow" ESS by selecting a Virtual Cell ESS for the Overflow for: setting. This means that when the named Virtual Cell ESS (that was created earlier) maxes out, it will overflow into this non-Virtual Cell ESS. This works by having the two ESS Profiles share an SSID so they can seamlessly move clients back and forth as needed. For more explanation, see *"Virtual Cell Overflow Feature"* ***on page 159***.
21. In release 5.1, WMM configuration in the ESSID has no effect. However, in order to enable or disable APSD features across APs, the WMM parameter must be set to on. For more information, see *"Supported WMM Features"* ***on page 158***.
22. For APSD support, select on or off. APSD stands for Advanced WMM Power Save. For more explanation, see *"Supported WMM Features"* ***on page 158***.
    On: Data packets for powersave mode clients are buffered and delivered based on the trigger provided by the client. This feature saves more power and provides longer lifetime for batteries than the legacy power save mode (TIM method). Note that you must have-WMM set to on for this to work - see previous step.
    Off: No APSD support.
23. In the Dataplane Mode list, select the type of AP/Controller configuration:
    - Tunneled: (default) In tunneled mode, a controller and an AP are connected with a data tunnel so that data and control packets from a mobile station are tunneled to the controller from the AP and vice versa.
    - Bridged: (Bridged mode was formerly Remote AP mode.) In bridged mode, data packets are not passed between AP and the controller; only control plane packets are passed. When bridged mode is configured, an AP can be installed and managed at a location separated from the controller by a WAN or ISP, for example at a satellite office. The controller monitors the remote APs through a keep-alive signal. Remote APs can exchange control information with the controller, including authentication and accounting information, but they are unable to exchange data. Remote APs can, however, exchange data with other APs within their subnet. ESSIDs in bridged mode cannot exchange dataplane traffic (including DHCP) with the controller and the following FortiWLC (SD) features are not available in a bridged configuration: Rate Limiting, and QoS (and all QoS-related features). For more explanation, see *"Bridging Versus Tunneling"* ***on page 161*** in this chapter.
      A VLAN tag can be configured for a Bridged mode profile (see Step 33 below) and then multiple profiles can be associated to that VLAN tag. The AP VLAN priority can be set in

Step 26 below.

24. Provide an AP VLAN tag between zero and 4094. This VLAN tag value is configured in the controller VLAN profile and is used for tagging client traffic for ESSIDs with dataplane mode bridged, using 802.1q VLAN. This field indicates whether an AP needs to map incoming VLAN 802.1p data packets into WMM ACs or not. By default in a bridged ESS, this field is disabled and an AP always honors DSCP field in IPV4 packet to map an incoming packet to one of WMM ACs. When turned on, an AP honors VLAN 802.1p priority over DSCP priority when the packet is mapped into one of WMM ACs.
25. To Enable VLAN Priority, set this field to **On**.
    - On: AP disregards the DSCP value in the IP header of a packet.
    - Off: AP honors the DSCP values in the IP header of a packet. AP converts the DSCP value in the IP header to appropriate WMM queues. This feature works only for downstream packets and only for an ESSID with dataplane mode set to bridged.
26. **Beacon Interval** sets the rate at which beacons are transmitted. Setting the beacon interval to a higher value decreases the frequency of unicasts and broadcasts sent by the access point. If the power-save feature is enabled on clients that are connected to access points, clients “wake up” less if fewer unicasts and broadcasts are sent, which conserves the battery life for the clients. In the Beacon Interval field, type the interval (in ms) at which beacons are transmitted. The beacon interval must be between 20 through 1000 milliseconds. If your WLAN consists mostly of Wi-Fi phones, and you have a low number of ESSIDs configured (for example, one or two), Fortinet recommends setting the beacon interval to 100.
27. **Isolate Wireless to Wireless Traffic** can be used to prevent two wireless stations operating on the same L2 domain from communicating directly with each other. This is not a common requirement, but can be necessary for some security policies. Set the option to On if your network requires this.

Note that this feature functions on both bridged and tunnel profiles and works only on an ESS profile utilized by a single AP.

28. In the **SSID Broadcast** list, select one of the following:
    - On: SSID is included in the beacons transmitted.
    - Off: SSID is not included in the beacons transmitted. Also Probe Responses will are not sent in response to Probe Requests that do not specify an SSID.
29. DTIM affects clients in power save mode. In the DTIM Period field, type the number of beacon intervals that elapse before broadcast and multicast frames stored in buffers are sent. This value is transmitted in the DTIM period field of beacon frames.
    The DTIM period can be a value from 1 through 255. The default DTIM period is 1. Setting the DTIM period to a higher value decreases the frequency of broadcasts sent by the access point. If power save is enabled on clients that are connected to access points, clients “wake up” less if fewer broadcasts are sent, which conserves battery life for the cli-

ents.
Only the behavior of clients currently in power-save mode is affected by the DTIM period value. Because broadcasts are generally wasteful of air resources, the Forti WLAN has devised mechanisms that mitigate broadcasts either with proxy services or with more efficient, limited unicasts. As an example, ARP Layer 2 broadcasts received by the wired side are not relayed to all wireless clients. Instead, the Forti WLC maintains a list of IP-MAC address mappings for all wireless clients and replies with proxy-ARP on behalf of the client.

30. For **Countermeasure**, select when to enable or disable MIC Countermeasures:
    - On: (default) Countermeasures are helpful if an AP encounters two consecutive MIC errors from the same client within a 60 second period. The AP will disassociate all clients from the ESSID where the errors originated and not allow any clients to connect for 60 seconds. This prevents an MIC attack.
    - Off: Countermeasures should only be turned off temporarily while the network administrator identifies and then resolves the source of a MIC error.
31. To provide faster connection to a phone moving in and out of a coverage area, select the specific **Voice Client Type**.
    - **Spectralink**: This phone type is used only for certification. It changes the minimum and maximum contention window parameters on an ESSID basis for supporting the calls along with FTP data.
    - **Ascom**: The clients probing to ESSID with Ascom, get a probe response when the station is assigned to the radio.
    - **None**: The clients probing to ESSID with None, get a probe response whether the client is assigned to the radio or not.
32. In the Enable Multicast MAC Transparency field, indicate on or off. For more explanation, see *"Multicast MAC Transparency Feature"* ***on page 166*** in this chapter.
    - On: All downstream multicast packets will have the MAC address of the streaming station.
    - Off: (default) All downstream multicast packets will have the MAC address of the controller.
33. Band steering balances multi-band capable clients by assigning bands to clients based on their capabilities. To use band steering for ABGN traffic, you could use A-steering to direct dual mode clients with A capability to the 5GHz band and use N-steering to direct all dual mode clients with AN capability to the 5GHz band. Band steering is also useful for directing multicast traffic. For this command to work as clients are added, also set the field New APs Join ESS to on. For more explanation, see *"Band Steering Feature"* ***on page 167*** in this chapter.Band Steering Mode options are:
    - Band Steering Disabled
    - Band Steering to A band: Infrastructure attempts to steer all A-Capable wireless clients to the 5GHz band when they connect to this ESS. This is the default.

- Band Steering to N band: Infrastructure attempts to steer all N-Capable wireless client that are also A-Capable to the 5GHz band when they connect to this ESS. Infrastructure also attempts to steer non N-Capable wireless clients to the 2.4GHz band.

34. Band Steering Timeout sets the number of seconds that assignment for a steered client is blocked on the forbidden band while it is unassociated. For this command to work, also set the field Band Steering to A-band or N-band (see above). Band Steering Timeout can be any integer from 1-65535.
35. Expedited Forward Override option is implemented to override the system's default DSCP-to-WMM priority mapping. IP datagrams marked with DSCP Expedited Forwarding (46) will be sent from the WMM queue (AC_VO) of the AP rather than the Video queue (AC_VI) in downstream (to stations). It is configured on a per-ESS Profile basis and works in both bridged and tunneled ESS profiles. For configuration, see *"Expedited Forward Override"* ***on page 170*** in this chapter.
36. For the remaining Supported and Base Transmit Rates for B, A, G, BG, BGN, and AN modes, enable or disable rates as needed.
37. Configure **IP Address Cache Timeout** (seconds) for wireless disabled clients residing behind a wireless bridge that might get disconnected when roaming. The IP address of such clients is retained for the configured cache timeout period and if the reconnection occurs within this period then the client connectivity is not impacted. This ensures that wireless bridge clients are not disconnected from the controller even if the wireless bridge is disconnected and connected back. This field supports both IPv4 and IPv6 addresses. The valid range is 0 – 36000 seconds. A value of 0 disables the feature.
38. The MCS index values determine the likely data rate of your WiFi connection using 11ax access points ONLY. Up to 4 spatial streams are allowed in the 2G and 5G bands. Configure the supported and base MCS index values in **AX 2G High Efficiency Settings/AX 5G High Efficiency Settings**.
    Setting the base rate specifies the mandatory rates that all connecting clients must support when connecting to the access point.
    Setting the supported rate specifies the rates at which clients can connect to an access point to transmit data provided the clients and the access points support the rate.
    If **None** is specified for all streams then 11ax capable clients connect as 11ac clients.
39. Click OK.

If Ascom i75 phones are used to connect to WPA2PSK profile with VCell enabled, then create an ESSID with all BGN Supported HT Transmit rates unchecked (set to none).

When is Virtualization Really on for an AP?

To enable virtualization, simply configure the RF Virtualization mode in each ESS profile to Virtual Cell, Native Cell, or Virtual Port.

The RF Virtualization mode is set to Native Cell on the radio interface by default, and it can be changed as desired. This setting overrides the RF Virtualization mode configuration at the ESS-level.

Adding an ESS with the CLI

Assigning an ESSID with the CLI

The ESSID is the ESS name that clients use to connect to the WLAN. An ESSID can be a string of up to 32 alphanumeric characters long. Do not use spaces or special characters.

The following example names an ESS ***corp-users*** and enters ESSID configuration mode:

```
controller# configure terminal
   controller(config)# essid corp-users
   controller(config-essid)#
```

Enable and Disable

The Enable and Disable field represents all the Enabled and Disabled services of a profile. If a specific ESS profile is Disabled, the NMS deletes all the Services that belong to the ESS profile. If a specific ESS profile is Enabled, the NMS creates all the Services that belong to the ESS profile. A client will not associate to the ESSID profile when its state is disabled.

The "Service" refers to client connectivity. When the ESSID state is disabled, the BSSID is removed from the AP and the client will not be able to view the Disabled SSID on air.

CLI Configuration

```
default# sh essid
```

ESS Profile Name Interface Type	Enable/Disable	SSID	Security Profile	Broadcast	Tunnel
Forti	enable	Forti	default	on	none
Fortiwpa	enable	Fortiwpa	Fortiwpa	on	none
Fortiwpa2psk	enable	Fortiwpa2psk	Fortiwpa2psk	on	none

```
ESS Profile(3)

default# configure terminal
   default(config)# essid Forti
```

```
default(config-essid)# disable
default(config-essid)# end
default# sh essid
```

ESS Profile Name Interface Type	Enable/Disable	SSID	Security Profile	Broadcast	Tunnel
corp-wifi	disable	corp-wifi	default	on	none
corpwpa	enable	corpwpa	corpwpa	on	none
corpwpa2psk	enable	corpwpa2psk	corpwpa2psk	on	none

```
ESS Profile(3)

default# sh essid corp-wifi
  ESS Profile

ESS Profile                                : corp-wifi
  Enable/Disable                             : enable
  SSID                                       : corp-wifi
  Security Profile                           : default
  Primary RADIUS Accounting Server           :
  Secondary RADIUS Accounting Server         :
  Accounting Interim Interval (seconds)      : 3600
  Beacon Interval (msec)                     : 100
  SSID Broadcast                             : on
  Bridging                                   : none

<---snipped ---

---

---

---
BGN Supported Transmit Rates (Mbps)     : 1,2,5.5,11,6,9,12,18,24,36,48,54

BGN Base Transmit Rates (Mbps)             : 11
BGN Supported HT Transmit Rates (MCS)      :
0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23
BGN Base HT Transmit Rates (MCS)           : none
AN Supported Transmit Rates (Mbps)         : 6,9,12,18,24,36,48,54
AN Base Transmit Rates (Mbps)              : 6,12,24
AN Supported HT Transmit Rates (MCS)       :
0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23
AN Base HT Transmit Rates (MCS)            : none
```

```
Owner                                        : controller
1 Stream VHT Base MCS Set (MCS)              : mcs0-9
2 Streams VHT Base MCS Set (MCS)             : mcs0-9
3 Streams VHT Base MCS Set (MCS)             : mcs0-9
1 Stream VHT Supported MCS Set (MCS)         : mcs0-9
2 Streams VHT Supported MCS Set (MCS)        : mcs0-9
3 Streams VHT Supported MCS Set (MCS)        : mcs0-9
default#
```

Security Profiles for an ESS

ESS profiles and Security profiles can be configured either from E(z)RF Network Manager or from the controller. You can tell where a profile was configured by checking the read-only field Owner; the Owner is either nms-server or controller. Each ESS must be associated with a security profile. If you do not create additional security profiles, an ESS is automatically associated with the default security profile named ***default***. To use additional security profiles, create them using the security-profile command in global configuration mode (see either this chapter, *"Add an ESS with the Web UI"* ***on page 139*** or **Chapter , ","** for details). Create the security profile before creating the ESS. You cannot alter profiles created in E(z)RF Network Manager from a controller.

The following CLI example associates a security profile named corp-access:

```
controller(config-essid)# security-profile corp-access
   controller(config-essid)#
```

Configuring CAC for an ESSID AP with the CLI

If implemented, Call Admission Control (CAC) limits the number of VoIP calls for all BSSIDs with the command qosvars calls-per-bssid (see *"Configuring QoS Rules With the CLI"* ***on page 413***). If you have special requirements for an ESSID, you can set the CAC maximum calls limit specifically for the ESS using the calls-per-bss command from the essid/ess-ap configuration sublevel. For example, to set a maximum of 10 calls for AP 1, interface 1 in the ESSID, use the following command:

```
controller(config-essid)# ess-ap 1 1
   controller(config-essid-essap)# calls-per-bss 10
   controller(config-essid-essap)# exit
```

Configuring Beacon Parameters with the CLI

You can set the following beacon parameters:

- Beacon DTIM period—DTIM affects clients in power save mode. In the DTIM Period field, type the number of beacon intervals that elapse before broadcast frames stored in buffers are sent. This value is transmitted in the DTIM period field of beacon frames.

The DTIM period can be a value from 1 through 255. The default DTIM period is 1. Setting the DTIM period to a higher value decreases the frequency of broadcasts sent by the access point. If power save is enabled on clients that are connected to access points, clients “wake up” less if fewer broadcasts are sent, which conserves battery life for the clients.

Only the behavior of clients currently in power-save mode is affected by the DTIM period value. Because broadcasts are generally wasteful of air resources, the Forti WLAN has devised mechanisms that mitigate broadcasts either with proxy services or with more efficient, limited unicasts. As an example, ARP Layer 2 broadcasts received by the wired side are not relayed to all wireless clients. Instead, the Forti WLC maintains a list of IP-MAC address mappings for all wireless clients and replies with proxy-ARP on behalf of the client.

- Beacon interval—Sets the rate at which beacons are transmitted.

  The beacon period setting affects unicasts and broadcasts. The beacon interval must be between 20 through 1000 milliseconds. Setting the beacon interval to a higher value decreases the frequency of unicasts and broadcasts sent by the access point. If the power-save feature is enabled on clients that are connected to access points, clients “wake up” less if fewer unicasts and broadcasts are sent, which conserves the battery life for the clients. The beacon period setting affects unicasts and broadcasts.

  If your WLAN consists mostly of Wi-Fi phones, ***and*** you have a low number of ESSIDs configured (for example, one or two), Fortinet recommends setting the beacon interval to 100.

The following example sets the beacon DTIM period to 10 and beacon interval to 240 TUs:

```
controller(config-essid)# beacon dtim-period 10
  controller(config-essid)# beacon period 240
```

Configuring ESSID Broadcasting with the CLI

By default, an ESSID is broadcast. When an ESSID is broadcast, it is included in the advertised beacon. Clients using passive scanning listen for beacons transmitted by access points. If ESSID broadcasting an is disabled, those clients listening for beacons cannot receive ESSID information.

Clients using active scanning send probe requests and wait for probe responses from access points. If broadcasting an ESSID is disabled, access points do not respond to probe requests, unless the probe request includes the ESSID.

To prevent the ESSID from being broadcast, use the no publish-essid command.

The following example prevents the ESSID from being broadcast:

```
controller(config-essid)# no publish-essid
```

Configuring ESSID Joining of Access Points with the CLI

By default, when a new access point is plugged into the WLAN, it joins all ESSIDs that are configured to have new access points automatically join upon discovery and a BSSID is created.

After you are satisfied with your WLAN configuration, you can disable the automatic joining so that new access points do not change your configuration. If you are adding a new ESS that you want to advertise on only a small subset of access points, it is easier to disable joining and add the ESS-AP mappings manually.

The following example prevents access points from automatically joining an ESSID:

```
controller(config-essid)# no ap-discovery join-ess
```

After preventing automatic joining, a BSSID must be assigned manually.

The status of this command is only evaluated when new ESS-AP mappings are created. ESS-AP mappings are either created manually with the **ess-ap** command, or automatically when a new ESS is created, or a new access point is discovered.

Configuring Virtualization Mode

The RF Virtualization Mode drop-down in the ESS Configuration page allows the user to specify the type of virtualization used by the specified ESS profile. This option contains three separate selections:

- Virtual Cell—
- Virtual Port—This option is not supported on Wave 1 and Wave 2 AP models.
- Native Cell—This option disables virtualization on the ESS and is the default setting for all APs.

Virtualization is on by default for Fortinet access points. The major benefit of Virtual Cell is infrastructure-controlled handoffs with seamless roaming between access points. Virtual Port enhances Virtual Cell by giving each client its own virtual access point. With Virtual Port, each client has its own access instead of sharing access with other clients. Because each client has its own Virtual Port, you can tailor it to match the client's needs. For example, different employees can be given different amounts of bandwidth, depending on the applications used in their jobs. A client can be given limited bandwidth but high quality of service. A guest is given lower priority and restricted access.

There are three types of limits on the number of Virtual Ports per controller:

- Restricted by the number of clients supported by the controller

- Restricted by the number of AP radios Fortinet's best practices recommendation is to have no more than 64 per radio.
- Restricted by Virtual Cell There is a hard limit of 2007 Virtual Ports per Virtual Cell. This number is set by the standard of having no more than 2007 associations per single BSSID. In Fortinet's environment, each BSSID represents a Virtual Cell.

Configuring Virtual Cell Support with Web UI

There are two steps for configuring Virtual Port:

1. Create an ESS with RF Virtualization mode set to Virtual Port.
2. Configure each radio for Virtual Port by following these steps:
   - Click Configure > Wireless > Radio
   - Select a radio.
   - Set RF Virtualization Mode as Virtual Port.
   - Save the configuration.

Configure multiple radios with Bulk Update.

Configuring Virtual Port Support with the CLI

Virtual Port is enabled by default in AP Radio.

You can see the Virtual Port setting by using the CLI command show interfaces Dot11Radio. For example:

```
vcell22# show interfaces Dot11Radio 398 1 ***************************
  Wireless Interface Configuration


AP ID                                  : 398

AP Name                                : AP-398

Interface Index                        : 1

AP Model                               : AP400

Interface Description                  : ieee80211-398-1

Administrative Status                  : Up

Operational Status                     : Disabled
```

```
Last Change Time                        : 08/01/2013 09:38:35

Radio Type                              : RF6

MTU (bytes)                             : 2346

Primary Channel                         : 6

Operating Channel                       : 6

Short Preamble                          : on

RF Band Support                         : 802.11abgn

RF Band Selection                       : 802.11bgn

Transmit Power High(dBm)                : 24

AP Mode                                 : Service

Scanning Channels                       : 1,2,3,4,5,6,7,8,9,10,11,12,

13,14,36,40,

44,48,52,56,60,64,100,104,108,112,116,120,124,128,132,136,140,149,15

3,157,161,165                                                                B/
  G Protection Mode                      : auto

HT Protection Mode                      : off

Number of Antennas                      : 1

Channel Width                           : 20-mhz

Channel Center Frequency Index          : 42

MIMO Mode                               : 2x2

802.11n only mode                       : off

RF Virtualization Mode                  : VirtualPort

Probe Response Threshold                : 15

Mesh Service Admin Status               : disable

Uplink Type                             : Downlink

Transmit Beamforming Support            : off

STBC Support                            : off
```

To turn Virtual Port off, use this version of the command:

```
vcell22# configure terminal
  vcell22(config)# interfaces Dot11Radio 398 1
  vcell22(config-if-802)# rf-virtual-mode ?
  <mode> (10) Enter RF Virtualization Mode.
  NativeCell Native Cell Mode
  VirtualPort Virtual Port Mode
  vcell22(config-if-802)# rf-virtual-mode NativeCell
```

APs on the same channel in RF Virtualization must have the same setting for these values:

RF-Mode

Channel Width

N-only Mode

Channel and MIMO mode

Configuring Probe Response Threshold

The Probe Response Threshold configures the way in which an AP responds to requests based on its distance from the transmitting device. It is designed to ensure that the AP responds more swiftly to requests sent from stations located nearby. It is configurable through GUI support in addition to the AP CLI. This feature is also configured via bulk update on a per-AP interface level.

This parameter configures the probe response, gratuitous authentication, and de-authentication thresholds.
The probe response threshold restricts the far away AP by not sending any probe response and quickly responds to the probe request sent from a nearby station. Gratuitous authentication threshold restricts the far away AP by not sending the authentication response and quickly responds to the authentication request sent from a nearby station. De-authentication threshold disconnects the far away client and is useful in staying clear of sticky clients, that is, (far away) clients who stick to a bad connection.

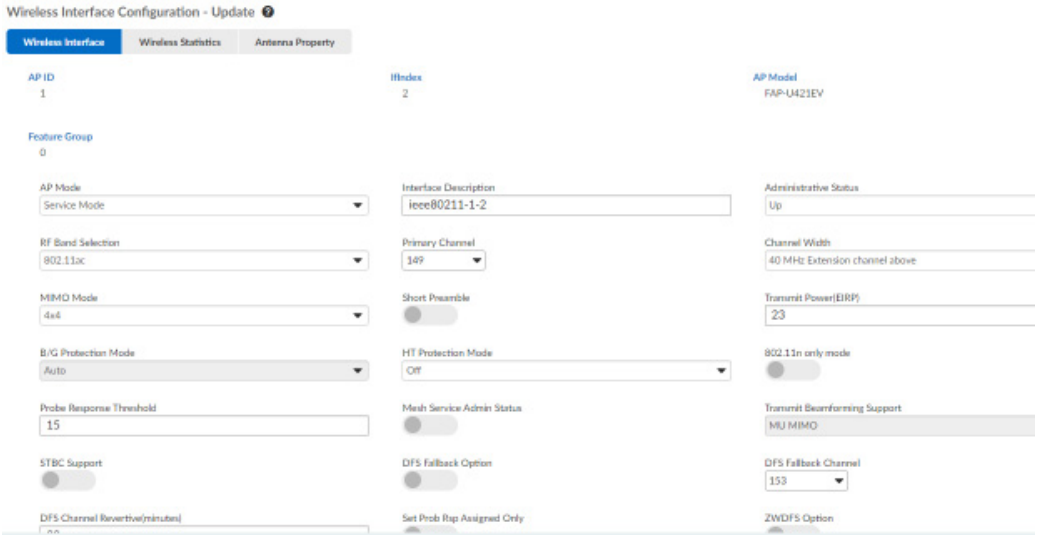
The valid range is 0-100. When set to 0, the probe response, gratuitous authentication and de-authentication thresholds are disabled; they are enabled when set to 1-100.
By default, the probe response threshold is set to 15, the gratuitous authentication threshold is set to 15 and de-authentication threshold is set to 12.

This feature is also configured via bulk update on per AP interface level. It is per interface configuration, the probe response threshold can be configured separately on both the interfaces. The value for the gratuitous authentication threshold is the same as that of the Probe Response Threshold. If you change the Probe Response Threshold value, the changes will take effect for gratuitous authentication threshold as well.

SNRRange

The GUI must have the SNR value ranging from 0 to 100, zero means probe response threshold disable.

GUI Page



Configuring Data Transmit Rates with the CLI

The default settings in use for these products are:
802.11b: Base (1,2,5.5,11), Supported (1,2,5.5,11)
802.11bg: Base (1,2,5.5,11), Supported (all)
802.11a: Base (all), Supported (all)

The data transmit rate is the data rate that the access points use to transmit data. There are two types of data rates:

- Base data transmit rates
  Mandatory rates that all connecting clients must support when connecting to access points. For 802.11AN/BGN, the data rate is selected using MCS Index. The actual data rate is computed based on MCS Index, Channel Width, and Guard Interval. When channel width selected is 40MHz Extension above, then the data rate for the client depends on associated clients channel width and guard interval capabilities. Valid rates are as follows:
  - 802.11b valid rates are 1, 2, 5.5, 11 Mbps, or all
  - 802.11g valid rates are 6, 9, 12, 18, 24, 36, 48, 54 Mbps, or all
  - 802.11bg valid rates are 1, 2, 5.5, 11, 6, 9, 12, 18, 24, 36, 48, 54 Mbps, or all

- 802.11bgn valid rates are 1, 2, 5.5, 11, 6, 9, 12, 18, 24, 36, 48, 54 Mbps, or all
- 802.11a valid rates are ***6, 9, 12, 18, 24, 36, 48, 54*** Mbps, or all
- 802.11an valid rates are 6, 9, 12, 18, 24, 36, 48, 54, or all
- 802.11an-mcs valid rates are MCS 0, MCS 1, MCS 2, MCS 3, MCS 4, MCS 5, MCS 6, MCS 7, MCS 8, MCS 9, MCS 10, MCS 11, MCS 12, MCS 13, MCS 14, MCS 15, or all
- 802.11bgn-mcs valid rates are MCS 0, MCS 1, MCS 2, MCS 3, MCS 4, MCS 5, MCS 6, MCS 7, MCS 8, MCS 9, MCS 10, MCS 11, MCS 12, MCS 13, MCS 14, MCS 15, or all

- Supported data transmit rates
  Rates at which clients can optionally connect, provided the clients and access points support the rates. Valid rates are as follows:
  - 802.11b valid rates are 1, 2, 5.5, 11 Mbps, or all
  - 802.11g valid rates are 6, 9, 12, 18, 24, 36, 48 and 54 Mbps, or all
  - 802.11bg valid rates are 1, 2, 5.5, 11, 6, 9, 12, 18, 24, 36, 48 and 54 Mbps, or all
  - 802.11bgn valid rates are 1, 2, 5.5, 11, 6, 9, 12, 18, 24, 36, 48 and 54 Mbps, or all
  - 802.11a valid rates are ***6, 9, 12, 18, 24, 36, 48, and 54*** Mbps, or all
  - 802.11an valid rates are ***6, 9, 12, 18, 24, 36, 48, and 54*** Mbps, or all
  - 802.11an-mcs valid rates are MCS 0, MCS 1, MCS 2, MCS 3, MCS 4, MCS 5, MCS 6, MCS 7, MCS 8, MCS 9, MCS 10, MCS 11, MCS 12, MCS 13, MCS 14, MCS 15, or all
  - 802.11bgn-mcs valid rates are MCS 0, MCS 1, MCS 2, MCS 3, MCS 4, MCS 5, MCS 6, MCS 7, MCS 8, MCS 9, MCS 10, MCS 11, MCS 12, MCS 13, MCS 14, MCS 15, or all

    All base rates must be entered as supported rates.

Changing the base rate in an ESS profile will cause all clients on all ESSIDs to reassociate.

The supported data rates are the rates supported by the access points. The basic data rates are a subset of the supported rates. The access point first tries to transmit at the highest data rate set to Basic. If there are problems encountered in the transmission, the access points steps down to the highest rate that allows data transmission.

Use the base-tx-rates command in ESSID configuration mode to configure the basic data rates, for example, for 802.11bg:

```
controller(config-essid)# base-tx-rates 802.11bg 1|2|5.5|11|9|12|18|24|36|48|54|all
```

Use the supported-tx-rates command in ESSID configuration mode to configure the supported transmit rates, for example, for 802.11bg:

```
controller(config-essid)# supported-tx-rates 802.11bg
   1|2|5.5|11|9|12|18|24|36|48|54|all
```

To remove a base transmit rate, use the no base-tx-rates command with the mode and speed value, for example, for 802.11bg:

```
controller(config-essid)# no base-tx-rates 802.11bg
   1|2|5.5|11|9|12|18|24|36|48|54|all
```

To remove a supported transmit rate, use the no supported-tx-rates command with the mode and speed value, for example, for 802.11bg:

```
controller(config-essid)# no supported-tx-rates 802.11bg
   1|2|5.5|11|9|12|18|24|36|48|54|all
```

To display the radio data rates, use the show essid command.

Assigning a VLAN with the CLI

When creating an ESSID, you can assign a VLAN to the ESSID. This allows you isolate an ESSID to a specific part of your network. By default, ESSIDs do not have VLANs assigned to them. You must create a VLAN using the vlan command in global configuration mode ***before*** assigning the VLAN to an ESSID.

The following example assigns a vlan named ***corp***:

```
controller(config-essid)# vlan corp
   controller(config-essid)#
```

To remove a VLAN assignment from an ESSID, use the no vlan name command. The following example removes the VLAN assignment from the ESSID:

```
controller(config-essid)# no vlan corp
   controller(config-essid)#
```

Supported WMM Features

In general, WMM contains these features:

- WMM (for QoS)
- WMM PS (U-APSD) - helps with battery life

FortiWLC (SD) supports WMM packet tagging for QoS on APs automatically (if the client is WMM); this feature cannot be turned off.

U-APSD is ideally suited to mobile devices that require advanced power-save mechanisms for extended battery life, and for applications like VoIP where the user experience rapidly degrades as latency increases. WMM Power Save was designed for mobile and cordless

phones that support VoIP. See the chart below for defaults and possible configurations of both the WMM QoS and WMM APSD features.

WMM-PS is an enhancement over the legacy power-save mechanisms supported by Wi-Fi networks. It allows devices to spend more time in a “dozing” state, which consumes less power, while improving performance by minimizing transmission latency. Furthermore, U-APSD promotes more efficient and flexible over-the-air transmission and power management by enabling individual applications to control capacity and latency requirements.

If a deployment utilizing AP models has WMM or WMM-APSD VoIP phones in use with DSCP set to Expedited Forwarding, a special QoS rule must be configured to support the deployment. This rule must have a DSCP parameter value of CS6 or CS7 in order to ensure that the AP queues packets properly, ensuring optimal call quality.

U-APSD capable stations download frames buffered from AP during unscheduled Service Periods (SP); the result is that there is no wait for beacons as there is in the legacy method. For U-APSD capable stations, APs negotiate U-APSD and use it to transmit data for the WMM Access Categories (priority levels) negotiated for U-APSD when a station is in power save mode. When a device is in power-save mode, the uplink data frame triggers AP to send frames buffered in U-APSD enabled WMM_AC-queues. Pending legacy mode frames are not transmitted. You can configure AP U-APSD support from the CLI using the ESSID command apsdsupport or you can configure APSD support for an ESSID from the Web UI (Configuration > Wireless > ESSID and then turn on U-APSD).

Configure U-APSD

APSD settings are configured per ESS and APSD support is on by default. To configure APSD from the Web UI, click Configuration > Wireless > ESS > select an ESS from the list > set APSD Support to on.

To turn on/off APSD support with the CLI, use the command apsd-support for the ESSID as shown in this example:

```
default# configure terminal
   default(config)# essid apsd
   default(config-essid)# no apsd-support
   default(config-essid)# end
```

Virtual Cell Overflow Feature

This feature, called Vcell Overflow, works by pairing a Virtual Cell ESS with a non-Virtual Cell ESS. The overflow ESS automatically inherits the parameters of the Virtual Cell ESS (except the setting for Virtual Cell). The non-Virtual Cell ESS is not used unless the Virtual Cell ESS is maxed-out; when this happens, the Virtual Cell ESS overflows into the other ESS as needed. The two ESS Profiles share same SSID so that clients seamlessly move back and forth. The

overflow decision is based on the percentage of airtime spent on beacons crossing a threshold; when the percentage reaches 50%, clients start to overflow.

When Would I Use Virtual Cell Overflow?

This feature is designed for a high density deployment and provides a solution for bottlenecks caused by transmitting beacons. Virtual Cell Overflow is useful in these situations:

- Beacon overhead has become very high due to the legacy b devices.
- A very dense network is consuming a lot of airtime with beacons.

Be aware that Virtual Cell Overflow has these tradeoffs:

- Trade-off between mobility and performance
- Trade-off between density and performance
- Not a solution to get good performance for overflow clients

Configure Virtual Cell Overflow with the Web UI

To set up Virtual Cell Overflow from the Web UI, follow these steps:

1. Create a Virtual Cell ESS by following the directions *"Add an ESS with the Web UI"* ***on page 139***. Be sure that the setting for Virtual Cell is set to On.
2. Create a non-Virtual Cell ESS by following the directions *"Add an ESS with the Web UI"* ***on page 139***. Be sure that the setting for RF Vitualization Mode is not Virtual Cell. Make this an Overflow ESS with the setting Overflow for; select the ESS you created in Step 1. This overflow ESS automatically inherits the remaining parameters of the Virtual Cell ESS.

Configure Virtual Cell Overflow with the CLI

In the CLI, a new command, overflowfrom-essprofile, has been added for this purpose. See the example below.

```
default(15)# show essid
   ESS Profile                    Enable/Disable SSID                    Secu-
   rity Profile Broadcast  Tunnel Interface Type
   vcelloverflow                    enable         vcelloverflow
   default         on        none
   ESS Profile(1)

   default(15)# configure terminal
   default(15)(config)#
   default(15)(config)# essid vcelloveflowoss
   default(15)(config-essid)# overflow-from vcelloveflow
   default(15)(config-essid)# end

   default(15)# show essid
```

```
   ESS Profile                    Enable/Disable SSID                    Secu-
   rity Profile Broadcast Tunnel Interface Type
   vcelloverflow                    enable         vcelloverflow
   default         on        none
   vcelloverflowoss                 enable         vcelloverflow
   default        on        none
   ESS Profile(2)

default(15)# show essid vcelloverflowoss                                  ESS
   Profile
   ESS Profile                              : vcelloverflowoss
   Enable/Disable                            : enable
   SSID                                     : vcelloverflow
   Security Profile                         : default
   Primary RADIUS Accounting Server          :
   Secondary RADIUS Accounting Server        :
   Accounting Interim Interval (seconds)     : 3600
   Beacon Interval (msec)                   : 100
   SSID Broadcast                           : on
   Bridging                                 : none
   New AP's Join ESS                        : on
   Tunnel Interface Type                    : none
   VLAN Name                                :
   Virtual Interface Profile Name            :
   GRE Tunnel Profile Name                   :
   Allow Multicast Flag                     : off
   Isolate Wireless To Wireless traffic      : off
   Multicast-to-Unicast Conversion           : on
   RF Virtualization Mode                   : NativeCell
   Overflow from                            : vcelloverflow
   APSD Support                             : on
   DTIM Period (number of beacons)           : 1
   Dataplane Mode                           : tunneled
   AP VLAN Tag                              : 0
   AP VLAN Priority                         : off
   Countermeasure                           : on
   Multicast MAC Transparency                : off
   Band Steering Mode                       : disable
   Band Steering Timeout(seconds)            : 5
```

Bridging Versus Tunneling

The bridged AP feature allows APs to be installed and managed at locations separated from the controller by a WAN or ISP, for example, in a satellite office. Encryption can be enabled on the bridged connection to provide security over ISP-based connections.

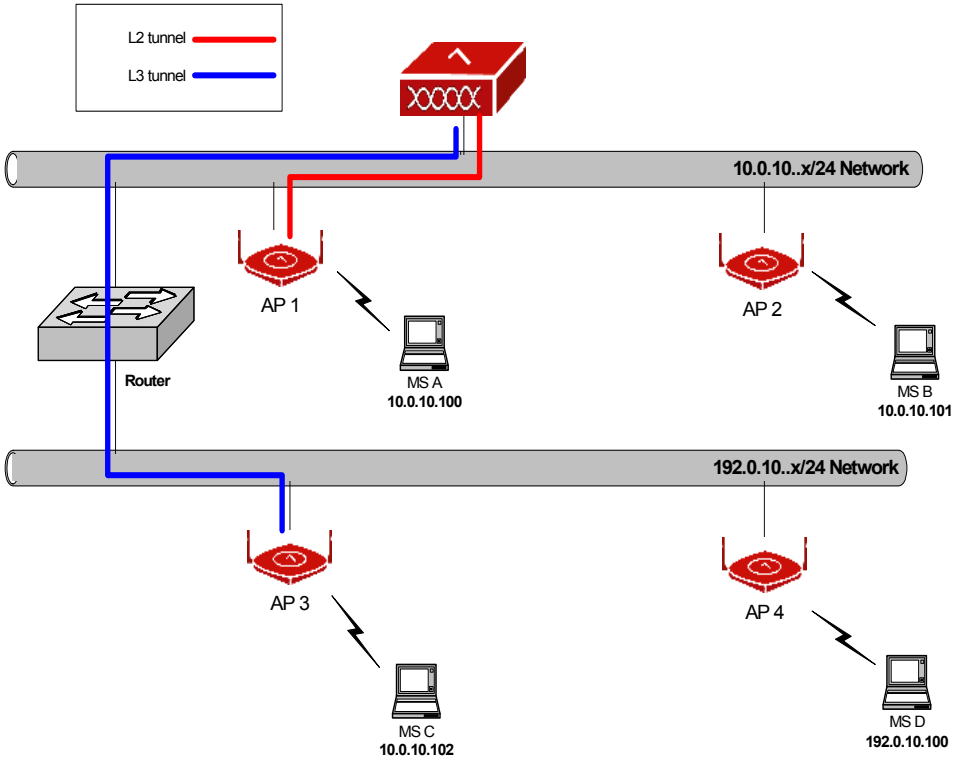
The controller, through a keep-alive signal, monitors the remote AP. Remote APs can exchange control information, including authentication and accounting information with the controller, but are unable to exchange data. (Remote bridged APs can, however, exchange data with other APs within their subnet.)W

For features support on the bridge and tunnel modes, see the *FortiWLC Support Matrix.*

Example of Bridged AP Deployment

The following figure is an example of remote bridged AP deployment. Notice that AP1 is configured for L2/local mode, AP2 is configured L2/Remote mode, AP3 is configured L3/local mode, and AP4 is configured for L3/Remote AP mode. The controller, AP1 and AP2 are located in the same 10.0.10.x/24 subnet, and AP3 and AP4 are in a different subnet, 192.0.10.x/24. The blue and red lines correspond to L2 and L3 data tunnel, respectively. Also, MS A through D are associated to AP 1 to 4, respectively. Note that the MS C and MS D have different IP addresses, even though they are associated to APs within the same IP subnet. The reason for this is because AP3 is configured in local mode and is tunneled back to the controller at Layer 3. This example demonstrates how a mobile client's IP domain is changed by the dataplane bridged or tunneled setting.

Figure 38: *Example Remote AP Topology*



Configure a Bridged Profile

For complete UI directions, see *"Add an ESS with the Web UI"* ***on page 139*** or click Configuration > Wireless > ESS and select an ESS to edit.

To configure a bridged AP for an existing ESSID with the CLI, follow these steps:

1. Enter the ESSID configuration mode and set the dataplane mode to bridged:

```
controller# configure terminal
   controller(config)# essid profile_name
   controller(config-ap)# dataplane bridged
   controller(config-ap)# exit
```

After you make the config changes, force the APs to do a hard reboot.

2. If the connection between the controller and the Remote AP should be secured, use the following command to encrypt only an AP connection:

```
controller# configure terminal
   controller(config)# ap ap#
   controller(config-ap)# dataplane-encryption on
   controller(config-ap)# exit
```

The Remote AP feature may require that corporate firewall configuration be updated to permit wireless access over certain Ethernet ports. The affected ports are:

- L2 (Ethernet) L3 (UDP)
- Data 0x4000 9393
- Comm 0x4001 5000
- Discovery 0x4003 9292

WAN Survivability

FortiWLC (SD) provides the following support for bridged and tunneled devices during a WAN connection outage.

When a Bridged APs Lose Controller Contact

When a bridged AP loses contact with its host controller, it will provide uptime for a default period of 120 minutes or for the time specified in controller's Link Probe (1 - 32000 minutes) setting. During this time existing clients will function normally but cannot roam between APs. New clients cannot join a bridged AP during this time.

In a tunneled mode:

- You can specify a backup ESS for both bridge and tunneled modes. This backup profile is activated with the controller link is down.
- New devices connecting during the outage will connect using clear and PSK profiles.

The clients will now be serviced until the links up and all new devices that connected during outage will reconnect after the link is up.

Multicast

Multicast is a technique frequently used for the delivery of streaming media, such as video, to a group of destinations simultaneously. Instead of sending a copy of the stream to each client, clients share one copy of the information, reducing the load on the network. Multicast is an advanced feature and can cause subtle changes in your network. By default, multicast is dis-

abled and should be enabled only for specific circumstances. Possible multicast applications include:

- Broadcast via cable or satellite to IPTV (for example, Vbrick or Video Furnace)
- Any broadcast application (for example, CEO address to company)
- Distance learning (live lectures)
- Video surveillance
- Video conferencing

For multicast to work, you need to complete these four tasks:

- Enable Virtual Port, see *"Configuring Probe Response Threshold"* ***on page 155*** for directions.
- Enable IGMP snooping on the controller - see *"Configuring IGMP Snooping on Controllers and APs"* ***on page 165***
- Enable IGMP snooping on the network infrastructure including intermediary switches. You must do this because Forti WLC do not source multicast group membership queries. We rely (as do most controllers) on the switches to perform that task.
- Map a Virtual Cell enabled ESS with the default VLAN - see *"Assigning a VLAN with the CLI"* ***on page 158***.

Configuring IGMP Snooping on Controllers and APs

Multicasting is implemented using IGMP snooping. In FortiWLC (SD) release 3.6, IGMP snooping was only done at the controller; the controller knew which clients were subscribed to specific multicast streams and sent the data for the subscribed multicast stream only to the APs with clients currently being serviced. Since the AP didn't know which clients subscribed to the specific stream, it would send multicast streams to all clients currently being serviced by the AP. (With Virtual Port, there would be N copies, one for each client). This wasted airtime and created unnecessary traffic and contention.

With FortiWLC release 8.6, IGMP snooping is supported for IPv6.

To reduce multicast/broadcast traffic, Fortinet recommends enabling IGMP snooping on the Controller.

In release 4.0 and later, IGMP snooping is done not only by the controller but also done by APs when using Virtual Cell. The controller passes the client subscription list for multicast streams to AP, which limits the multicast streams to only subscribed clients, reducing wireless traffic and saving time. (There are no changes in sending multicasts for stations connected to non-Virtual Cell ESS profiles.)

Note: IGMP snooping is enabled by default on controller installation and upgrade.

Commands to Configure IGMP Snooping

The following command is used to enable/disable IGMP snooping on the controller and APs:
igmp-snoop state [enable, disable]

Command to show igmp-snoop status:
show igmp-snoop

```
Command to see which multicast groups are currently active:
   show igmp-snoop forwarding-table

Command to see which stations have joined multicast groups:
   show igmp-snoop subscription-table
```

Multicast MAC Transparency Feature

This feature enables MAC transparency for tunneled multicast, which is needed for some clients to receive multicast packets. Multicasting is an advanced feature and can cause subtle changes in your network. By default, multicasting is disabled. To enable it, use either the multicast-enable command (see example below) or Configuration > Wireless > ESS > Add in the Web UI (see example below).

Multicasting is an advanced feature. Enabling multicasting in the WLAN can cause subtle changes in your network. Contact Fortinet Customer Service Technical Assistance Center before enabling multicasting.

Enable Multicast From the Web UI

To enable multicasting from the Web UI, add or modify an ESS. For directions, see *"Add an ESS with the Web UI"* ***on page 139***.

Enable Multicast with the CLI

The following example enables multicasting with the CLI:

```
controller(config-essid)# multicast-enable
```

For command details, see the ***FortiWLC (SD) Command Reference***.

View Mapping Between VLANs and ESS Profiles

Use the following command to see the VLANs and ESS profiles currently mapped:

```
controller# show vlan ess-profile
```

For command details, see the ***FortiWLC (SD) Command Reference***.

Multicast Restriction per VLAN

When "multicast to unicast" conversion is enabled, multicast/broadcast packets will be restricted to respective VLANs only.

This restriction is applicable only across wireless clients and not for wired port profile clients.

GRE ESSID Feature

The ESSID configuration for GRE tunneling is described in chapter See *"Configuring VLANs" on page 343.*

Band Steering Feature

Band steering works with multi-band capable clients by letting you assign bands to clients based on their capabilities. Without band steering, an ABG client could formerly associate on either the A or the B/G channels, leading to overcrowding on one band or the other.

Band steering is designed to encourage a dual-band capable device to connect on the 5GHz band. This is where the access point hears a request from a client device to associate on both the 2.4GHz and 5GHz bands, and steers the client by responding only to the 5GHz association request and not the 2.4 GHz request. As a result it reduces co-channel contention and frees up the 2.4GHz band, creating a better overall distribution of users for bandwidth availability. Band-steering to the A band encourages all 5GHz capable devices to connect to the 5GHz band.

Band-steering to the N band encourages all dual band HT (high throughput) capable clients that can associate at a HT data rate (above 54Mbps) to connect to the 5GHz band. This can improve 5GHz performance by leaving dual-band capable clients that are connected at low-data rates in the 2.4GHz band.

Configure Band Steering with the Web UI

Band Steering is enabled on a per-ESS basis. When you create or modify an ESS, you can enable band steering. To do this with the Web UI, follow the directions *"Add an ESS with the Web UI"* ***on page 139*** setting the field Enable Band Steering to On. The field Band Steering Timeout defaults to 5 seconds; this is the number of seconds that assignment for a steered client is blocked on the forbidden band while it is unassociated. For this command to work as clients are added, also set the field New APs Join ESS to on in the ESS.

Configure Band Steering with the CLI

Two new CLI commands have been added for band steering. band-steering-mode enables band steering on an ESS and band-steering-timeout sets the number of seconds that assignment for a steered client is blocked on the forbidden band while it is unassociated. The command band-steering-mode disable turns off band steering. To use band steering, create an ESS with the following configuration:

```
ESS Profile
   ESS Profile                                : bandsteering
   Enable/Disable                             : enable
   SSID                                       : bandsteering
   Security Profile                           : default
   Primary RADIUS Accounting Server           :
   Secondary RADIUS Accounting Server         :
   Accounting Interim Interval (seconds)      : 3600
   Beacon Interval (msec)                     : 100
   SSID Broadcast                             : on
   Bridging                                   : none
   New AP's Join ESS                          : on
   Tunnel Interface Type                      : none
   VLAN Name                                  :
   Virtual Interface Profile Name             :
   GRE Tunnel Profile Name                    :
   Allow Multicast Flag                       : off
   Isolate Wireless To Wireless traffic       : off
   Multicast-to-Unicast Conversion            : on
   RF Virtualization Mode                     : VirtualCell
   Overflow from                              :
   APSD Support                               : on
   DTIM Period (number of beacons)            : 1
   Dataplane Mode                             : tunneled
   AP VLAN Tag                                : 0
   AP VLAN Priority                           : off
   Countermeasure                             : on
   Multicast MAC Transparency                 : off
   Band Steering Mode                         : a-steering
   Band Steering Timeout(seconds)             : 5
```

This example sets band steering to the A channel on the existing ESS named bandsteering:

```
default(15)# configure terminal
   default(15)(config)# essid bandsteering
   default(15)(config-essid)# dataplane bridged
   default(15)(config-essid)# band-steering-mode a-steering
   default(15)(config-essid)# end
   default(15)#
```

```
default(15)# show essid bandsteering
ESS Profile
ESS Profile                                 : bandsteering
Enable/Disable                              : enable
SSID                                        : bandsteering
Security Profile                            : default
Primary RADIUS Accounting Server            :
Secondary RADIUS Accounting Server          :
Accounting Interim Interval (seconds)       : 3600
Beacon Interval (msec)                      : 100
SSID Broadcast                              : on
Bridging                                    : none
New AP's Join ESS                           : on
Tunnel Interface Type                       : none
VLAN Name                                   :
Virtual Interface Profile Name              :
GRE Tunnel Profile Name                     :
Allow Multicast Flag                        : off
Isolate Wireless To Wireless traffic        : off
Multicast-to-Unicast Conversion             : on
RF Virtualization Mode                      : VirtualPort
Overflow from                               :
APSD Support                                : on
DTIM Period (number of beacons)             : 1
Dataplane Mode                              : bridged
AP VLAN Tag                                 : 0
AP VLAN Priority                            : off
Countermeasure                              : on
Multicast MAC Transparency                  : off
Band Steering Mode                          : a-steering
Band Steering Timeout(seconds)              : 5
```

This example disables band steering:

```
default(15)# configure terminal
  default(15)(config)# essid bandsteering
  default(15)(config-essid)# band-steering-mode disable
  default(15)(config-essid)# end
  default(15)#
  default(15)# sh essid bandsteering
  ESS Profile
  ESS Profile                               : bandsteering
  Enable/Disable                            : enable
  SSID                                      : bandsteering
  Security Profile                          : default
  Primary RADIUS Accounting Server          :
  Secondary RADIUS Accounting Server        :
```

```
Accounting Interim Interval (seconds)     : 3600
Beacon Interval (msec)                    : 100
SSID Broadcast                            : on
Bridging                                  : none
New AP's Join ESS                         : on
Tunnel Interface Type                     : none
VLAN Name                                 :
Virtual Interface Profile Name            :
GRE Tunnel Profile Name                   :
Allow Multicast Flag                      : off
Isolate Wireless To Wireless traffic      : off
Multicast-to-Unicast Conversion           : on
RF Virtualization Mode                    : VirtualPort
Overflow from                             :
APSD Support                              : on
DTIM Period (number of beacons)           : 1
Dataplane Mode                            : bridged
AP VLAN Tag                               : 0
AP VLAN Priority                          : off
Countermeasure                            : on
Multicast MAC Transparency                : off
Band Steering Mode                        : disable
Band Steering Timeout(seconds)            : 5
```

Expedited Forward Override

The Expedited Forward Override option is implemented to override the system's default DSCP-to-WMM priority mapping. IP datagrams marked with DSCP Expedited Forwarding (46) will be sent from the WMM queue (AC_VO) of the AP rather than the Video queue (AC_VI) in downstream (to stations). This feature is disabled by Default. It is configured on a per-ESS Profile basis and works in both bridged and tunneled ESS profiles.

Steps to configure Expedited Forward Override

1. Steps to Enable Expedited Forward Override Feature in ESSID:

```
default # config terminal
   default(config)# essid Forti
   default(config-essid)# expedited-forward-override
   default(config-essid)# end

   default# show essid Forti
   ESS Profile
   ESS Profile                            : Forti
   Enable/Disable                         : enable
   SSID                                   : Forti
```

```
Security Profile                          : default
Primary RADIUS Accounting Server          :
Secondary RADIUS Accounting Server        :
Accounting Interim Interval (seconds)     : 3600
Beacon Interval (msec)                    : 100
SSID Broadcast                            : on
Bridging                                  : none
New AP's Join ESS                         : on
Tunnel Interface Type                     : none
VLAN Name                                 :
Virtual Interface Profile Name            :
GRE Tunnel Profile Name                   :
Allow Multicast Flag                      : off
Isolate Wireless To Wireless traffic      : off
Multicast-to-Unicast Conversion           : on
RF Virtualization Mode                    : VirtualPort
Overflow from                             :
APSD Support                              : on
DTIM Period (number of beacons)           : 1
Dataplane Mode                            : tunneled
AP VLAN Tag                               : 0
AP VLAN Priority                          : off
Countermeasure                            : on
Multicast MAC Transparency                : off
Band Steering Mode                        : disable
Band Steering Timeout(seconds)            : 5
Expedited Forward Override                : on
SSID Broadcast Preference                 : till-association
B Supported Transmit Rates  (Mbps)        : 1,2,5.5,11
B Base Transmit Rates  (Mbps)             : 11
```

2. Steps to Disable Expedited Forward Override Feature in ESSID:

```
Forti# config terminal
   Forti(config)# essid Forti
   Forti (config-essid)# no expedited-forward-override
   Forti(config-essid)# end
   Forti # show essid Forti
   ESS Profile
   ESS Profile                            : Forti
   Enable/Disable                         : enable
   SSID                                   : Forti
   Security Profile                       : default
   Primary RADIUS Accounting Server       :
   Secondary RADIUS Accounting Server     :
   Accounting Interim Interval (seconds)  : 3600
   Beacon Interval (msec)                 : 100
```

```
SSID Broadcast                              : on
Bridging                                    : none
New AP's Join ESS                           : on
Tunnel Interface Type                       : none
VLAN Name                                   :
Virtual Interface Profile Name              :
GRE Tunnel Profile Name                     :
Allow Multicast Flag                        : off
Isolate Wireless To Wireless traffic        : off
Multicast-to-Unicast Conversion             : on
RF Virtualization Mode                      : VirtualPort
Overflow from                               :
APSD Support                                : on
DTIM Period (number of beacons)             : 1
Dataplane Mode                              : tunneled
AP VLAN Tag                                 : 0
AP VLAN Priority                            : off
Countermeasure                              : on
Multicast MAC Transparency                  : off
Band Steering Mode                          : disable
Band Steering Timeout(seconds)              : 5
Expedited Forward Override                  : off
SSID Broadcast Preference                   : till-association
B Supported Transmit Rates  (Mbps)          : 1,2,5.5,11
B Base Transmit Rates  (Mbps)               : 11
```

SSID Broadcast for Vport

The SSID Broadcast for Vport function is designed to improve connectivity when using Cisco phones.

Configuration of SSID Broadcast for Vport

The SSID Broadcast for Vport option is similar to that for the ESSID configuration parameter. From the ESSID configuration, the SSID Broadcast for Vport option has three configurable parameters from GUI and IOSCLI as follows:

1. Disable: This is the default configuration on the ESSID profile page. Configuring the parameter to “Disable” makes the AP not to advertise the SSID in the beacon. Example for configuring the option to Disable from IOSCLI:

```
default# configure terminal
  default(config)# essid assign
  default(config-essid)# publish-essid-vport disabled
  default(config-essid)# exit
  default(config)# exit
```

2. Always: Configuring the parameter to “Always” enables the AP to advertise the SSID on the beacons always. This must not be configured unless recommended.
   Example for configuring the option to till association from IOSCLI:

```
default# conf terminal
  default(config)# essid assign
  default(config-essid)# publish-essid-vport always
  default(config-essid)# end
```

3. Till-Association: Configuring the parameter to “Till-Association” enables the AP to advertise the SSID in the beacons until the association stage of the client and disables the SSID broadcast in the later part of connectivity. This parameter is preferable to configure for the certain version of phones which will resolves the connectivity issues with the Vport ON. Once station associated, The AP will stop broadcasting SSID string. Here the users are allowed to configure SSID broadcast for VPort parameter from controller GUI per ESS basis in addition to AP CLI.
   Example for configuring the option to till association from IOSCLI:

```
default# conf terminal
  default(config)# essid assign
  default(config-essid)# publish-essid-vport till-association
  default(config-essid)# end
```

Multiple ESSID Mapping

The following configuration example shows how to create three ESSIDs and map them to three different VLANs to separate guest users, corporate users, and retail traffic.

The first ESSID, guest-users, is mapped to a VLAN named ***guest***. This ESSID is configured to use the default security profile, which requires no authentication method or encryption method. The VLAN IP address is 10.1.1.2/24 with a default gateway of 10.1.1.1. The DHCP server IP address is 10.1.1.254. This ESSID is configured so that it is added to each access point automatically and is also part of a Virtual Cell. (All access points on the same channel with this ESSID share the same BSSID.)

The second ESSID, corp-users, is mapped to a VLAN named ***corp***. This ESSID is configured to use a security profile called corp-access, which requires 64-bit WEP for an authentication/encryption method. The static WEP key is set to ***corp1***. The VLAN IP address is 10.1.2.2/24 with a default gateway of 10.1.2.1. The DHCP server IP address is 10.1.2.254. This ESSID is configured so that it is added to each AP automatically and is also part of a Virtual Cell.

The third ESSID, retail-users, is mapped to a VLAN named ***retail***. This ESSID is configured to use a security profile called retail-access, which requires 802.1x as an authentication method.

The 802.1x rekey period is set to 1000 seconds. The primary RADIUS server IP address is set to 10.1.3.200, the primary RADIUS port is set to 1812, and the primary RADIUS secret is set to ***secure-retail***. The VLAN IP address is set to 10.1.3.2/24 with a default gateway of 10.1.3.1. The DHCP server IP address is 10.1.3.254. This ESSID is configured so that it is added to the access point with node id 1 only. Also, the broadcasting of this ESSID value in the beacons from the access point is disabled, and the ESS is given a BSSID of 00:0c:e6:02:7c:84.

Use the show vlan command to verify the VLAN configuration:

```
controller# show vlan
   VLAN Configuration
   VLAN Name    Tag  IP Address      NetMask          Default Gateway
   guest        1    10.1.1.2        255.255.255.0    10.1.1.1
   corp         2    10.1.2.2        255.255.255.0    10.1.2.1
   retail       3    10.1.3.2        255.255.255.0    10.1.3.1
```

Now that the VLANs and security profiles have been created, the new ESSIDs can be created and configured.

```
controller# configure terminal
   controller(config)# essid guest-users
   controller(config-essid)# security-profile default
   controller(config-essid)# vlan guest
   controller(config-essid)# exit
   controller(config)# essid corp-users
   controller(config-essid)# security-profile corp-access
   controller(config-essid)# vlan corp
   controller(config-essid)# exit
   controller(config)# essid retail-users
   controller(config-essid)# security-profile retail-access
   controller(config-essid)# vlan retail
   controller(config-essid)# no ap-discovery join-ess
   controller(config-essid)# no publish-essid
   controller(config-essid)# ess-ap 1 1
   controller(config-essid-ess-ap)# bssid 00:0c:e6:03:f9:a4
   controller(config-essid-ess-ap)# exit
   controller(config-essid)# exit
   controller(config)# exit
   controller#
```

To verify the creation of the new ESSIDs, use the show essid command.

To view detailed configuration for each of the new ESSIDs, use the show essid ***essid-name*** command.

To verify that the ***guest-users*** and ***corp-users*** ESSIDs were automatically joined to both access points connected to the controller and that the ***retail-users*** ESSID was only joined to AP 1, use the show ess-ap ap ***ap-node-id*** or the show ess-ap essid ***essid-name*** commands.

```
controller# show ess-ap ap 1
   ESS-AP Configuration
   AP ID: 1
   ESSID                   AP Name        Channel  BSSID
   guest-users             AP-1            6       00:0c:e6:01:d5:c1
   corp-users              AP-1            6       00:0c:e6:02:eb:b5
   retail-users            AP-1            6       00:0c:e6:03:f9:a4

   controller# show ess-ap ap 2
   ESS-AP Configuration
   AP ID: 2
   ESSID                   AP Name        Channel  BSSID
   guest-users             AP-2            6       00:0c:e6:01:d5:c1
   corp-users              AP-2            6       00:0c:e6:02:eb:b5

controller# show ess-ap essid retail-users
   ESS-AP Configuration
   ESSID: retail-users
   AP ID   AP Name        Channel  BSSID
   1       AP-1            6       00:0c:e6:03:f9:a4

controller# show ess-ap essid corp-users
   ESS-AP Configuration
   ESSID: corp-users
   AP ID   AP Name        Channel  BSSID
   1           AP-1            6       00:0c:e6:02:eb:b5
   2           AP-2            6       00:0c:e6:02:eb:b5
   Bridged AP300 in a Remote Location
   When bridged mode is configured in an ESSID, an AP using that ESSID can be
   installed and managed at a location separated from the controller by a WAN or
   ISP, for example at a satellite office. The controller monitors remote APs
   with a keep-alive signal. Remote APs exchange control information, including
   authentication and accounting information, with the controller but cannot
   exchange data. Remote APs exchange data with other APs within their subnet.
```

Because Remote APs cannot exchange data-plane traffic (including DHCP) with the controller, certain Fortinet Wireless LAN features are not available for remote AP configurations. These include:

- QoS
- Captive Portal
- L3 mobility

The features that are available are:

- VLAN
- Virtual Cell
- 802.1x authentication
- High user density
- Multiple ESSIDs
- Dataplane encryption for backhoe on L3 tunnel

Configure Bridged Mode with the Web UI

Configure bridged mode when you add or modify an ESS with the Web UI; for directions, see *"Add an ESS with the Web UI"* ***on page 139***.

Configure Bridged Mode with the CLI

This example creates the ESSID abcjk, sets its mode to bridged, assigns a tag, and then gives top priority to abcjk.

```
test (config-essid)#
   test# configure terminal
   test (config)# essid abcjk
   test (config-essid)# dataplane bridged
   test (config-essid)# ap-vlan-tag 11
   test (config-essid)# ap-vlan-priority
   test (config-essid)# end
```

For details of the commands used here, see the Command Reference Guide.

Utilizing Multiple IPs on a Single MAC

In current implementations, a typical client machine (or station) is granted a single IP Address per wireless adapter in use. However, with the growing use of Virtual Machine models (provided by VMware, Parallels, etc.), a single station can run multiple Operating Systems from a single client. With this release of Fortinet FortiWLC (SD), each Virtual Machine can now be provided with an individual IP Address, making it much easier to troubleshoot packet transmissions.

To support this function, the FortiWLC (SD) ESS Profile screen has a new function labeled MIPS, which is disabled by default. With this function enabled, packets are bridged across from the "host", or main, Operating System to the "guest", or virtual, system(s) as needed. The following notes apply:

- All data packets sent from the client will have the host OS MAC address as their source address.

- All data packets sent to the client will have the host OS MAC address as their destination address.
- Each OS has a different client hardware address that is transmitted as part of the DHCP payload.
- “Guest” OS hardware devices have MAC addresses that start “00:0c:29”; this is the global standard OUI for VMware. This hardware address is used by the DHCP server to identify guest OSes, allowing them to be provided separate IP addresses.
- Grat ARP packets transmitted by any IP will have their corresponding unique client hardware addresses.
- All broadcast packets received by the host OS will also be delivered to the guest OS(es).
- All unicast packets received by the host OS will be delivered to the guest OS(es) based on the packets’ destination IP address.

In order to support this capability, a command has been added to the CLI:

- show station multiple-ip—Displays all IP addresses provided by each individual station along with MAC addresses (labeled ‘vmac’ for virtual devices). Note that for the host device, the Client MAC and Virtual MAC will be identical.

- IPv4 and IPv6 address types are supported.
- All IP addresses belonging to a single station are assumed to be part of the same VLAN.
- IP addresses provided to Virtual OSes are always dynamic; static addresses are not supported.
- ICR is not supported when this feature is enabled.

Time Based ESS

You can schedule the availability of an ESS based on pre-define time intervals. By default, ESS profiles are always ON and available to clients/devices. By adding a timer, you can control the availability of an ESS profile based on pre-defined times during a day or across multiple days.

To create a time based ESS profile, you must first create a timer profile and then associate the timer profile to the ESS profile.

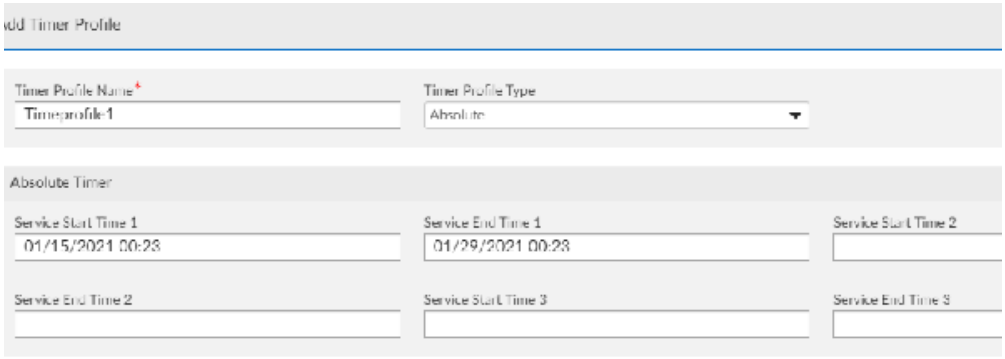
Creating a Timer Profile

You can create timer profile using WebUI or CLI.

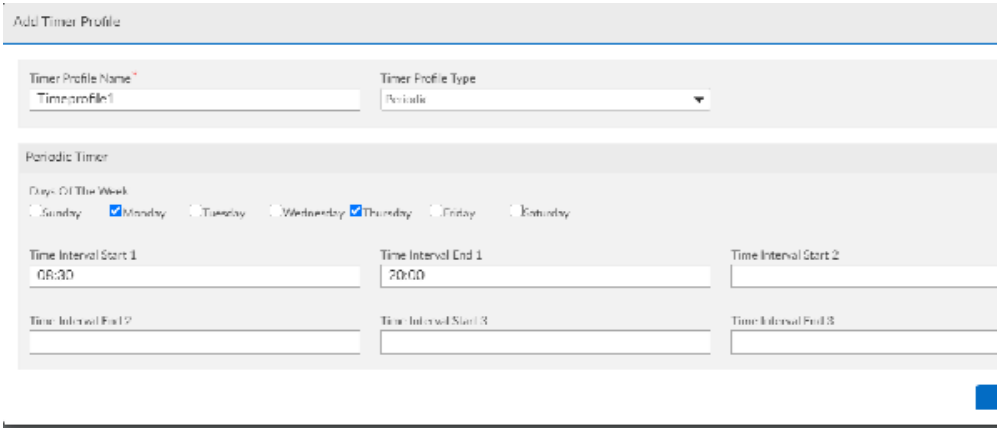
Using WebUI

Go to Configuration > Timer and click the Add button.

In the Add Timer Profile pop up window, enter Timer Profile Name and select Timer Type:



- Absolute timer profiles can enable and disable ESS visibility for time durations across multiple days. You can create up to 3 specific start and end time per timer profile. To enter start of the end time, click the Date picker box. See label 1 in figure 1.
- Periodic timer profiles are a set of start and end timestamp that can be applied across multiple days of a week. To create a period timer profile, enter the time in hh:mm format. Where hh, represent hours in 2-digits and mm represent minutes in 2-digits. Figure 2, illustrates a timer profile that will be applied on Sunday, Monday, Tuesday, and Thursday from 08:10 a.m. or 14:45 (2.45 p.m).



Using CLI

A new CLI command timer-profile with various options is available to create a timer profile.

Syntax

```
#(config-mode) timer-profile <profile-name>
```

```
#(timer-config-mode) <timer-type> <timer-slot> start-time <"mm/dd/yyyy hh:mm">
   end-time <"mm/dd/yyyy hh:mm">
```

- timer-type is either absolute-timer or periodic timer
- Absolute timer profile allows creation of 3 timer slots.
- Time must be specified within double quotes in this format: mm/dd/yyyy <space> hh:mm

Example: Creating an absolute timer profile

```
default# configure terminal
```

```
default (config)# timer-profile monthly-access
```

```
default (config-timer)# absolute-timer time-slot-1 start-time "01/01/2014
   10:10" end-time "02/02/2014 08:45"
```

6 Wireless Intrusion Prevention System (WIPS)

Fortinet's WIPS provides complete wireless threat detection and mitigation into the wireless network infrastructure. It detects wireless intrusions using predefined and custom signatures on an integrated platform with other WLAN management applications.

You can set up WIPS management system to detect intrusions.

While creating the *AP Packet Capture* profile, the following are mandatory parameter values to be configured for WIPS.

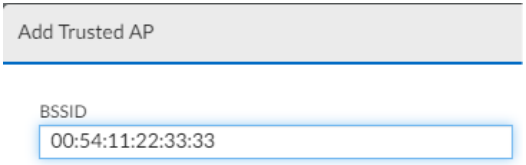
- **Destination**: L3 mode
- **UDP Port**: 9178
- **IP Address**: Specify the controller or FortiWLM IP address, wherever WIPS is enabled.

Note: Fortinet recommends to configure the AP in **ScanRogues** Mode (*Configuration* > *Wireless* > *Radio*).

Configuring WIPS

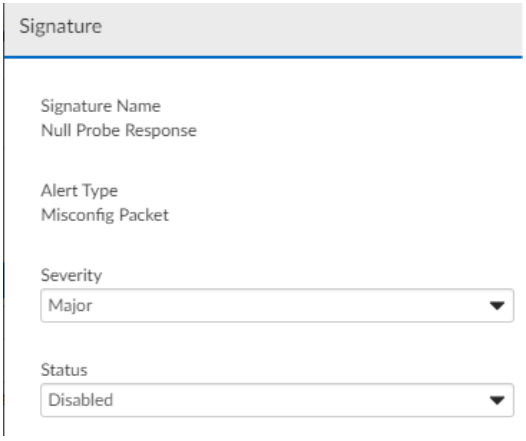
1. To get started with intrusion detection, enabled WIPS service, by clicking **START**. The status of the WIPS service is indicated in the WIPS Service Status field. You can stop and restart the WIPS service.

2. (Optional) Next, start adding list of trusted APs by their BSSID. To add an AP, click **ADD** under the Trusted AP section and enter the BSSID.



3. Select the type of intrusions to detect. To detect an intrusion, click on the edit icon of a signature and configure the following:

- Severity: To classify the intrusions severity
- Status: Select enable to start detecting this alert type.



This is a short description of each signature:

- Adhoc Network: Adhoc networks are peer-to-peer networks between wireless computers that cause a security hole by providing an unintended bridge into the corporate network thereby compromising the critical corporate data.
- Antistumbler: The netstumbler is a wireless scanning utility that allows the detection and configuration of wireless LANs by sending out periodic probe requests and could open up the network to other attacks. It raises an alert if the number of probe requests sent by a station crosses the configured count within the expiration timeout.
- Association Flood: A flood of Association requests from malicious stations to APs use up the internal resources of APs thus causing a Denial of Service attack on APs.
- Authentication Flood: A flood of Authentication requests from malicious stations to APs use up the internal resources of APs thus causing a Denial of Service attack on APs.
- Channel Hogger: A single station hogs the channel for too long a time and doesn't allow other stations to use the channel.
- De-authentication Flood: A flood of De-authentication requests from malicious stations to APs use up the internal resources of APs thus causing a Denial of Service attack on APs.
- Disassociation Flood: A flood of Disassociation requests from malicious stations to APs use up internal resources of APs, causing a Denial of Service attack on APs.
- EAP Handshake Failure: Attempts by hackers to crack EAP authentication passwords by doing a dictionary or brute force attack
- EAPoL Logoff Flood: A flood of EAPoL Logoff requests from malicious stations to APs use up the internal resources of APs, causing a Denial of Service attack on APs.

- EAPoL Start Flood: A flood of EAPoL Start requests from malicious stations to APs use up the internal resources of APs, causing a Denial of Service attack on APs.
- Fake AP: Fake AP tool can generate beacons with varying MAC address, SSID, channel number and transmission power for every packet, thus causing stations confusion because there are many spoofed APs in the network.
- Fragmentation and Re-Assembly: Malicious stations deliberately send fragments so that APs resources and processing capacity can be exhausted in reassembly. This constitutes a Denial of Service attack on APs. The following are the parameters which are considered for this signature.
- Large Duration ID: A station can specify large duration values in the frames it transmits and use up the medium continuously for transmission thereby denying access to other stations.
- MAC Spoof: A wireless station or AP may spoof the MAC address of a valid station or a valid AP thus causing man-in-the-middle attacks and compromising the wireless network.
- Null Probe Response: Denial of Service attack carried out by sending many probe packets with NULL SSIDs.
- Overutilized AP: AP sends too many authentication responses that fill up its internal tables thereby resulting in a Denial of Service attack.
- PRGA: WEP networks are vulnerable to arbitrary packet injection attacks using Pseudo Random Generation Algorithm (PRGA) determination techniques. An attacker that observes the WEP challenge/ response exchange can XOR the contents of the challenge and the response together to generate 128-bytes of PRGA thus compromising the wireless network.
- Rogue AP: A malicious AP masquerading as a valid AP causes stations to associate with itself thereby compromising the wireless network.
- Long SSID: Denial of Service attack carried out by sending many probe packets with very large SSID.
- Unregulated Channel: Wireless devices configured to use channels that are not regulated for use in a particular geographic domain cause interference to other radio systems.

Configuring Client Exclusion Policies

WIPS monitors clients based on specific parameters configured in the client exclusion policy; clients detected with a suspicious pattern based on the configured parameters in the policy are deemed malicious and blocked.

Navigate to ***Configuration > WIPS > Client Exclusion Policies*** on the FortiWLC GUI.

In the **Configuration** tab, enable the following monitoring events for clients, based on your requirement and configure the maximum number of failures wherever applicable. Occurrence of the configured maximum number of failures of a certain event within 60 seconds results in blocking that client from connecting to the network.

- Authentication Failures
- Association Failures
- 802.1x AAA Failures
- Web Authentication Failures

- IP Theft/Reuse Failures

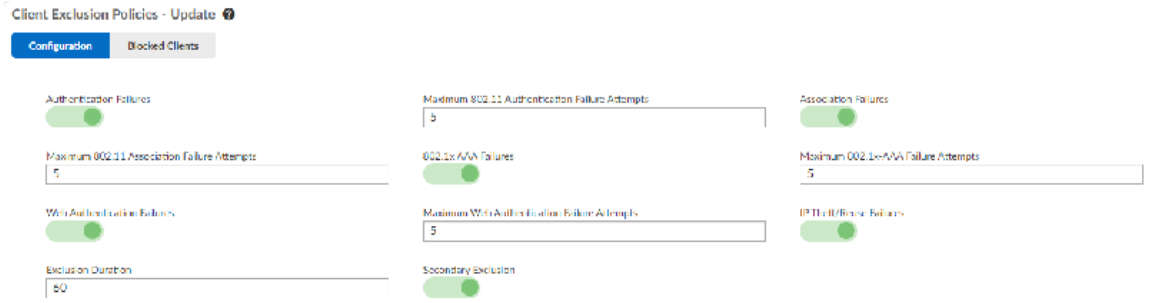
The default value for the maximum number of failures for all configurable parameters is 3 and the valid range is 3 – 10. The client is blocked for the configured **Exclusion Duration;** default value is 60 seconds**.**

Enable **Secondary Exclusion** to monitor client activity after the **Exclusion Duration** is over. Client is monitored for 5 minutes and is blocked indefinitely if it is excluded more than 3 times for any of the failures; the client remains blocked until it is manually unblocked. When unblocked, the monitoring status of this client is deleted and the next failure is considered the first incidence.

Note: To unblock a client prior to the completion of the **Exclusion Duration** or when **Secondary Exclusion** is enabled**,** you can delete it from the **Blocked Clients** list.

The **Blocked Clients** tab displays the **MAC Address** of the blocked client, the **Exclusion Reason**, **Time Remaining,** and **IP address** (IP theft/reuse failure only) of the exclusion duration.

Figure 39: *Client exclusion*



Station Quarantine

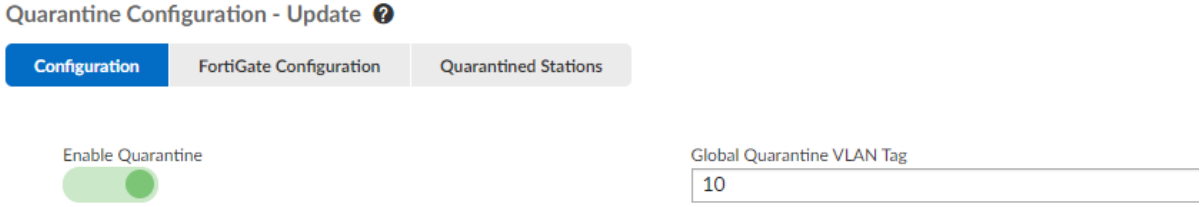
A wireless station perceived to be a security threat can quarantine to a restricted VLAN as a security measure. The connected quarantined wireless station is de-authenticated. FortiWLC receives information to quarantine a station from FortiGate when it detects a security event or a station MAC address can be manually configured to be quarantined.

This feature allows a global quarantine VLAN or per ESS/Port profile.

Quarantine Configuration

The basic station quarantine configuration requires the following.

Figure 40: *Station quarantine basic configuration*



1. **Enable Quarantine** configuration.
2. Specify the **Global Quarantine VLAN Tag**. The valid range is 1 – 4094.

FortiGate Configuration

Configure a FortiGate controller to receive information on quarantining stations.

Figure 41: *FortiGate configuration for quarantine*

1. Specify the **FortiGate IP address**.
2. Specify the **Access Port** and **Access Token** for the FortiGate controller for authentication. The valid range for the access port is 0 – 65535.
3. Specify the **Poll Interval**, the interval at which the FortiGate polls information on stations to be quarantined. The valid range is 1 – 60 minutes.

Quarantined Stations

Manually configure the station to be quarantined.

Figure 42: *Manual quarantine configuration*

1. Enter the **MAC Address** of the station.
2. Specify a **Reason** for quarantining the station. The valid range is 0 – 32 characters.
3. Specify the **VLAN Tag** assigned to the station. The valid range is 0 – 4094.

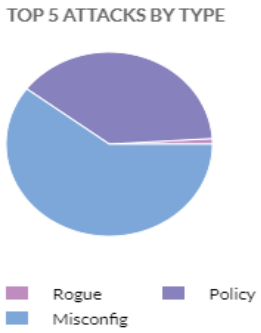
WIPS Dashboard

The WIPS dashboard provides information regarding the alerts raised in the WIPS system. The dashboard consists of two graphs – a graph with alert types and a graph with alert source.

Display the dashboard by clicking *Monitor* > *Dashboard* > *WIPS*.

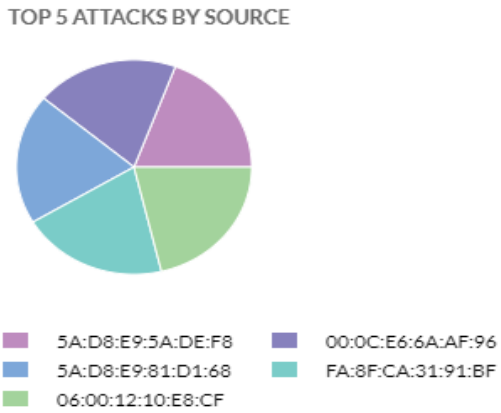
Top 5 Attacks by Type – Displays the top 5 attacks based on the type of intrusion detected and of the following types:

- Misconfigured packets
- Policy Violation
- Dictionary Attack
- Tool Attack
- Flood Attack



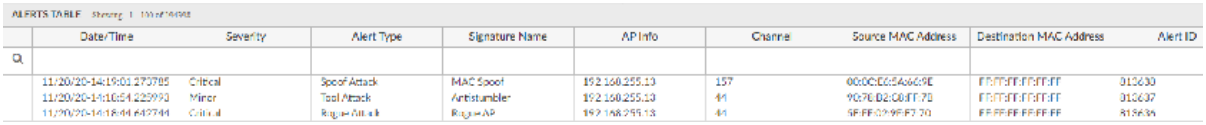
The above type of alerts are displayed if they are enabled in the WIPS Management page.

Top 5 Attacks by Source – Displays the top 5 attacks that came from clients connected to AP. The graphs displays the MAC address of the source AP.



Alerts Table – Paginated list of alerts detected by the WIPS system. The alerts table displays the following details about an alert:

- Date/Time
- Severity
- Alert Type
- Signature Name
- AP Info
- Channel
- Source MAC Address
- Destination MAC Address



Search – Use the search box to get list of alerts by any field of the alerts table.

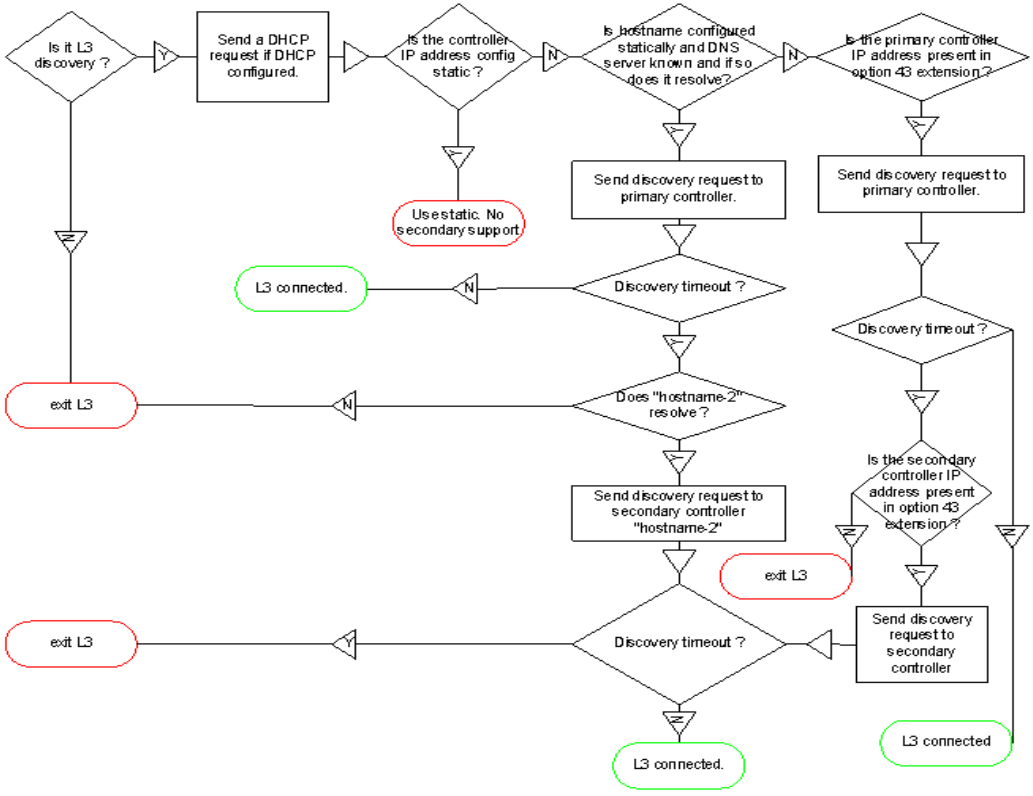
7 Implementing Redundancy

There are three options available for controller redundancy:

- Redundant Ethernet: With this Ethernet link level redundancy, if one Ethernet link goes down, another Ethernet link on the same controller will take over.
- N+1: With this controller level redundancy, if one controller goes down, a designated slave controller will take over for the failed master controller.
- Option 43: With this controller level redundancy, an AP is aware of both the primary and secondary controller. If the primary controller goes down, the APs automatically associate with the secondary controller. If the primary controller comes back up, they associate to the primary controller.
- NPlus1 failover/redundancy can be configured between 64-bit hardware controllers and 64-bit virtual controllers of the same model, from FortiWLC 8.6 onwards.

This chapter contains the following sections:

Figure 43: *Redundancy Flow*

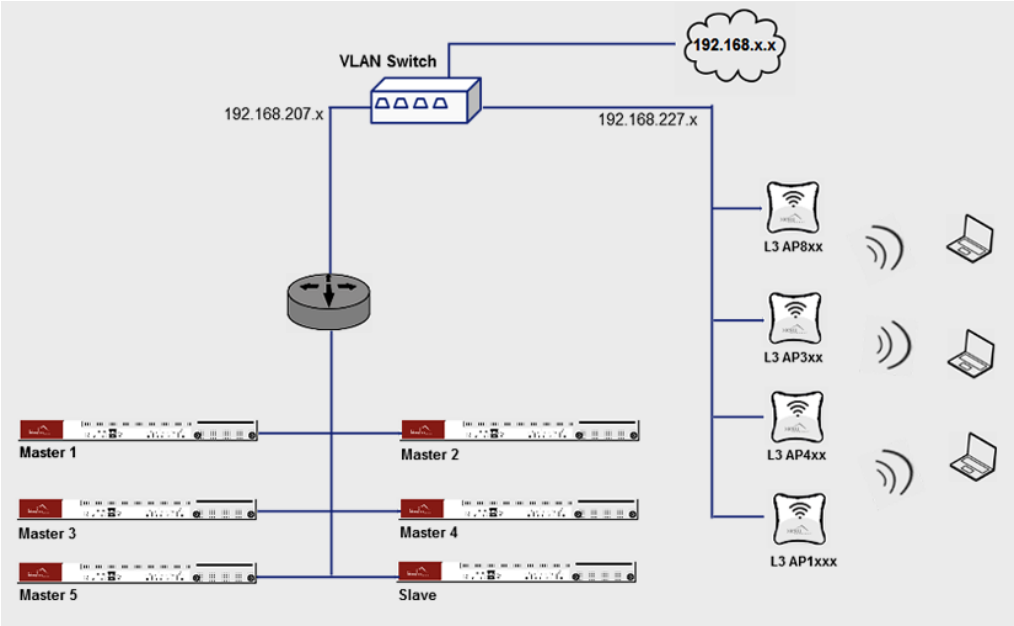


For any redundancy option to work without issues, make sure that the VLANs are the same across all the ports on the external manageable switch.

With N+1, the backup controller must be in the same subnet as the primary controllers. With DHCP Option 43, you can specify a primary and backup controllers for the APs and with this configuration, the backup controller can be in a different subnet from the primary controller.

N+1 Discovery Mechanism

The following flowchart illustrates the N+1 mechanism.



Redundant Ethernet

Ethernet redundancy can be enabled at any time by simply following the steps outlined in the following sections.

If bonding mode is dual then both g1 and g2 interfaces has to be plugged in for both master and slave.

To enable dual bonding, enter the following commands and reboot the controller:

```
default# configure terminal
   default(config)# bonding dual
   default(config)# exit
   default# copy running-config startup-config
```

Configure Redundant Ethernet Failover With the CLI

The following commands configure Ethernet interface 2 on a controller as a backup to Ethernet interface 1:

```
default# configure terminal
   default(config)# interface FastEthernet 2
   default(config-if-FastEth)# type redundant
   default(config-if-FastEth)# exit
   default(config)# exit
   default# copy running-config startup-config
```

In the redundant configuration, the IP address for the second Ethernet interface cannot be configured. It will receive the IP address of the primary Ethernet interface when the failover occurs.

The system requires a reboot for the change to become effective. Reboot the system now, and then check the redundant second interface configuration with the show second_interface_status command:

```
default# show second_interface_status
```

Recovering From Redundant Ethernet Failover

Once Dual Ethernet Redundant mode configuration is complete, the controller needs to be rebooted - see directions above. After the reboot, if the first Ethernet interface link goes down, then the second Ethernet interface takes over the controller connectivity. Redundant Ethernet failover is based on LinkID and does not require any spanning-tree configuration. When a LinkID is missing, the failover will occur in under one second. This failover will be transparent to the access points. The second interface remains active and serving all APs, even if the first interface comes up again. Verify this with the CLI command show second-interface-status. Only when the second interface goes down will the first interface (if it is up) take over the controller connectivity.

In hardware controllers bringing the switch port down will be detected as interface down and a link down alarm will be generated, rather in a virtual controller bringing the switch port down will not be detected as interface down and hence no link down alarm will be generated.

An alarm will be generated when the mapped interface in the VMWare client software is configured as disconnected.

When N+1 or L3 redundancy is also configured and controller 1 fails, the APs move to controller 2. When controller 1 comes back online, the APs immediately begin to move back to controller 2. Also see **Recovering From N+1 with Dual Ethernet Failover**.

N+1 Redundancy

The optional N+1 redundancy software feature, when implemented, allows a standby N+1 slave controller in the same subnet to monitor and seamlessly failover more than one master controller.

A set of master controllers and a standby slave controller are configured via static IP addressing to reside in the same subnet, and are considered to be an N+1 cluster. The standby slave monitors the availability of the master controllers in the cluster by receiving advertisement messages sent by the masters over a well known UDP port

at expected intervals. If four successive advertisements are not received, the standby slave changes state to an active slave, assumes the IP address of the failed master, and takes over operations for the failed master. Because the standby slave already has a copy of the master's latest saved configuration, all configured services continue with a short pause while the slave switches from standby to active state.

Note: When the master controller (which is being monitored by slave controller) is rebooted manually, a manual re-enabling of the master is not required, unless the master controller is upgraded.

N+1 Fallback

While in the active slave role, the slave controller's cluster monitoring activities are put on hold until the failed master rejoins the cluster. An active Slave detects the restart of a master through ARP. When the active slave is aware of the master's return (via the advertisement message) it will continue to remain as active slave and the original master moves to passive state. The now passive master is assigned with original slave's IP address. To move passive master to active master status, use the nplus1 revert command in active slave.

```
NP-controller-master(15)(config)# nplus1 revert
   NP-controller-master(15)(config)# end
   NP-controller-master(15)# sh nplus1
   ------------------------------------------------

            Current State : Active->Passive Slave
           Heartbeat Period : 1000 milliseconds
         Heartbeat Threshold : 4 threshold
                  Master IP : 172.19.215.31
             Master Hostname : NP-controller-master
                    Slave IP : 172.19.215.32
              Slave Hostname : NP1-controller-slave
                License Type : Demo
   License Usage (Used/Tot) : 1/1
   ------------------------------------------------

             Master Controllers

            Hostname       IP Address  Admin    Status
   ------------------------------------------------------------

     NP-controller-master    172.19.215.31  Enable   Passive->Active
```

If it is necessary for the failed master to be off-line for a lengthy interval, the administrator can manually set the active slave back to the standby slave, thereby ensuring the standby slave is able to failover for another master.

Note: When the Nplsu1 service is stopped on the master controller in an Nplus1 cluster, the administrative status of master controller added to the slave controller gets disabled. You are required to enable the master controller on the slave controller, so that configuration between the master and slave controllers is synchronized.

Auto Fallback

After a failover, the passive master listens to advertisements (at time intervals specified using the nplus1 period command) from active slave. If the passive master does not receive advertisements from active slave within the time period the passive master initiates auto-fallback.

Auto Revert

When the master controller goes down, the slave controller takes over as active slave controller. When the master controller that was down became active, it continues to stay as passive controller till the `nplus1 revert` command is executed on the active slave controller. You can enable auto revert so that after the master controller come online, it takes over as the original master controller.

By default this option is disabled. To enable auto-revert, use the `nplus1 autorevert enable` command. By enabling auto revert; the active slave controller triggers a fallback by itself.

Failover Scenarios

Scenario	Description
Power outage	Failover is initiated on power outage on the master controller.
Switch Port Failure	Failover is initiated during a port failure in the switch.
Ethernet cable unplugged	If the Ethernet cable in the master controller is unplugged, the slave controller takes over and becomes active slave.
Manual Failover	You can execute the nplus1 takeover command in the master controller to force a failover.
np1adv process kill	Failover is initiated if the np1 process in the master is killed.
Auto Failover	Auto failover is initiated if heartbeats from a controller is not received within the time specified in the nplus1 period command.
Failover on “no reload”	no reload commands trigger a failover. In such scenario, the master must be manually enabled. Reload commands sends a notification to slave about force enabling master and hence the master status becomes disable on the slave.
Continuous process restarts	Failover is initiated when continuous restarts of the following critical controller processes occur. • Wncagent • NMSAgent • Coordinator • Hostapd • XEMS • SecurityMM • CwAc
Mail box errors	Failover is initiated when any critical process mailbox is more than 90% full.
Low disk space (persistent & temporary)	Failover is initiated in case of low disk space. This occurs when more than 95% of the persistent and/or temporary file systems are used.
System memory full	Failover is initiated when the system memory is 90% full (32-bit controllers)/85% full (FortiWLC-3000/1000D).

In most cases with a cluster of N+1 Masters, the APs all have to be in L3 Connectivity mode, but if you only have one Master and one Slave unit (N=1) the APs can be in L3 only connectivity mode. However, if the APs are in L2

mode, then they will move to reboot after failover.

Heartbeat Period and Heartbeat Timeout Recommendations

Various factors in your network environment including latency can impact the N+1 failover. In networks with high latency, missing heartbeats between master and slave controller can trigger N+1 failover. We recommend that if your network experiences high latency, you should set the heartbeat period and heartbeat timeout to higher values.

The default heartbeat period is 1000ms and heartbeat timeout is 4 timeouts. Use the following commands to set high values:

```
# nplus1 timeout 40

# nplus1 period 100
```

The failure detection time (to initiate failover) is calculated as Heartbeat Period x Heartbeat Timeout.

Default timeout and period:

- Heartbeat Period (HP): Default 1000 ms, Range 100 - 30,000 (ms)
- Heartbeat Timeout (HT): The lost heartbeat threshold is the number of consecutive heartbeat packets. Default 4 timeouts, Range 4 - 60 (timeouts)
- Actual Failure Detection Time (AFDT) = HP (1000 ms) x HT (4) = 4000 ms = 4 Seconds

Preparing the Network

The N+1 cluster must be configured within a set of guidelines to operate as described in the previous section. While configuring your network for N+1 redundancy, the following guidelines must be followed:

The following table lists the supported pairing (master and slave) of controller models in an N+1 cluster.

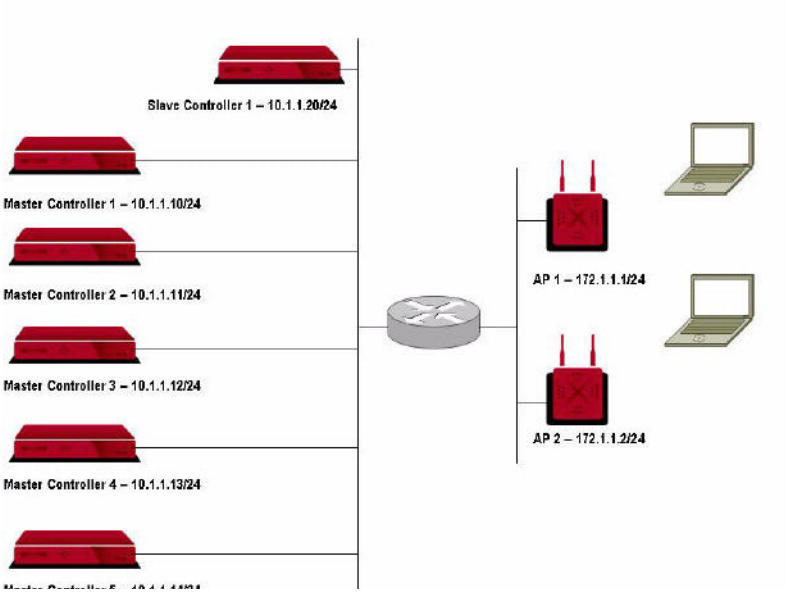
Slave	Master									
	FWC-50D	**FWC-VM-50**	**FWC-200D**	**FWC-VM-200**	**FWC-500D**	**FWC-VM-500**	**FWC-1000D**	**FWC-VM-1000**	**FWC-3000D**	**FWC-VM-3000**
FWC-50D	✓	✓	X	X	X	X	X	X	X	X
FWC-VM-50	✓	✓	X	X	X	X	X	X	X	X
FWC-200D	X	X	✓	✓	X	X	X	X	X	X

FWC-VM-200	X	X	✓	✓	X	X	X	X	X	X
FWC-500D	X	X	X	X	✓	✓	X	X	X	X
FWC-VM-500	X	X	X	X	✓	✓	X	X	X	X
FWC-1000D	X	X	X	X	X	X	✓	✓	X	X
FWC-VM-1000	X	X	X	X	X	X	✓	✓	X	X
FWC-3000D	X	X	X	X	X	X	X	X	✓	✓
FWC-VM-3000	X	X	X	X	X	X	X	X	✓	✓

- All master and slave controllers must use static IP addressing to ensure consistency and control of N+1 clustering. (DHCP addresses are not supported for controllers participating in the N+1 cluster).
- Master and slave controllers must be on the same IP subnet.
- All APs in the network should be configured for Layer 3 connectivity with the controller.
- Spanning tree should be disabled on the switch port to which the controllers are connected. To disable spanning tree on the port, refer to your switch configuration documentation.
- Set same date and time on the master and slave controller. Mismatch in date and time between master and slave will result in incorrect AP uptime information after a failover. You can also configure NTP on the master to avoid incorrect AP uptime information.

Configuring the N+1 Clusters shows a simplified network diagram of a recommended N+1 deployment.

Figure 44: *Example N+1 Redundancy Network Deployment*



Configuring the N+1 Clusters

This can only be configured using the CLI and up to five masters and one slave. You will need passwords for all controllers involved in the N+1 configuration. A summary of the steps to configure and start N+1 follows:

Step	Command	Description
1.	nplus1 start master	On each master, start N+1 redundancy.
2.	nplus1 start slave	Start N+1on the slave controller.
3.	nplus1 add master_hostname master_IP_address	Add the master controller's hostname and IP address to the slave's cluster list.

Starting N+1 on Master Controllers

N+1 must first be started on the Master Controllers.

To configure a master controller:

1. On each master controller, enter configuration mode and start the N+1 software:

```
NP-controller-master(15)# configure terminal
   NP-controller-master(15)(config)# nplus1 start master
```

2. Exit configuration mode and check that the N+1 software has been started on that controller:

```
NP-controller-master(15)(config)# exit
   NP-controller-master(15)# sh nplus1
   ----------------------------------------------------
   Master controller
   Master IP : 172.19.215.31
   Master Hostname : NP-controller-master
   Master Status : Active
   Slave IP : 172.19.215.32 <-- This is not displayed if Slave is not started
   Slave Status : Passive <-- This is displayed as Unknown if slave is not started
   ----------------------------------------------------
```

Configuring N+1 on the Slave Controller

After starting N+1 on each of the Master Controllers, start N+1 on the Slave Controller, and then add each Master Controller to the Slave Controller.

The Slave Controller must be the last controller in the cluster to start N+1. All Master Controllers must be added to the cluster before starting N+1 on the Slave Controller.

To configure N+1 on the slave controller, follow these steps:

1. Enter configuration mode and start the N+1 software:

```
NP1-controller-slave(15)# configure terminal
   NP1-controller-slave(15)(config)# nplus1 start slave
   Setting up this controller as a Passive Slave controller
```

2. Check that the software has started on the slave with the show nplus1 command (note that no masters display in the Master Controllers list):

```
NP1-controller-slave(15)(config)# show nplus1
   Current State : Passive
   Heartbeat Period : 1000 milliseconds
   Heartbeat Threshold : 4 threshold
   Slave IP : 172.19.215.32
   Slave Hostname : NP1-controller-slave
   License Type : Demo
   License Usage (Used/Tot) : 0/1
   ------------------------------------------------------------------------
           Master Controllers

   Hostname  IP Address  Admin Status Switch  Reason Missed Adverts SW Version
```

```
--------------------------------------------------------------------------------
```

3. Supply the hostname and IP address of each master controller in the cluster. You will be prompted for the controller's password to complete the addition:

```
NP1-controller-slave(15)# configure terminal
   NP1-controller-slave(15)(config)# nplus1 add NP-controller-master  172.19.215.31
   admin@172.19.215.31 Password:
```

4. Exit configuration mode and check that the master controller has been enabled (the Admin status is now Enable):

```
NP1-controller-slave(15)#sh nplus1

--------------------------------------------------------------------------------

            Current State : Passive
           Heartbeat Period : 1000 milliseconds
         Heartbeat Threshold : 4 threshold
                    Slave IP : 172.19.215.32
              Slave Hostname : NP1-controller-slave
                License Type : Demo
    License Usage (Used/Tot) : 1/1

--------------------------------------------------------------------------------
                         Master Controllers

                                                                          Hostname
   IP Address  Admin  Status Switch  Reason  MissedAdverts  SW Version
   ------------------------------------------------------------------------------

NP-controller-master 172.19.215.31  Enable  Active  Yes     -    0        6.1-2-15
```

Monitoring the N+1 Installation

The show nplus1 command allows you to check the current controller configuration and show the status of the controller. Some sample output displays are included to show the information displayed in the various controller states.

- N+1 on master—displays both basic master and slave controller identification information

```
NP-controller-master(15)# sh nplus1
   ----------------------------------------------------
   Master controller
   Master IP : 172.19.215.31
   Master Hostname : NP-controller-master
   Master Status : Active
   Slave IP : 172.19.215.32
   Slave Status : Passive
```

- N+1 on a standby slave—basic slave controller identification information plus the status for the master controllers in the cluster (accompanying table describes status fields)

```
NP1-controller-slave(15)#sh nplus1

--------------------------------------------------------------------------------

            Current State : Passive
           Heartbeat Period : 1000 milliseconds
         Heartbeat Threshold : 4 threshold
                   Slave IP : 172.19.215.32
              Slave Hostname : NP1-controller-slave
                License Type : Demo
    License Usage (Used/Tot) : 1/1

--------------------------------------------------------------------------------
                         Master Controllers

                                                                                Hostname
   IP Address  Admin  Status Switch  Reason  MissedAdverts  SW Version
   ------------------------------------------------------------------------------

NP-controller-master 172.19.215.31  Enable  Active  Yes     -    0        6.1-2-15
```

The descriptions of the display fields are provided in the following table:

Field	Description
Hostname	Hostname of the master controller
IP Address	Static IP address assigned to the master controller
Admin	Status of N+1 redundancy on the master: • Enable—N+1 redundancy has been enabled on the master • Disable—N+1 redundancy has been disabled
Switch	Ability of the slave to assume active slave for the master: • Yes—Slave and master model/FortiWLC (SD) version number are compatible • No—Slave and master model/sFortiWLC (SD) version number are incompatible or the administrator has disabled N+1 on the master

Field	Description
Reason	If Switch is No, describes why switch cannot be made: • Down: Master has been disabled by the user • SW Mismatch: The FortiWLC (SD) software is out of sync (update the Master Controller). • No Access: The Passive Slave was not able to access the Master because it did not receive a copy of the configuration. This is a rare message that occurs if show nplus1 is executed almost immediately after adding a controller.
Missed Adverts	Number of consecutively missed (not received) advertisements (a maximum of 4 triggers a failover if the Switch field is Yes).
SW Version	The software version of FortiWLC (SD) on the controller.

- N+1 on an active slave—the master IP address, hostname, and status are added to the display. Passive status indicates the original master is UP, Down status indicates the original master is not reachable.

```
NP-controller-master(15)# sh nplus1
   ------------------------------------------------
              Current State : Active Slave
           Heartbeat Period : 1000 milliseconds
         Heartbeat Threshold : 4 threshold
                   Master IP : 172.19.215.31
            Master Hostname : NP-controller-master
                  Slave IP : 172.19.215.32
             Slave Hostname : NP1-controller-slave
               License Type : Demo
    License Usage (Used/Tot) : 1/1
   ------------------------------------------------
                 Master Controllers
               Hostname       IP Address  Admin    Status
   ------------------------------------------------------------------
       NP-controller-master    172.19.215.31  Enable   Passive
```

Slave configuration commands are not operable when the Slave is Active.

Managing the N+1 Installation

The tasks to manage an N+1 installation include:

- **Syncing Running Configuration**
- **Disabling and Deleting N+1 Master Controllers**
- **Stopping N+1 Installations**
- **Replacing a Master Controller**
- **Working with N+1 Syslog**

Syncing Running Configuration

Running configuration between master and slave are automatically synced every 30 minute.

Disabling and Deleting N+1 Master Controllers

To disable N+1 operation on a master controller, but still maintain its configuration in the cluster, from the slave controller, use the nplus1 disable command, with the IP address of the controller you are deleting:

```
NP1-controller-slave# configure terminal
   NP1-controller-slave(config)# nplus1 disable 10.1.1.10
   NP1-controller-slave(config)# end
```

To remove an N+1 master controller from the cluster, from the slave controller, use the nplus1 delete command, with the IP address of the controller you are deleting:

```
NP1-controller-slave# configure terminal
   NP1-controller-slave(config)# nplus1 delete 10.1.1.10
   NP1-controller-slave(config)# end
```

Stopping N+1 Installations

N+1 Slave and N+1 Master Controllers must be stopped separately.

Stopping N+1 Slave Controllers

To stop N+1 on a Slave Controller:

```
NP1-controller-slave# configure terminal
   NP1-controller-slave(config)# nplus1 stop
   Making this a normal controller.
   NP1-controller-slave(config)# exit
   NP1-controller-slave#
```

Stopping N+1 Master Controllers

To stop N+1 on a Master Controller:

```
3000-1# configure terminal
   3000-1(config)# nplus1 stop
   3000-1(config)# exit
```

The following commands cannot be executed in an active slave controller and if executed on an active master, these commands will not trigger failover.

- poweroff controller
- reload
- reload default
- reload default factory

Replacing a Master Controller

To replace a a new master controller, do the following:

1. Power off the original master controller. The slave controller becomes the active controller.
2. Replace the new controller. Ensure that the new controller contains the same configuration for bonding, interface mode, and IP address(es) as the original master controller.
3. Run "nplus1 start master" command on the new controller in order to make this new controller the master controller.
4. Run "nplus1 slave <slave's IP address>" command on the the new master controller in order to detect slave controller. The new master controller takes passive role.
5. Run "nplus1 access <slave's IP address>" command on active slave controller in order to generate authorized key on the new passive master controller.
6. Then, copy the latest running configuration to the new passive master controller after executing the "nplus1 revert" command on the active slave controller

The the new active master controller automatically runs with the latest running configuration.

Working with N+1 Syslog

If the syslog host is configured on the slave controller, then the slave controller also sends syslog host messages with the slave tag keyword added on the syslog messages. The message includes the hostname, company name, product name, and the build details, for example, *Slave-3000D FORTINET|FORTIWLC|SD8.5-0dev-17|SLAVE|*. These syslog messages are visible on the active slave controller as well; the active slave controller also sends syslog messages in the same format with the slave tag keyword added.

The show nplus1 debugloglevel command shows the level of verboseness set for the N+1 log messages.

```
NP1-controller-slave# sh nplus1 debugloglevel
   nplus1 Debug Logging Level: 0
   NP1-controller-slave#
```

Setting the syslog Debug Level

The nplus1set debugloglevel command sets the level of verboseness for the N+1 log messages. The level can be set from 0 to 3, where 1 is the least verbose. The default 0 setting disables syslog messaging.

```
NP1-controller-slave(config)# nplus1 setdebugloglevel 1
```

N+1 Syslog Messages

Syslog messages are generated and sent to a log file on the syslog server configured with the syslog-host command. These message are sent by a standalone N+1 slave controller when an error condition occurs. A sample syslog message follows:

```
Oct 26 14:02:45 slave nplus1_Slave: <error message>
```

The list of syslog messages are as follows:

Error Message	Description/Remedy
IP address not assigned. Please run setup before using nplus1	The command nplus1 start slave executed, but no IP address exists for the controller. Run the setup command on that controller and assign the controller a static IP address.
ERROR: Could not get software version from file: forti_sw_version_file	Couldn't determine the FortiWLC (SD) software version.
Rejecting record number due to parsing issues	Error reading the persistent record of configured masters. Manually add the Master Controllers again.
Could not open socket for CLI server	Problem initializing the N+1 CLI.
CLI server: Bind error for server ip: ip port: port	Issues in initializing N+1 CLI.
ALERT: Software Mismatch: Master (master_ip): software_version Slave (slave_ip): software_version	The Master Controller advertisement revealed a software mismatch. While the version mismatch occurs, the Master Controller cannot provide redundancy. Install on the Master Controller the same software version as the Slave Controller (or vice versa).
Copyback failed for master controller: master_ip	Configuration of Master Controller changed while the Slave was active, and the copyback failed. Remove the new Master Controller configuration changes, failback the Master Controller, and then perform the needed configuration changes.

For MC: master_ip State: SW Mismatch -> No Access - Saved Config does not exist	Software mismatch was resolved, but the Master Controller is not accessible from the Slave Controller and cannot provide redundancy. Ensure that the Master Controller is accessible using the command nplus1 access master_ip.
Could not access host: master_ip. Setting No Access Count to: count	Could not access the Master Controller. The Master Controller cannot provide redundancy until it is accessible. Access will be rechecked after count (default is 60 seconds). The problem may be caused by a gateway failure. Ensure that the Master Controller is accessible, and verify by using the command nplus1 access master_ip.

Upgrading

Controllers in a N+1 network can be upgraded like any controller in a standalone deployment. However, only active master and standby slave controllers can be upgraded. Controllers in failover mode cannot be upgraded.

Recovering From N+1 Failover

When an N+1 master controller goes down, the slave controller transitions from passive slave to active slave (failover) and starts acting as the master controller. When the original master comes back up, the active slave continues to be active slave and the original master becomes passive master. The APs (if in L2 mode) will now reboot.

Recovering From N+1 with Dual Ethernet Failover

On the Master controller, when the first Ethernet interface goes down, the controller fails over to second interface of the same controller. If the second interface goes down, Nplus1 failover takes place and the N+1 passive slave becomes an active slave with Dual Ethernet redundant configuration.

The active slave is now in control. If the first active slave Ethernet interface goes down, the slave controller fails over to the second Ethernet interface.

To revert the failover, verify that the first interface on the Slave controller is up and running. Then, bring up the first interface of the original Master controller. The N+1 active slave continues to be active slave and the original N+1 master becomes passive.

Option 43

Option 43 is not part of any Fortinet product; it is a method for mapping controllers. With DHCP Option 43, you can specify a primary and backup controller for APs. With this configuration, the backup controller can be in a different subnet from the primary controller. Option 43 implements redundancy by specifying which controllers (primary and secondary) an AP should associate to. This feature is supported across all access points. A backup controller can be configured using either DHCP or DNS.

For example, using Option 43, if “wlan-controller” is mapped to P1 (and P1 has a redirect to P2) and “wlan-controller-2” is mapped to S1 (and S1 has a redirect to S2), the discovery order would be P1, P2, S1, S2. If a controller has both a DNS entry and Option 43 enabled, the AP will first use the host address as configured on the AP (default value = wlan-controller). If the host address is configured as 0.0.0.0 or if the host is a name and the name cannot be resolved using DNS, only then will the AP look at the DHCP Option 43 value.

AP Aware Redundancy using DHCP Option 43

- Configure APs with L3 preferred and the controller name as 0.0.0.0
- On the DHCP server, Option 43 values need to be configured with primary and secondary controller IPs and/or hostnames. Then, when an AP contacts the DHCP server to obtain an IP address, it also receives primary and secondary controller IP information using the Option 43 value from the DHCP server.

AP Aware Redundancy using DNS

- Configure APs with L3 preferred and the controller name as the hostname of the controller.
- Configure a DNS entry to resolve the primary hostname on the DNS server. Configure a DNS entry to resolve the secondary hostname on the DNS server.
- Configure the hostname of the primary controller on the AP with L3 preferred mode.

8 Configuring Network Interfaces

One of the first steps when setting up a controller is to configure the networking parameters using the setup program**.** If you did not run the setup program, or if you want to change the settings that were configured with the setup script, you can use the commands described in the section **Configuring Basic Networking for the Interface**.

Because controllers have more than one FastEthernet ports, you may want to configure the second port for additional operation. The second port can be used as redundant interface or as a second active FastEthernet interface. To configure the Dual-Ethernet feature, refer to the section **Dual-Ethernet Operation**. Note that after a change like this, you need to reboot the controller.

Configuring Basic Networking for the Interface

Use the following commands to configure network parameters, if necessary:

- To change the parameters of the FastEthernet port, use the interface FastEthernet command.
- To set up a dynamic IP address assignment for the wireless clients using the DHCP relay server, use the ip dhcp-server ip-address command.
- To set the IP address of the controller, use the ip address ip-address netmask command.
- To set the default gateway, use the ip default-gateway ip-address command.
- To set the domain name, use the ip domainname name command.
- To add one or more DNS name servers, use the ip dns-server ip-address command.

For more information about the listed commands, see the ***FortiWLC (SD) Command Reference.***

802.11d Support

The original 802.11 standard defined operation in only a few regulatory domains (countries). 802.11d added the ability for 802.11 WLAN equipment to operate in additional countries by advertising the country code in the beacon. Devices pick up the country code and adjust communication accordingly. You do not have to configure or enable this feature; the Fortinet implementation currently works automatically for all countries listed in setup. There is no show

command that displays this feature. Validate 802.11d in the 802.11 Beacons and Probe Response, Country code IE field.

Dual-Ethernet Operation

Dual-Ethernet support enables the controller's second Ethernet port and provides the ability for it to work either as a redundant interface or a second active interface.

If the second interface is configured as redundant, it will serve as a backup interface to the first interface. This means that it will be idle as long as the first interface is functional and will perform all functions of the first interface if the first interface fails. In a redundant configuration, the first interface can have static or DHCP IP address.

If the second interface is configured as active, it can be configured as a separate interface that can support an additional configuration, for example to support GRE tunneling while the first interface is configured for VLANs.

The first Ethernet interface is treated as the default interface. The responsibility of the default interface is to pass wireless tunnel traffic between the APs and the controller. In addition to the general support of GRE and VLAN, the default interface is also the designated management interface for the controller, providing support for management access traffic via SSH and HTTPS.

It is implicit in the configuration of redundant mode that the second Ethernet interface should be connected to a switch port in which it can perform the same functions as the default Ethernet interface.

Note that when changing from redundant to dual active operation, a controller reboot is required.

Configuring Dual Ethernet

The second Ethernet interface can be configured as either redundant or active. An active interface can be used to support a VLAN or GRE (Generic Routing Encapsulation) tunneling. A redundant interface is a backup interface in case the primary interface fails.

Do not insert an Ethernet cable into the second Ethernet port until it has been configured as active or redundant.

Configuring a Redundant Interface

See the chapter **Implementing Redundancy**.

Configuring an Active Interface

The following commands configure Ethernet port 2 as an active interface that can be used to support a VLAN or GRE (Generic Routing Encapsulation) tunneling. The ip address specifies the IP address of the VLAN or GRE local endpoint followed by the associated netmask. The gw command specifies the gateway address, and is a mandatory field.

```
default# configure terminal
   default(config)# interface FastEthernet 2
   default(config-if-FastEth)# ip address 172.26.16.200 255.0.0.0
   default(config-if-FastEth)# gw 172.26.16.1
   default(config-if-FastEth)# type active
   default(config-if-FastEth)# exit
   default(config)# exit
```

When changing from redundant to dual active operation, a controller reboot is required.

After completing the interface configuration above, to configure a GRE tunnel, see **Configure GRE Tunnels** in the Security chapter.

Viewing FastEthernet Interface Information

To view the FastEthernet interface 1 configuration, use the show interfaces FastEthernet controller or show interfaces FastEthernet ap commands to display information relating to each type of interface.

To view the FastEthernet interface 2 redundant configuration, use the command show second_interface_status.

Interface and Networking Commands

The following interface and networking configuration commands are available.

TABLE 8: *Interface and Networking Commands*

Command	Purpose
controller(config)# interface FastEthernet controller interface-index	Specify the controller interface index (0-31) and enter FastEthernet interface configuration submode.
controller(config)# ip address ip-address mask	Specifies the IP address and subnet mask for the controller. This is used to specify the static IP address if you are not enabling DHCP.
controller(config)# gw ip-address	Specifies the IP address of the default gateway. Used to specify the gateway if you are not using DHCP.
controller# setup	Interactive script that helps set up hostname and other system and networking parameters.
controller# show interfaces FastEthernet statistics	Displays the summary table of Ethernet statistics for the controller and APs.
controller# show interfaces FastEthernet statistics controller	Displays the Ethernet statistics for the controller.
controller# show interfaces FastEthernet statistics ap id	Displays the Ethernet statistics for the AP with the given node ID.
controller# show second_interface_status	Displays the status of the second FastEthernet interface when configured for redundant mode.

Configuring Port Profiles

The Port Profile configuration screen allows you to create custom Ethernet profiles that can be applied to non-primary Ethernet ports on deployed devices. Certain AP models implement multiple Ethernet ports, and while one is always used for wireless service, the remaining ones can be configured by applying a Port Profile to them. If this functionality is not needed, the port can also be disabled via the Port Profile feature.

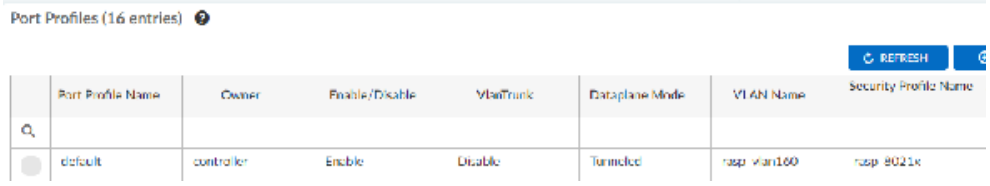
Each device that is connected to a non-primary port (either directly or through a switch that is wired to the port) can be monitored as a wired station in the controller WebUI (via Monitor > Devices > All Stations). If the interface is configured for tunneled operation and the connected device is a VoIP phone utilizing SIP, the phone will be visible as a SIP phone in the controller's phone database. Note that the maximum number of wired stations supported per wired interface is 128.

Refer to the following sections for steps on how to configure and apply Port Profiles.

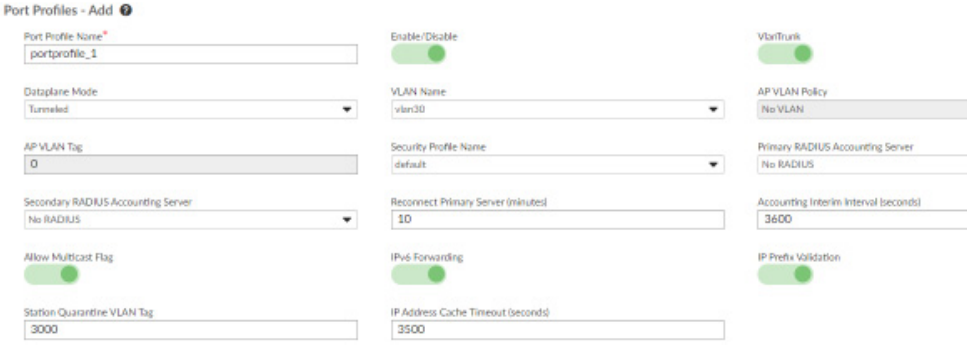
Creating a Port Profile

By default, a default Port Profile is configured in the controller interface. To view the existing Port Profiles, simply open the WebUI and navigate to Configuration > Wired > Port. See **Figure 45**.

Figure 45: *Port Table*



Several options can be configured as part of a Port Profile.



The following table describes each field displayed.

TABLE 9: *Port Profile Options*

Field	Description
Port Profile Name	The name provided for the port profile during profile creation.
Enable/Disable	Displays whether the profile is currently enabled for use.
Dataplane Mode	Allows the profile to be configured for either Tunneled or Bridged configuration.
AP VLAN Tag	This field is only configured when the profile is operating in Bridged mode. The VLAN tag is an integer from 0 to 4094 that identifies the VLAN on which the AP resides.
VLAN Name	This field is only used when the profile is operating in Tunneled mode. It allows you to specify the VLAN on which the profile is configured.
Allow Multicast Flag	This option allows you to specify whether multicast transmissions will be permitted via the port in use.
IPv6 Forwarding	IPv6 forwarding allows ICMPv6, DHCPv6, and other IPv6 traffic to be passed through the controller in tunnel mode. If disabled, all the IPv6 packets coming into the controller are dropped. IPv6 Forwarding is disabled by default; however, on upgrade the older (pre-upgrade) configuration is retained, whether enabled or disabled.

If desired, the default profile can be modified by checking the box alongside it in the table and clicking Settings. To add a new profile, perform the following steps:

1. From the WebUI, navigate to Configuration > Wired > Port.
2. Click Add. The screen refreshes to display the Port Table - Add page.
3. Configure the profile as desired. Refer to **Table 9** for descriptions of the configuration options.
4. When finished, click OK to save the new profile.

Once a profile has been created, it can be applied to the desired port(s) on network devices. Refer to the following section for instructions.

Enabling a Port Profile on a Specific Ethernet Port

To specify a port profile for a given Ethernet port, you must access the Port AP Table; from the Port Profile Table, select the desired profile and click Configuration. The Port AP Table is the second tab provided on the resulting screen.

By default, the Port AP Table is blank; you can manually add ports as desired. To add a port for the profile:

1. From the Port AP Table screen, click Add. The resulting table will allow you to select the AP and Interface ID to which the port profile will apply.
2. Use the drop-down lists to select the desired AP and Ethernet IDs. Note that if the Ethernet Interface Index specified is an Uplink interface (i.e., the interface is its primary connection to the network), it cannot be configured for a port profile and an error message will appear.
3. Click OK to save the changes.

These steps may be repeated for as many profiles as desired.

Enable 802.1x Authentication

Wired clients can be connected to the AP's Wired Interface directly or can be connected via an L2 switch. In a deployment that uses L2 switch for multiple wired clients, the L2 switch must be configured to pass through 802.1x packets.

To enable 802.1 x authentication for wired clients, do the following:

1. Create a RADIUS profile and security profile (using 802.1x L2 authentication mechanism with Clear Encryption mode)
2. Attach the security profile to the respective port profile configuration.

Enabling using CLI

Create RADIUS Profile

```
default(15)(config)#

default(15)(config)# radius-profile dot1xport

default(15)(config-radius)# ip-address 10.10.10.10

default(15)(config-radius)# key Forti2002

default(15)(config-radius)# port 1812

default(15)(config-radius)# exit
```

Create Security Profile

```
default(15)# configure terminal

default(15)(config)# security-profile dotxportauth

default(15)(config-security)# allowed-l2-modes 802.1x

default(15)(config-security)# encryption-modes clear
```

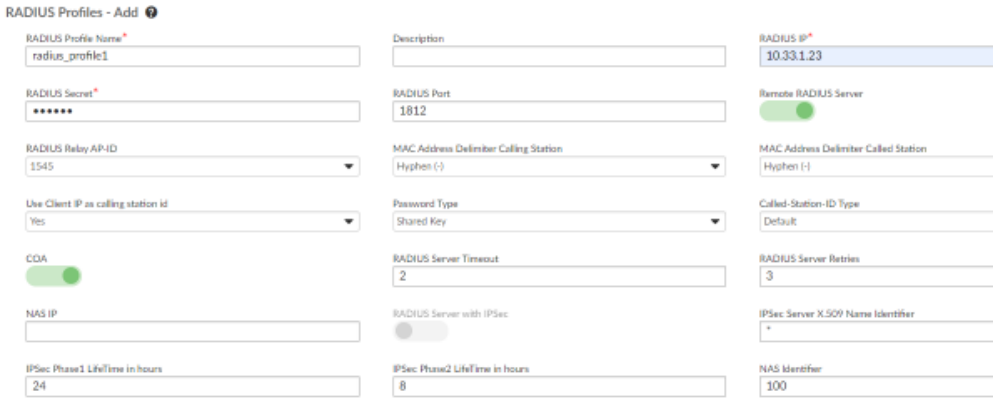
```
default(15)(config-security)# radius-server primary dot1xport
default(15)(config-security)# exit
```

Create Port Profile

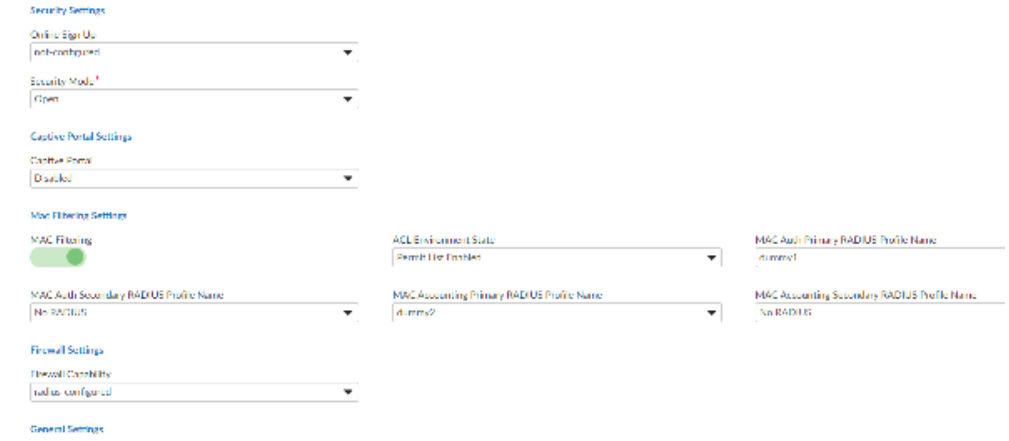
```
default(15)# configure terminal
default(15)(config)# port-profile dot1xauth
default(15)(config-port-profile)# enable
default(15)(config-port-profile)# dataplane tunnelled
default(15)(config-port-profile)# security-profile dot1xportauth
default(15)(config-port-profile)# exit
default(15)#
```

Enabling using WebUI

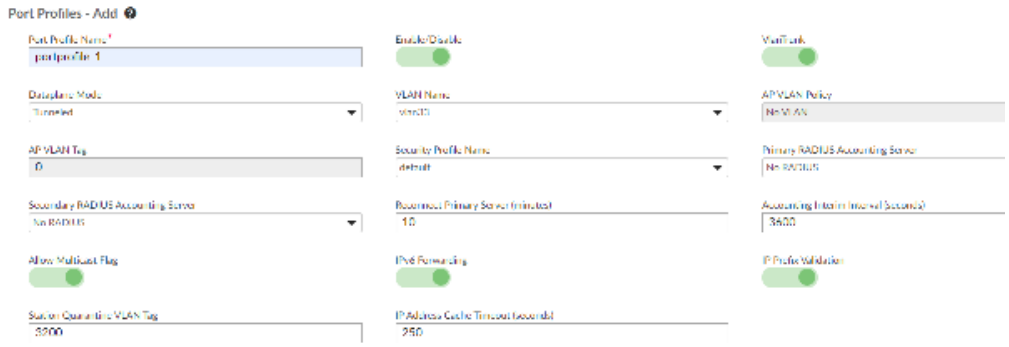
Create RADIUS Profile



Create Security Profile



Create Port Profile



Link Aggregation

Link aggregation allows data traffic across both Ethernet ports on AP resulting in increased throughput and redundancy. You can configure LACP only on the second interface of the AP. Before you configure LACP on the second interface of the AP, enable bonding on the switch that terminates AP. When configured for link aggregation, the second interface of the AP will inherit all properties of the first interface. When enabled, LACP is functional on both ports.

The second interface of the AP is disabled by default and when enabled it functions as the bonded pair to the first interface. The second interface cannot be used in standalone mode. However, when LACP is enabled and if one of the interfaces fails, the second interface takes

over and passes traffic. During a failover, the second interface will function only if there is an external power supply or if the switch can provide only power via PoE.

If the switch that terminates the AP does not support LACP, the AP will fall back to non-LACP mode with only one interface passing data traffic. Static bonding is not supported.

Pre-requisites

Before you enable LACP on the AP, ensure that you do the following

- Remove port AP entry from the port profile of that AP.
- Enable LACP support for the ports on the switch that terminates the AP.
- AP requires 802.3at power to support LACP.

NOTE: By default, AP832 requests 802.3af power via LLDP. Use static 802.3at power for LACP and Bluetooth.

If the switch does not support LACP, the AP will work in non-LACP mode.

Configuring LACP

Note: Ensure that LACP should be disabled on the switch ports before you enable it on the access point.

1. Connect both the LAN ports of the access point to any two ports of the switch.
2. Configure the downlink port of the access point for Uplink-LACP.
   Navigate to *Configuration* > *Devices* > *AP* > *Ethernet interface* and enable **LACP**
   OR
   Run the *lacp enable* command.
3. Configure the switch ports for LACP.
4. Reboot the access point, run the *reload ap <AP ID>* or *sys reboot* command.

Since only one interface is configured for LACP, the bonding status of only the downlink interface is set to **Enabled** (*config show ethernet* command).

To batch enable LACP on multiple APs, navigate to *Configuration* > *Wired* > *Ethernet*, select all APs and click the **Bulk Update** button. Enable LACP.

LACP bulk update can be done only from the WebUI

Enabling LACP in CLI

Use the lacp enable command on an AP's ethernet interface to enable LACP.

```
controller(15)# config terminal

controller(15)(config)# interface ap 108 2

controller(15)(config-if-WiredEth)# lacp enable
```

Verifying LACP Status

The Uplink Type and LACP column in the show interfaces ap <ap-id> command displays the status of LACP for an AP.

```
Controller(15)# show interfaces Ethernet ap 108

Type        ID  Name           IfIndex MTU     MAC Address       Admin State Op
   State  Last Change          Uplink Type LACP

ap          108 AP-108         1       1500    00:0c:e6:13:01:a9 Up          Dis-
   abled  05/19/2014 20:05:12  Uplink      disable

ap          108 AP-108         2       1500    00:0c:e6:13:01:a9 Up          Dis-
   abled  05/20/2014 23:51:48  Uplink-lacp enable

        Ethernet Table(2 entries)
```

For additional diagnostics, you can view the Tx and Rx errors of AP interface using the show interfaces Ethernet statistics <ap-ID> command.

```
Controller(15)# show interfaces Ethernet statistics ap 13

 IfIndex   Node ID Node Name       Type        In Octets     In Errors     Out
   Octets    Out Errors


1        13     AP-13          ap         78217745     0           4637677
   0

2        13     AP-13          ap         0            0           0
   0

LACP     13     AP-13          ap         78217745     0           4638109
   0

        Ethernet Statistics(3 entries)
```

Configuring Management Interfaces

The Management Interfaces table (Configuration > Devices > System Settings > Management Interfaces) allows the user to control how traffic is sent from the controller to the wireless network. Refer to the following sections for each tab in the table.

Physical Interfaces

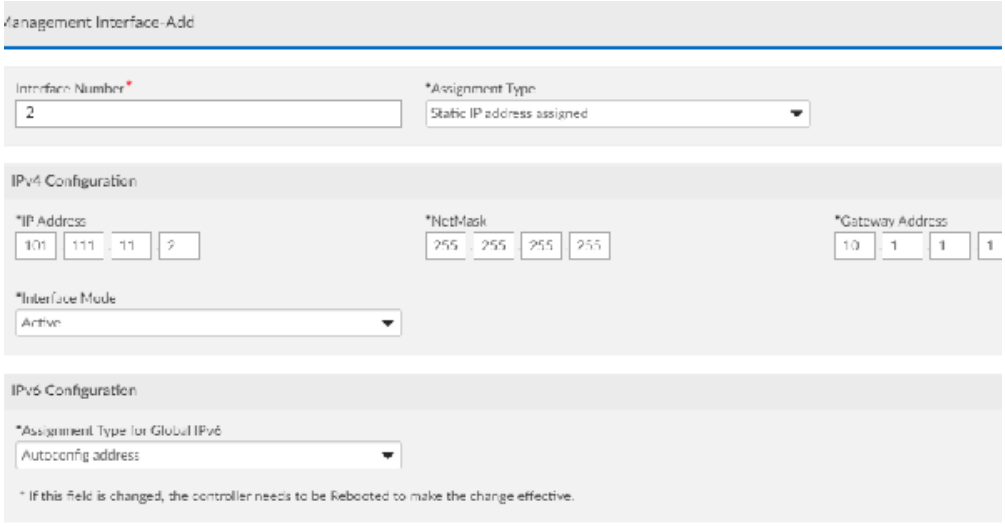
The Physical Interfaces table is where the user may configure the IP information for the physical Ethernet ports on the controller. The number of ports that may be configured will vary depending on the controller model purchased.

Add a Physical Interface

To configure a new physical interface, follow the steps below:

1. From the Physical Interfaces table, click Add. The Management Interface-Add window appears.

Figure 46: *Adding a Physical Interface*



2. Update the required configuration.

The following able describes the IPv4 configuration.

Field	Description
Interface Number	The number for the desired interface.
Assignment Type	Specifies whether the interface utilizes a Static or Dynamic IP address.
IP Address	If using a static IP, enter the IP address to be used by the interface.
NetMask	If using a static IP, enter the NetMask for the interface.
Gateway Address	If using a static IP, enter the gateway address for the interface.
Interface Mode	Specify whether the interface will be a active redundant.

The following able describes the IPv6 configuration.

Field	Description
Interface Number	The number for the desired interface.
Assignment Type for Global IPv6	**Static IP address assigned** For the Static option, the user must configure the Controller IP address manually. The following are the Static options displayed: • IPv6 Prefix - Provide a new global scope IPv6 prefix. • IPv6 Link Local Prefix - Provide a new unique link-local IPv6 prefix. • IPv6 Global Addr - Provide a new global scope IPv6 address. • IPv6 Link Local Addr - Provide a new unique link-local IPv6 address. **DHCP** For the DHCP option, the controller procures the IP address from the DHCP server. The user must ensure that a DHCP server is reachable. **Autoconfig address** The IPv6 address acquisition is based on the flags set in the router advertisement.

3. Click Save to save the interface. Note that the controller must be rebooted in order to apply the changes.

VLAN Interfaces

VLAN Interfaces allow the user to specify VLANs that are to be used specifically for Management traffic on the network. This traffic includes:

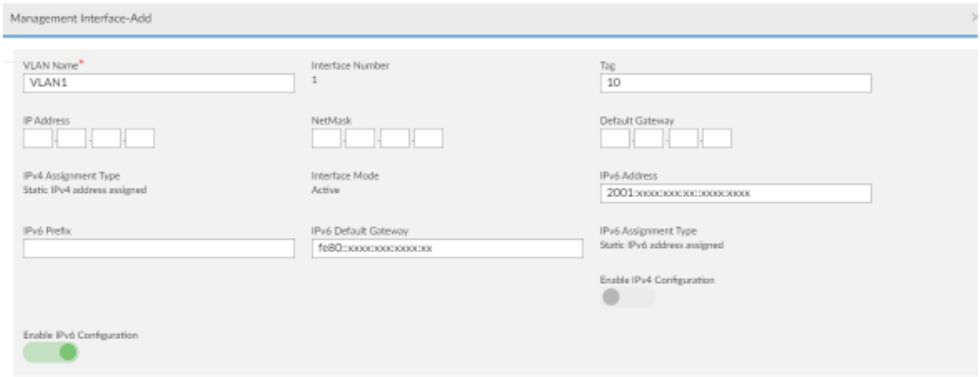
- Communications between the controller and APs or controller to controller
- Access to the WebUI or CLI
- SNMP traffic
- Communications to the Network Management server and any additional Fortinet applications (SAM, Spectrum Manager, etc)
- Syslog messages
- Authentication server traffic (RADIUS, TACACS+, etc)
- NTP communications

Using this functionality, users can isolate management traffic from the rest of the network and route it specifically to the devices for which it is intended. Follow the steps in the section below to create a VLAN interface. VLAN interfaces created on the controller acquire IPv6 addresses from router advertisements only.

Add a Management VLAN Interface

1. From the VLAN Interfaces table, click Add. The Management Interface-Add window appears.

Figure 47: *Adding a VLAN Interface*



2. Add in the required data as described in the table below.

Field	Description
VLAN Name	Enter a name for the VLAN.
Interface Number	The physical interface number to be used. Note: Management VLANs must utilize Interface number 1, so this field cannot be modified.
Tag	Enter a tag for the VLAN.
Enable IPv4 Configuration/Enable IPv6 Configuration	Enable IPv4/IPv6 configuration VLAN management interface.
IP Address/IPv6 Address	Enter the IPv4/IPv6 address to be used by the VLAN.
IPv6 Prefix	The IPv6 address prefix.
NetMask	Enter the NetMask for the VLAN.
Gateway Address/IPv6 Gateway Address	Enter the IPv4/IPv6 gateway to be used by the VLAN.
IPv4 Assignment Type/IPv6 Assignment Type	Management VLANs can only be implemented on static IP addresses, so this field cannot be changed.
Interface Mode	Management VLANs can only operate on Active interfaces, so this field cannot be changed.

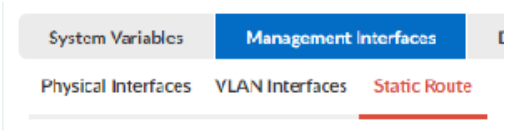
3. Click Save to save the VLAN. The new VLAN will appear in the VLAN Interfaces table.

Using Static Routes

Static routes allow the system administrator to manually define the adapters that are permitted access to configured subnets. This is of particular use in smaller deployments where only a few routes are needed, or in larger ones where certain subnets must be kept separate from each other. Static routing can also be advantageous in that it doesn't require the processing power that dynamic routes (in which the network router automatically determines the best delivery path for packets) can.

To view the static route table, access the WebUI and navigate to Configuration > Devices > System Settings > Management Interfaces > Static Route.

Figure 48: *Static Route Table*

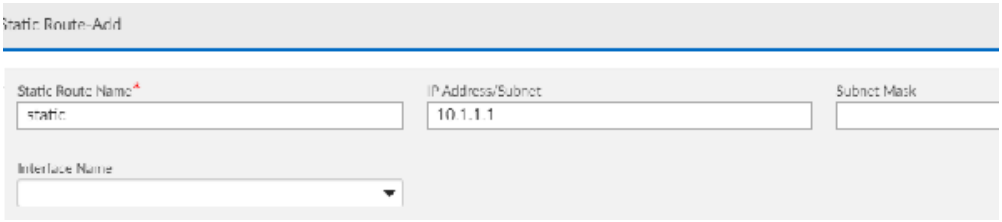


Until at least one route has been created, the table will be blank.

Adding a Static Route

To create a new static route, access the Static Route Table and click Add. The Static Route Configuration - Add screen appears.

Figure 49: *Creating a Static Route*



Provide the required details as described in the following table.

TABLE 10: *Static Route Fields*

Field	Description
Static Route Name	Enter a descriptive name for the route. Note that this must be between 1 and 16 characters in length.
IP Address/Subnet	Enter the subnet for which the route provides access. This is typically in the xxx.xxx.xxx.0 format, as shown above.
Subnet Mask	Enter the subnet mask for the route. This is typically in the 255.255.255.0 format, as shown above.
FastEthernet	Use this drop-down to specify which Ethernet adapter will utilize the route. The specified adapter will subsequently gain access to the configured subnet.
Interface Name	The name of the interface used for the route.
Default Gateway	The default gateway for the route.

Once the fields are filled in, click OK to save the route. Repeat this process for as many routes as desired.

9 Configuring Security

FortiWLC (SD) provides industry-standard security options that can be implemented according to the requirements of the ESSID (and VLAN, if so configured) to protect the site's wireless and, as a result, wired LAN infrastructure.

The Fortinet Security Fabric is an end-to-end security solution that expands network visibility by interconnecting wireless and security domains. All elements in the Security Fabric collaborate at different levels for advanced threat detection by sharing intelligence between security and network devices to detect and remediate attacks with coordinated responses. You can monitor your network for threat detection by the application and management of specific policies across the Security Fabric. The JSON REST API used is an open standard that facilitates the integration of FortiWLC into the Security Fabric and allows third party products to be a part of Fortinet's Fabric-Ready Partner Program.

Note:
FortiWLC 8.5.0 is ready for integration into Fortinet's Security Fabric. Fortinet will issue the required notification about the availability of the FortiOS version with support for FortiWLC integrated Security Fabric.

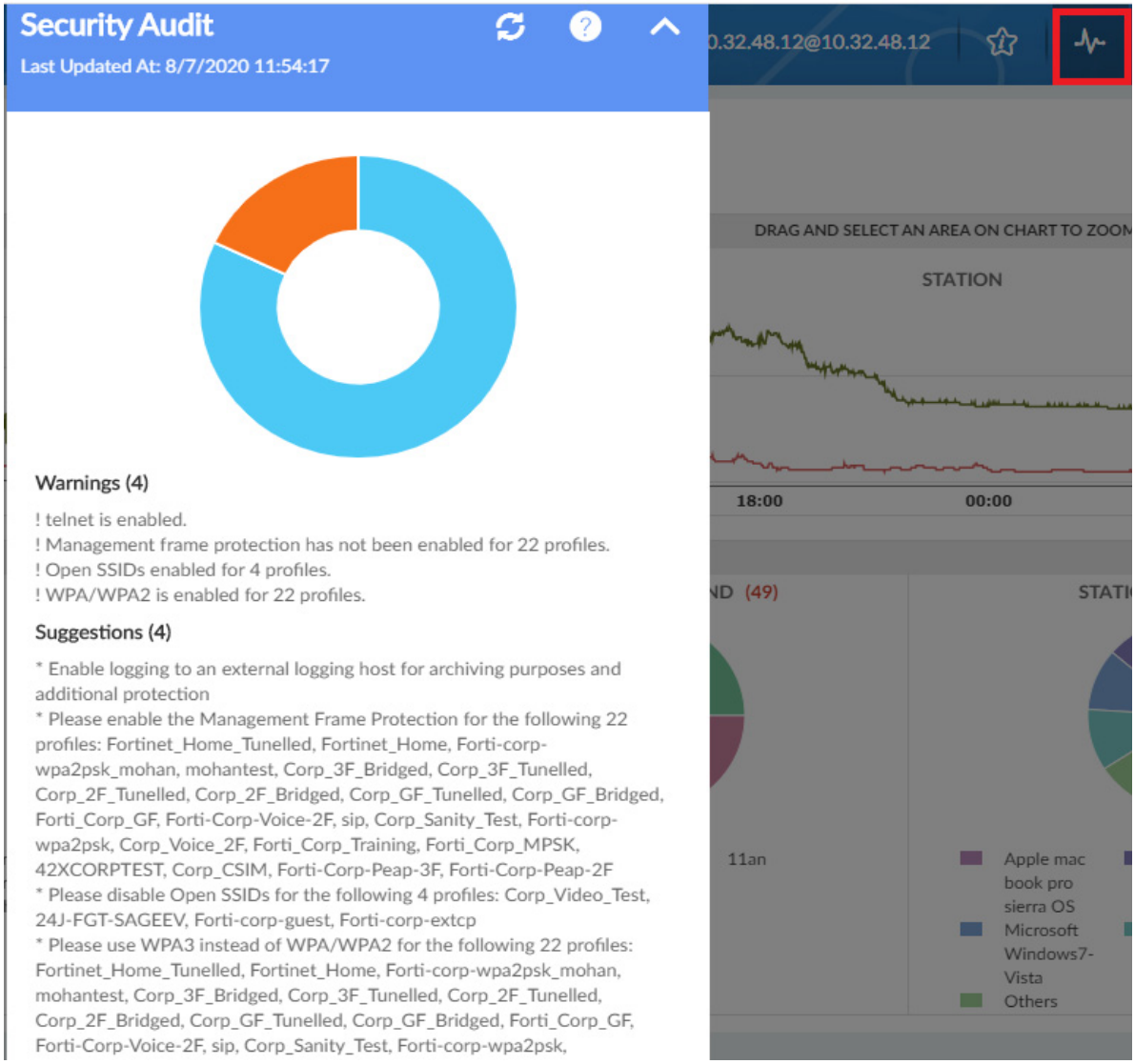
Also see the security-related chapters **Authentication**, **Captive Portals**, and **Rogue AP Detection and Mitigation**.

Security Audit

The security audit results are obtained by an in-built tool in FortiWLC that keeps your system secure by detecting security related issues and vulnerabilities. The security audit results report the potential risks/vulnerabilities in your system and provides suggestions to mitigate these and optimize your system. The security audit runs an extensive health scan and measures the hardness of your system.

Click on the security audit icon in the FortiWLC GUI home page to view the results.

Figure 50: *Security audit*



Configuring Wireless LAN Security

In Wireless LAN System, Layer 2 and Layer 3 security options are enforced by creating Security Profiles that are assigned to an ESSID. As such, they can be tailored to the services and the structure (virtual Port, Virtual Cell, etc.) offered by the ESSID and propagated to the associated APs. Security profiles for a controller can also be

configured from E(z)RF Network Manager. You can tell where a profile was configured by checking the read-only field Owner. The Owner is either E(z)RF or controller. The general security configuration tasks are as follows:

1. Create VLANs to keep the client traffic in each SSID secure and separate from clients in other SSIDs. See the chapter **Configuring VLANs** for directions.
2. Set up the Certificate Server or RADIUS server configuration (see the RADIUS server documentation for instructions).
3. Configure Security Profiles based on the type of security required (continue with the following sections).
4. Configure one or more ESSIDs (see the chapter **Configuring an ESS** for directions) and assign the VLAN and Security Profile to them.

Configure a Security Profile With the Web UI

To configure Security Profile parameters, follow these steps:

1. Click Configuration > Security > Profile.
2. In the Security Profile Name box, type the name of the security profile. The name can be up to 32 alphanumeric characters long and cannot contain spaces.
3. In the L2 Modes Allowed area, select one of the following Layer 2 security modes:
   - Clear: The WLAN does not require authentication or encryption, and the WLAN does not secure client traffic. This is the default setting.
   - 802.1x: Can provide 802.1x authentication and WEP64 or WEP128 encryption.
   - Static WEP keys: Requires that stations use a WEP key (see step 6).
   - WPA2: Requires 802.1x RADIUS server authentication with one of the EAP types (see step 4 to select a pre-configured RADIUS server profile). For more information, see *"Wi-Fi Protected Access (WPA3/WPA2)" **on page 234***.
   - WPA2 PSK: Uses the CCMP-AES encryption protocol and requires a pre-shared key (see step 12 to enter the pre-shared key).
   - WPA3-SAE/CCMP-AES**:** Uses the Simultaneous Authentication of Equals (SAE) encryption method and requires a pre-shared key.
   - WPA2-WPA3/CCMP-AES**:** Uses the CCMP-AES and SAE encryption methods and requires a pre-shared key.
   - WPA2-TKIP
   - MIXED: Allows WPA2 clients using a single security profile.
   - MIXED PSK: Allows pre-shared key clients to use a single security profile.
   - WAI: Uses the WPI-SMS4 encryption protocol.
   - WAI PSK: Uses the WPI-SMS4 encryption protocol and requires a shared key.
4. In the Data Encrypt area, select one of the following (available choices are determined by the L2 Mode selected):
   - Clear: The WLAN does not require encryption.

- WEP64: A 64-bit WEP key is used to encrypt packets. For more information, see *"WEP Security Features" **on page 235***.
- WEP128: A 128-bit WEP key is used to encrypt packets. For more information, see *"WEP Security Features" **on page 235***.
- CCMP-AES: A 128-bit block key is used to encrypt packets with WPA2. For more information, see *"CCMP-AES" **on page 235***.
- WPI-SMS4: Encryption algorithm used with WAI and WAI PSK.

If you select WEP64 or WEP128, you need to specify a WEP key, as described in step 6. If you specify CCMP-AES for WPA2-PSK, a pre-shared key must be set, as described in step 12.

5. From the Primary RADIUS Profile Name list, select one of the configured RADIUS Server Profiles for use as the primary server or select the No RADIUS option. If no RADIUS Server Profiles have been configured, the selectable list is unavailable and the text "No Data for Primary RADIUS Profile Name" displays. To configure a RADIUS Server Profile, click Configuration > Security > RADIUS.
6. From the Secondary RADIUS Profile Name list, select one of the configured RADIUS Server Profiles for use as the secondary server or select the No RADIUS option. If no RADIUS Server Profiles have been configured, the selectable list is unavailable and the text "No Data for Primary RADIUS Profile Name" displays. To configure a RADIUS server profile, click Configuration > Security > RADIUS.
7. In the WEP Key box, specify a WEP key. If you selected Static WEP Keys in step 2, you need to specify a WEP key in hexadecimal or text string format.

A WEP64 key must be 5 octets long, which you can specify as 10 hexadecimal digits (the hexadecimal string must be preceded with 0x) or 5 printable alphanumeric characters (the ! character cannot be used). For example, 0x619B947A3D is a valid hexadecimal value, and ***wpass*** is a valid alphanumeric string.

A WEP128 key must be 13 octets long, which you can specify as 26 hexadecimal digits (the hexadecimal string must be preceded with 0x) or 13 printable alphanumeric characters (the ! character cannot be used). For example, 0xB58CE2C2C75D73B298A36CDA6A is a valid hexadecimal value, and mypass8Word71 is a valid alphanumeric string.

8. In the Static WEP Key Index box, type the index number to be used with the WEP key for encryption and decryption. A station can have up to four static WEP keys configured. The static WEP key index must be an integer between 1 through 4 (although internal mapping is performed to handle wireless clients that use 0 through 3 assignments).
9. In the Re-Key Period box, type the duration that the key is valid. Specify a value from 0 to 65,535 seconds. The default re-key value is zero (0). Specifying 0 indicates that re-keying is disabled, which means that the key is valid for the entire session, regardless of the duration.
10. In the BKSA Caching Period (seconds), the duration that the key is valid. Specify a value from 0 to 65,535 seconds. The default value is 43200.
11. In the Captive Portal list, select one of the following:
    - Disabled: Disables Captive Portal.
    - WebAuth: Enables a WebAuth Captive Portal. This feature can be set for all L2 Mode selections.

12. If you want to use a third-party Captive Portal solution from a company such as Bradford, Avenda, or Cloud-Path change the value for Captive Portal Authentication Method to external. For more information, see **Captive Portal (CP) Authentication for Wired Clients**.
13. The Captive Portal AP Offload can be configured when creating the Security profile. Enabling this option allows URL redirection to be offloaded to the APs, thereby, reducing the load on the controller and allowing more concurrent captive portal authentication requests to be handled. This option is disabled by default.
14. To use 802.1x, select one of the following in the 802.1x Network Initiation list:
    - On: The controller initiates 802.1x authentication by sending an EAP-REQUEST packet to the client. By default, this feature is enabled.
    - Off: The client sends an EAP-START packet to the controller to initiate 802.1x authentication. If you select this option, the controller cannot initiate 802.1x authentication.
15. Tunnel Termination: Tunnel-Termination is provided by IOSCLI and Controller GUI, to perform configuration on per-security profile basis. Select one of the following in the Tunnel Termination list:
    - PEAP: PEAP (Protected Extensible Authentication Protocol) is a version of EAP, the authentication protocol used in wireless networks and Point-to-Point connections. It is designed to provide more secure authentication for 802.11 WLANs (wireless local area networks) that support 802.1x port access control. It authenticates the server with a public key certificate and carries the authentication in a secure Transport Layer Security (TLS)
    - TTLS: TTLS (Tunneled Transport Layer Security) is a proposed wireless security protocol.

Note that when Tunnel Termination is enabled, Fortinet's default certificate is used. In this case, the certificate must be "trusted" on the wireless client end in order for authentication to be successful. Refer to **Security Certificates** for details on how to import a certificate.

When PEAP/TTLS is configured on the RADIUS server, PEAP/TTLS termination should be disabled.

16. If the Static WEP Key mode is used, in the Shared Key Authentication list, select one of the following:
    - On: Allows 802.1x shared key authentication.
    - Off: Uses Open authentication. By default, this feature is off.
17. In the Psk Profile Name drop-down, select the secured PSK profile to be mapped to the Security profile. In the Pre-shared Key text box, enter the key if WPA2-PSK or WPA3 was selected as the security mode. The key can be from 8 to 63 ASCII characters or 64 hex characters (hex keys must use the prefix "0x" or the key will not work).
18. Configure **802.11W - Management Frame Protection**.
    - **Required** allows only those devices to associate with the SSID that support 802.11w and prevents devices that do not support 802.11w from associating.

- **Capable** allows devices that do not support 802.11w along with those that support 802.11w to associate with the SSID and use the 802.11w features.
- **Disable** disables the usage of 802.11w management protection frames.

19. In the Group Keying Interval text box, enter the time in seconds for the interval before a new group key is distributed.
20. In PMK Caching, select On or Off.
21. In the Key Rotation drop-down list, select whether to enable or disable this feature.
22. The timeout value for Backend Authentication Server Timeout can be 1-65535 seconds.
23. You can configure the 802.1x Session and Idle timeout only for RADIUS/Enterprise security modes. After the timeout, client requests for re-authentication.
    - **Session Timeout(min)**: Configures the timeout for 802.1x active session. The default is 480 minutes and the valid range is 0-1440 minutes.
      Note: The session timeout value obtained from the RADIUS server takes precedence.
    - **Idle Timeout(min)**: Configures the timeout for 802.1x idle session. The default is 60 minutes and the valid range is 0-1440 minutes.
24. You can configure the EAP timeout and retries between the access point and wireless clients only for RADIUS/Enterprise security modes. After the timeout, authentication fails and the client tries to reconnect as per the configured EAP retries.
    - **EAP Timeout(second)**: Configures the EAP authentication timeout between the access point and the wireless clients. The default is 5 seconds and the valid range is 1-30 seconds.
    - **EAP Retries**: The maximum number of retries before EAP timeout. The default is 3 retries and the valid range is 1-3 retries
25. For Re-authentication, select one of the following:
    - On: Causes the controller to honor and enforce the "Session-timeout" RADIUS attribute that may be present in a RADIUS Access-Accept packet. A customer would use this option if the Session-timeout attribute is used to require stations to re-authenticate to the network (802.1x) at a specified period. If "Session-timeout" is not used, there is no reason to enable re-authentication.
    - Off: Disables re-authentication for this security profile.
26. In the MAC Filtering list, select one of the following:
    - On: Enables MAC Filtering for this security profile.
    - Off: Disables MAC Filtering for this security profile.
27. In the MAC Auth Primary RADIUS Profile Name list, select the name of a previously configured authentication server profile.
28. In the MAC Auth Secondary RADIUS Profile Name list, select the name of a previously configured authentication server profile.
29. In the MAC Accounting Primary RADIUS Profile Name list, select the name of a previously configured RADIUS accounting server profile or the No RADIUS option.
30. In the MAC Accounting Secondary RADIUS Profile Name list, select the name of a previously configured RADIUS accounting server profile or the No RADIUS option.
31. In the Firewall Capability drop-down list, select one of the following:

- Configured: The controller defines the policy through configuration of the Firewall filter-id.
- RADIUS-configured: The RADIUS server provides the policy after successful 802.1x authentication of the user. This option requires the RADIUS server have the filter-id configured. If this is not configured, the firewall capability is not guaranteed.
- None: Disables the Firewall Capability for this security profile.

32. In the Firewall Filter ID text box, enter the firewall filter-id that is used for this security profile. The filter-id is an alphanumeric value that defines the firewall policy to be used on the controller, when the firewall capability is set to configured. For example, 1.

33. In the Security Logging drop-down list, select one of the following:

- On: Enables logging of security-related messages for this security profile.
- Off: Disables logging of security-related messages for this security profile

34. In the Passthrough Firewall Filter ID text box, enter a firewall filter ID that was created using Configuration > QoS > System Settings > QoS and Firewall Rules > Add. The filter ID is an alphanumeric value that defines the firewall policy to be used on the controller for a Captive Portal-enabled client that has no authentication.

35. Click OK.

Wi-Fi Protected Access (WPA3/WPA2)

Fortinet Wireless LAN System supports WPA3, WPA2, and 802.1x protocols that have been presented by the Wi-Fi Alliance as interim security standards that improve upon the known vulnerabilities of WEP until the release of the 802.11i standard.

The WPA3 uses the Simultaneous Authentication of Equals (SAE) encryption method that is a secure password based authentication and requires a pre-shared key. Hence, WPA3-Personal protects individual users by providing a robust authentication mechanism.

In WPA2, the WPA Message Integrity Code (MIC) algorithm is replaced by a message authentication code, CCMP, that is considered fully secure and the RC4 cipher is replaced by the Advanced Encryption Standard (AES), as described in *"CCMP-AES"* ***on page 235***.

If 802.1x authentication is not available (in a SOHO, for example), WPA2-Personal can be implemented as alternatives and provide for manual key distribution between APs and clients.

To achieve a truly secure WPA2 implementation, the installation must be "pure," that is, all APs and client devices are running WPA2-Enterprise. Implement this for Wireless LAN System with an ESS that uses a Security Profile that configures WPA2, leverages the site's 802.1x user authentication and includes TKIP or CCMP encryption. Once associated with this profile, users and enterprises can be assured of a high level of data protection.

To configure these security options see the sections *"Configure a Security Profile With the Web UI"* ***on page 230*** and *"Configure WPA2/WPA3 With the CLI"* ***on page 243***.

Encryption Support

Wireless LAN System offers CCMP-AES for WPA2. WPA2 uses CCMP/AES as encryption method. Descriptions of these technologies are provided in this section. Fortinet also supports the original 802.11encryption protocols provided by WEP64 and WEP128.

We recommend using the more secure CCMP-AES encryption solution if your site's client hardware cannot support CCMP.

CCMP-AES

AES is the Advanced Encryption Standard and is used by the US Department of Defence as a replacement for older encryption standards. As such, it is very secure. AES can be used in several modes, and CCMP is the mode used by WPA2. Both terms are commonly used interchangeably.

WEP Security Features

Wired Equivalent Privacy (WEP64 and WEP128) is a Layer 2 security protocol specified in the IEEE Wireless Fidelity (Wi-Fi) standard, 802.11. WEP is designed to provide a wireless LAN with comparable level of security and privacy to what is usually expected of a wired LAN. A wired LAN is generally protected by physical security mechanisms, such as controlled access to a building, that are effective for a controlled physical environment. However, such security mechanisms do not apply to WLANs because the walls containing the network do not necessarily bind radio waves. WEP seeks to establish protection similar to that offered by the wired network's physical security measures by encrypting data transmitted over the WLAN. Data encryption protects the vulnerable wireless link between clients and access points. Once this measure has been taken, other typical LAN security mechanisms such as authentication, password protection, and end-to-end encryption, can be put in place to protect privacy.

With the WEP protocol, all access points and client radio NICs on a particular wireless LAN must use the same encryption key. Each sending station encrypts the body of each frame with a WEP key before transmission, and the receiving station decrypts it using an identical key. This process reduces the risk of someone passively monitoring the transmission and gaining access to the information contained within the frames.

The WEP implementation allows the Security Profile configuration to specify one of four possible WEP keys that can be configured by a user station key management program.

To configure WEP, see the section *"Configure 802.11 WEP Encryption"* ***on page 245***.

Operation of the WEP Protocol

If a user activates WEP, the NIC encrypts the payload, which consists of the frame body and cyclic redundancy check (CRC), of each 802.11 frame before transmission using an RC4 stream cipher provided by RSA Security. The receiving station, such as an access point or another radio NIC, performs decryption when it receives the frame. As a result, 802.11 WEP only encrypts data between 802.11 stations. Once the frame enters the wired side of the network, such as between access points, WEP no longer applies.

As part of the encryption process, WEP prepares a key schedule (“seed”) by concatenating the shared secret key supplied by the user of the sending station with a randomly-generated 24-bit initialization vector (IV). The IV lengthens the life of the secret key because the station can change the IV for each frame transmission. WEP inputs the resulting “seed” into a pseudo-random number generator that produces a key stream equal to the length of the frame's payload plus a 32-bit integrity check value (ICV).

The ICV is a checksum that the receiving station later recalculates and compares to the one sent by the sending station to determine whether the transmitted data underwent any form of tampering while in transit. In the case of a mismatch, the receiving station can reject the frame or flag the user for potential security violations.

With WEP, the sending and receiving stations use the same key for encryption and decryption. WEP specifies a shared 40- or 104-bit key to encrypt and decrypt data (once the 24-bit IV is added in, this matches FortiWLC (SD)’s 64- or 128-bit WEP specification, respectively). Each radio NIC and access point, therefore, must be manually configured with the same key.

Before transmission takes place, WEP combines the key stream with the payload and ICV through a bit-wise XOR process, which produces cipher text (encrypted data). WEP includes the IV in the clear (unencrypted) within the first few bytes of the frame body. The receiving station uses this IV along with the shared secret key supplied by the user of the receiving station to decrypt the payload portion of the frame body.

Limitations of the WEP Protocol

WEP is vulnerable because the relatively short IVs and keys remain static. Within a short amount of time, WEP eventually uses the same IV for different data packets. For a large busy network, the same IVs can be used within an hour or so. This results in the transmitted frames having key streams that are similar. If a hacker collects enough frames based on the same IV, the hacker can determine the shared values among them (the key stream or the shared secret key). This can allow to the hacker to decrypt any of the 802.11 frames.

A major underlying problem with the existing 802.11 standard is that the keys are cumbersome to change. The 802.11 standard does not provide any functions that support the exchange of keys between stations. To use different keys, an administrator must manually configure each access point and radio NIC with a new common key. If the WEP keys are not updated continuously, an unauthorized person with a sniffing tool can monitor your network and decode encrypted frames.

Despite the flaws, you should enable WEP as a minimum level of security. Many hackers are capable of detecting wireless LANs where WEP is not in use and then use a laptop to gain access to resources located on the associated network. By activating WEP, however, you can at least minimize this from happening. WEP does a good job of keeping most honest people out.

Configure GRE Tunnels

The GRE tunneling provides packet isolation from one endpoint to another, encapsulated within an IP tunnel to separate user traffic.

GRE Tunneling facilitates configurations as shown in **Figure 51**, where guest users who are logged into a guest ESS are given “guest” Internet access at Level 1 and have their traffic separated from corporate users who are on a common shared link to the corporate campus. Contract users have similar connection as corporate users but are restricted in access to certain sites by user firewall policies.

GRE tunneling provides an option to segregate users’ traffic by allowing an ESS profile to be tied to a GRE profile. This provides an alternative to VLANs for segregating traffic.

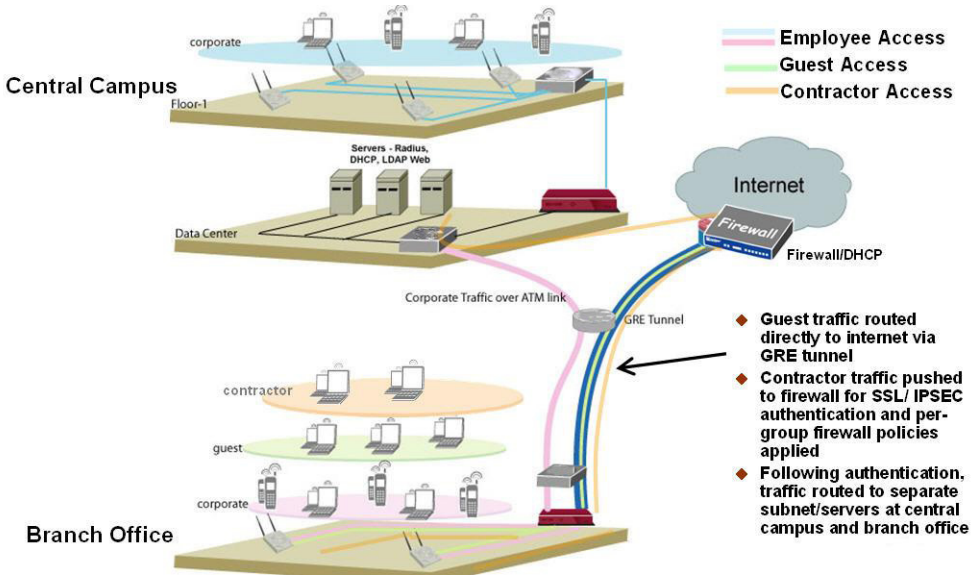


Figure 51: *Example GRE Tunneling Configuration*

To configure GRE tunneling, create the GRE tunnel profile as well as an ESSID that specifies the GRE tunnel and also references a Security Profile. GRE can also be configured from E(z)RF Network Manager.

All IP addresses configured for the tunnel must be unique; these IP addresses define the endpoints of the tunnel, with the controller FastEthernet IP address defining the local endpoint and the ip remote-external-address specifying the remote endpoint.The ip tunnel-ip-address defines the tunnel network.

If the GRE Tunnel is to be configured on the second interface of a Dual-Ethernet configuration, be sure to configure the second Ethernet interface, as described in the section *“Configuring an Active Interface”* ***on page 211***”.

The following example shows the commands for configuring a GRE tunnel profile on the second FastEthernet interface, where the IP address of the tunnel’s local endpoint is 13.13.13.13 and the remote endpoint is 172.27.0.206, and the DHCP server is at 10.0.0.12:

```
default(config)# gre guest
   default(config-gre)# interface FastEthernet controller 2
   default(config-gre)# ip tunnel-ip-address 13.13.13.13 255.255.255.0
   default(config-gre)# ip remote-external-address 172.27.0.206
   default(config-gre)# ip dhcp-override
   default(config-gre)# ip dhcp-server 10.0.0.12
   default(config-gre)# end
```

To check the configuration of the GRE tunnel, use the show gre command:

```
default# show gre
   GRE Name   Remote External Address   Tunnel IP address   Tunnel IP Netmask   LocalExternal
   vlan1      172.27.0.162              12.12.12.12         255.255.0.0          1
   gre1       172.27.0.206              13.13.13.13         255.255.0.0          2
            GRE Configuration(2 entries)
```

To configure the GRE ESSID, specify the GRE profile name, a tunnel-type and Security Profile, as shown in the following example:

```
default(config)# essid guest
   default(config-essid)# gre name guest
   default(config-essid)# tunnel-type gre
   default(config-essid)# security-profile default
   default(config)# exit
```

- The GRE ESSID name must be the same as the GRE Tunnel Profile name specified in the preceding GRE Configuration procedure (for example, guest). The GRE Tunnel Profile name is specified in the gre name.
- For the tunnel-type, the gre parameter must be specified for GRE Tunnel configuration.
- Specify the Security Profile name with the security-profile command—typically the default profile is used.

To check the status of the a GRE tunnel, use the command:

```
default# test gre gre_name ip_address
```

where gre_name is the GRE Profile name and ip_address is the IP address of the machine that is connected behind the tunnel (optional).

By default, the command will ping the remote endpoint.

The following points should be noted when configuring a GRE tunnel:

- The DHCP relay pass-through flag always should be off for a GRE tunnel. This ensures the DHCP relay is always on and hence the DHCP request packets are forwarded to the DHCP Server specified by DHCP Server IP Address.
- DHCP traffic associated with users connecting to a GRE tunnel are relayed to the configured DHCP Server located at the remote location through the associated GRE tunnel.
- Only IPv4 support is provided for GRE tunneling.

Configure a Security Profile With the CLI

The controller supports the ability to define multiple Security Profiles that can be assigned to different wireless LAN extended service sets (ESS) according to the level and type of security required. A Security Profile is a list of parameters that define how security is handled within an ESS. With Security Profiles, you can define the Layer 2 security method, including the cipher suite, primary and secondary RADIUS server, static WEP key entries and key index position, and other parameters. The various Security Profiles you create allow you to support multiple authentication and encryption methods within the same WLAN infrastructure.

Only one Layer 2 method can be defined in each Security Profile.

The controller is shipped with OPEN authentication, meaning that there is no authentication, and that any wireless client can connect to the controller. These setting are defined in the default Security Profile named ***default***.

You can view the default Security Profile using the show security-profile default command.

```
default# show security-profile default
   Security Profile Table
   Security Profile Name                              : default
   L2 Modes Allowed                                   : clear
   Data Encrypt                                       : none
   Primary RADIUS Profile Name                        :
   Secondary RADIUS Profile Name                      :
   WEP Key (Alphanumeric/Hexadecimal)                 : *****
   Static WEP Key Index                               : 1
   Re-Key Period (seconds)                            : 0
   Captive Portal                                     : disabled
   802.1X Network Initiation                          : off
   Tunnel Termination                                 : PEAP, TTLS
   Shared Key Authentication                          : off
   Pre-shared Key (Alphanumeric/Hexadecimal)          : *****
   Group Keying Interval (seconds)                    : 0
   PMK Caching                                        : disabled
   Key Rotation                                       : disabled
   Reauthentication                                   : off
```

```
MAC Filtering                                   : off
Firewall Capability                             : none
Firewall Filter ID                              :
Security Logging                                : off
Passthrough Firewall Filter ID)                 :
```

The ***default*** Security Profile is configured to allow “clear” Layer 2 access with no authentication method, encryption, or cipher suite specified.

The Tunnel Termination is configured separately for PEAP and TTLS.

Configure 802.1x RADIUS Security With the CLI

To allow WLAN access to your site’s 802.1x authorized and authenticated users, set up 802.1x RADIUS authentication. To do this:

- Create a global RADIUS Server Profile that specifies how to communicate with the primary RADIUS server in your network. If an optional secondary RADIUS server is to be used, a separate profile is also created for it.
- Create a Security Profile for the ESS that configures 802.1x Layer 2 security and assigns a primary RADIUS profile and optional secondary RADIUS profile

Refer to your RADIUS server documentation regarding how to configure the type of EAP protocol for your site and the procedure for installing any necessary certificates. The actual RADIUS server configuration is not covered here, only the configuration for enabling the communication between the RADIUS server and the controller is described.

The following commands set up a profile for the primary RADIUS server, main-auth, that specify the server’s IP address and secret key. All other default parameters (such as the port number (1812)) are acceptable, and not changed:

```
default# configure terminal
   default(config)# radius-profile main-auth
   default(config-radius)# ip-address 10.1.100.10
   default(config-radius)# key secure-secret
   default(config-radius)# exit
```

For additional reliability, configure a secondary RADIUS Server Profile to serve as a backup should the primary server become unavailable.

```
default# configure terminal
   default(config)# radius-profile backup-auth
   default(config-radius)# ip-address 10.1.100.2
   default(config-radius)# key secure-secret2
   default(config-radius)# exit
```

Next, create the Security Profile that enables 802.1x and points to the profiles that describe the RADIUS primary and secondary servers.

Example Security Profile with 802.1x RADIUS

In the following example, the Security Profile ***8021x-data is created. It*** supports 802.1x authentication and uses the RADIUS profile main-auth to enable the primary RADIUS authentication server and the backup-auth profile for the secondary RADIUS server.

```
default(config)# security-profile 8021x-data
   default(config-security)# allowed-l2-modes 802.1x
   default(config-security)# radius-server primary main-auth
   default(config-security)# radius-server secondary backup-auth
   default(config-security)# exit
   default(config)# exit
```

802.1x PTK Rekey

With the 802.1x PTK rekey feature, whenever the rekey interval expires, the Access Point sends a unicast key and a broadcast key to the client. These two key packets are NOT encrypted.

To enable 802.1x PTK rekey, enter the following command from the Security Profile configuration: (n can be from 0 to 65535 (60 minutes), and is specified in seconds)

```
default(config-security)# rekey period n
```

To disable 802.1x PTK rekey, enter the following command from the Security Profile configuration:

```
default(config-security)# rekey period 0
```

802.1x GTK Rekey

To configure the 802.1x GTK rekey period, from the Security Profile configuration, add the following command (the rekey period is specified in seconds):

```
default(config-security)# group-rekey interval n
```

To disable 802.1x GTK rekey, enter the following command from the Security Profile configuration:

```
default(config-security)# no group-rekey interval
```

802.1x RADIUS Server Command Summary

The following commands are used to configure the RADIUS servers:

TABLE 11: *Commands to Configure the 802.1x RADIUS Servers*

Command	Purpose
radius-profile name	Creates a RADIUS server profile with the specified name and enters RADIUS profile configuration submode (maximum 16 characters).
called-station-id-type	Configures the called station ID Type for the RADIUS profile.
description text	Configures a description of the profile (maximum 128 characters).
ip-address	Configures the IP address of the RADIUS profile (required parameter).
key	Specifies the shared secret text string used by the controller for the RADIUS profile (required parameter if password-type is shared-secret). Maximum 64 characters.
password-type shared-secret | mac-address	Specifies whether the password type is the RADIUS key (shared-secret) or is the MAC address of the client, as determined by the client setup in RADIUS for MAC Filtering configuration.
mac-delimiter colon | hyphen | singlehy-phen | none	Optional. Sets the RADIUS profile delimiter character.
mac-delimiter-called-station	Sets the delimiter character for the called station in the RADIUS server profile.
mac-delimiter-calling-station	Sets the delimiter character for the calling station in the RADIUS server profile.
nas-ip-address	Configures the **NAS IP** address to be used in RADIUS access requests.
port	Optional. Configures the RADIUS profile port (the default port 1812, is configured by default).
vlan	Optional. Configures a VLAN for the RADIUS server. Use the command if the RADIUS server is located on a VLAN so that RADIUS requests are sent to the VLAN interface instead of default/untagged interface.
pmkcaching | disable	Enables or disables PMK caching.

TABLE 11: *Commands to Configure the 802.1x RADIUS Servers*

Command	Purpose
rekey period ***n***	Sets the PTK rekey period. The default is set to 60 seconds and the allowable range is 60 seconds to 60 minutes.
[no] group-rekey interval ***n***	Sets the GTK group rekey period. The default is set to 60 seconds and the allowable range is 60 seconds to 60 minutes

TABLE 12: *Commands Used to Create Security Profiles*

Command	Purpose
allowed-l2-modes 802.1x	In Security Profile configuration, enables 802.1x authentication.
radius-server primary profile	In Security Profile configuration, specifies the RADIUS profile containing the configuration parameters for the primary RADIUS server.
radius-server secondary profile	Optional. In Security Profile configuration, specifies the RADIUS profile containing the configuration parameters for the secondary RADIUS server.
rekey multicast-enable	Optional. In Security Profile configuration, enable the multicast key broadcast.
[no] 8021x-network-initiation	In Security Profile configuration, determines 802.1x initiation method. When enabled (default), the AP sends the first EAP packet (an EAP ID request) to the wireless station to start 802.1x after the wireless station completes 802.11 authentication and association to an 802.1x-enabled ESSID. With the command no 8021x-network-initiation, the wireless station sends an EAPOL Start packet to the AP to start the 802.1x exchange.

Configure WPA2/WPA3 With the CLI

The controller supports the WPA2 and WPA3 standard that includes CCMP and SAE encryption methods which are considered extremely secure. Implementing these security modes provides the highest level of security that the Fortinet Wireless LAN System offers.

Additionally, if 802.1x is implemented at the site, automatic key exchange is provided by the RADIUS server. Existing primary and secondary RADIUS Server Profiles can be assigned from within the Security Profile to leverage the existing 802.1x authentication. Otherwise, the WPA2-PSK configuration can be implemented.

Example WPA2 Configuration

To configure WPA2 security with the Web UI, click *Configuration* > *Security* > *Profile*. Click Help for option details.

The following CLI example creates the profile named ***wpa2-ccmp*** that enables WPA2 for Layer 2, sets the encryption mode to CCMP-AES, and names the RADIUS server in the main-auth profile as the primary RADIUS authentication server.

```
default(config)# security-profile wpa2-ccmp
default(config-security)# allowed-l2-modes wpa2
default(config-security)# encryption-modes ccmp
default(config-security)# radius-server primary main-auth
default(config-security)# exit
default(config)# exit
```

Example WPA3 Configuration

To configure WPA3 security with the Web UI, click *Configuration* > *Security* > *Profile*. Click Help for option details.

The following CLI example creates the profile named ***wpa3-sae*** that enables WPA3 for Layer 2, sets the encryption mode to CCMP, and uses the secured multiple PSK profile *FortiMPSK*.

```
default(config)# security-profile wpa3-sae
default(config-security)# allowed-l2-modes wpa3-sae
default(config-security)# encryption-modes ccmp
default(config-security)# psk-profile FortiMPSK
default(config-security)# exit
default(config)# exit
```

Example WPA2-PSK Configuration

To configure security with the Web UI, click *Configuration* > *Security* > *Profile*. Click Help for option details.

When setting the PSK key with the CLI, use a key from 8 to 63 ASCII characters (the characters ! \ " ? must be escaped with the backslash (\) character; for example \! \?) or 64 hex characters (hex keys must be prefixed with “0x” or the key will not work).

The following example creates the profile named ***wpa2-psk*** that enables WPA2-PSK for Layer 2, sets the encryption mode to CCMP, and sets the preshared key to theSecretKeyForNov28.

```
default(config)# security-profile wpa2-psk
default(config-security)# allowed-l2-modes wpa2-psk
default(config-security)# encryption-modes ccmp
default(config-security)# psk key theSecretKeyForNov28
default(config-security)# exit
default(config)# exit
```

Opportunistic PMK Caching for WPA

Opportunistic PMK caching allows the controller, acting as the 802.1x authenticator, to cache the results of a full 802.1x authentication so that if a client roams to any AP associated with that controller, the wireless client needs to perform only the 4-way handshake and determine new pair-wise transient keys. PMK caching is supported only for KDDI phones when using WPA with TKIP and 802.1x authentication.

The system automatically detects the KDDI phone using the KDDI Vendor ID and applies PMK caching if available.

From with the Security Profile configuration, enable or disable PMK caching for KDDI phones. This option is only available when WPA is chosen for L2 encryption.

To enable PMK caching, add the following line to the WPA Security Profile configuration:

```
default(config-security)# pmkcaching enabled
```

To disable PMK caching, execute the following command at the WPA Security Profile configuration:

```
default(config-security)# pmkcaching disabled
```

Configure 802.11 WEP Encryption

The controller supports two WEP cypher suites: WEP128 and WEP64.

The key configuration parameters allow the setting of the mutually shared key and the choice of key slot positions from 1 to 4, as allowed by most user key configuration programs.

Example 802.11 WEP Configuration

The following example creates the profile named ***wep-*** that supports a static 128-bit WEP encryption for users. The static WEP key is defined as and uses the third key index position on a user station's WEP key definition.

```
default(config)# security-profile wep-
   default(config-security)# allowed-l2-modes wep
   default(config-security)# encryption-modes wep128
   default(config-security)# static-wep key
   default(config-security)# static-wep key-index 3
   default(config-security)# exit
   default(config)# exit
   default#
```

802.11 WEP Command Summary

The following summarizes the commands that can be used to configure 802.11 WEP security.

TABLE 13: *Commands to Configure 802.11 WEP Security*

Command	Purpose
encryption-modes wep128|wep64	Sets the cipher suite to WEP128, or WEP64 respectively.
static-wep key key	Sets the WEP key: • For WEP64, also known as WEP or WEP40, the key is a 5-character ASCII (for example, 123de) or 10-character hex key (for example, 0x0123456789) (the 0x prefix must be entered). • For WEP128, the key must be 13 ASCII characters or 26 hex digits (the 0x prefix must be entered).
static-wep key-index position	Sets which WEP key is in use. position can be set from 1 to 4.
allowed-l2-modes wep | clear	Enables or disables 802.11 WEP security. The clear option sets the mode to open.

Checking a CLI Configuration

To view all Security Profiles currently configured, use the show security-profile command.

```
# sh security-profile
   Profile Name                    L2 Mode        Data Encrypt Firewall Filter
   default                         clear          none
   captive-portal                  clear          none
   wep                             wep            wep64
   802.1x                          802.1x         wep128
   wpa                             wpa            tkip
   wpapsk                          wpa-psk        tkip
   wpa2                            wpa2           ccmp
   wpa2psk                         wpa2-psk       ccmp
           Security Profile Table(8)
```

To view the details of an individual Security Profile, use the show security-profile ***profile-name*** command.

```
default# show security-profile wpa-leap
   Security Profile Table
   Security Profile Name                                  : wpa-leap
   L2 Modes Allowed                                       : 802.1x
   Data Encrypt                                           : none
   Primary RADIUS Profile Name                            : ACS-87-8#
   Secondary RADIUS Profile Name                          :
   WEP Key ASCII:(default) 13 chars / 0x:26 chars         : *****
   Static WEP Key Index                                   : 1
```

```
Re-Key Period (seconds)                          : 0
Enable Multicast Re-Key                          : off
Captive Portal                                   : disabled
802.1X Network Initiation                        : on
Tunnel Termination                               : PEAP, TTLS
Shared Key Authentication                        : off
Pre-shared Key (Alphanumeric/Hexadecimal)        : *****
Group Keying Interval (seconds)                  : 0
PMK Caching                                      : disabled
Key Rotation                                     : disabled
Reauthentication                                 : off
MAC Filtering                                    : off
Firewall Capability                              : none
Firewall Filter ID                               :
Security Logging                                 : off
```

Use the commands show web login-page and show web custom-area to find out what set of web pages are used for Captive Portal and WebAuth.

Policy Enforcement Module

The optional Policy Enforcement Module feature makes it possible to control network content by dropping/allowing traffic based on configured policies applied on a firewall tag associated with a user group. This includes Captive Portal users in release 3.7 and later.

Fortinet's firewall is generic, and can be used to prevent any subnet to subnet communication, for specific ports or all ports. With the Filter ID, we can also prevent any user from any SSID from accessing specific subnets.

The per-user firewall filtering is implemented either by:

- A RADIUS-returned filter-id attribute, that is created on the RADIUS server and assigned to users
- A configured firewall filter-id parameter that is part of the Security profile configuration and is applied to clients associated with an ESS

For the RADIUS-based per-user firewall, the returned filter-id attribute is part of Access-Accept message returned for a user, and is used as the firewall tag. The filtering action is determined by the configured firewall polices for this firewall tag.

In the absence of a RADIUS configuration, a configured firewall tag in the Security profile can be used for defining the filtering based on the configured firewall polices. In this case, all users connecting to a given ESS profile are allocated the same firewall tag as configured for the profile.

For successful operation using a RADIUS configuration, the *Filter-id* attribute that is configured on the RADIUS Server must match that used on the controller. In some RADIUS Servers, a Filter ID must be created.

The policies that filter the traffic are created using the standard QoS qosrule configuration, and the inherent priorities and configuration parameters are described in detail in Chapter 15 of this manual as well as in the qosrule entry in the ***FortiWLC (SD) Command Reference***.

Configure Firewall Policies with the CLI

Begin the Policy Enforcement Module configuration by configuring a set of qosrule policies to manage the traffic.

The following example shows the creation of qosrule 200 as a policy for Firewall filter-id 1:

```
default# configure terminal
   default(config)# qosrule 200 netprotocol 6 qosprotocol none
   default(config)# netprotocol-match
   default(config-qosrule)# dstport 80
   default(config-qosrule)# dstport-match on
   default(config-qosrule)# action drop
   default(config-qosrule)# firewall-filter-id 1
   default(config-qosrule)# firewall-filter-id-match on
   default(config-qosrule)# qosrule-logging on
   default(config-qosrule)# qosrule-logging-frequency 30
   default(config-qosrule)# exit
   default(config)# exit
```

To check the configuration of the policy, use the show qosrule command:

```
default# show qosrule
   ID    Dst IP          Dst Mask        DPort Src IP          Src Mask        SPort Prot QoS
   Action   Drop  Firewall Filter
   1     0.0.0.0         0.0.0.0         1720  0.0.0.0         0.0.0.0         0     6    h323
   capture  head

2     0.0.0.0         0.0.0.0         0     0.0.0.0         0.0.0.0         1720  6    h323
   capture  head

3    0.0.0.0        0.0.0.0        5060  0.0.0.0        0.0.0.0        0    17   sip   capture
   head

4    0.0.0.0        0.0.0.0        0    0.0.0.0        0.0.0.0        5060  17   sip   capture
   head

7     0.0.0.0         0.0.0.0         5200  0.0.0.0         0.0.0.0         0     17   none
   forward  head

8     0.0.0.0         0.0.0.0         0     0.0.0.0         0.0.0.0         5200  17   none
   forward  head

200   0.0.0.0        0.0.0.0        80    0.0.0.0        0.0.0.0        0    6    none  drop
   tail  1

        QoS Rules(7 entries)
```

```
default#
```

The following commands are required to apply the example filter ID 1 to the Security Profile.

```
default(config-security)# firewall-capability configured
   default(config-security)# firewall-filter-id  1
   default(config-security)# security-logging off
```

Once you create a firewall rule, you cannot modify the rule to enable or disable firewall logging. As a workaround, either create the firewall rule with the required option or delete the rule and re-apply it with the required option.

Troubleshooting Per-User Firewall

- Turn on the QoS rule logging feature available in QoS rule page. If the client traffic hits the rule, the same will be displayed in the syslog server or via the CLI command show syslog-file firewall.

For command details, see the ***FortiWLC (SD) Configuration Guide***.

RSA SecurID Authentication

RSA SecurID is two-factor authentication mechanism. This authentication mechanism primarily involves three components:

- RSA SecurID Authenticator token (hardware based or software based) that generates a unique authentication code
- RSA SecurID Server (Authentication Manager)
- RSA Authentication Agent

RSA SecurID Authenticator Token and Code

Each RSA SecurID token includes a factory-encoded, unique ‘seed.’ The token uses this unique seed to generate an authentication code at fixed intervals (for example 60 seconds). By utilizing the built-in-clock time and the unique seed, the authentication code keeps changing at fixed intervals. Since the token's clock and the server's clock are synchronized. the server generates authentication codes at the same fixed intervals as the token. Possession of the resulting code is then combined with knowledge of a PIN number to produce secure authentication.

RSA SecurID Server

Users are authenticated against the RSA SecurID Server with the username and the passcode, which is the combination of the authentication code generated/displayed by the token and the PIN (see above).

The first time a user uses the token, they are asked to choose a new PIN. The server also requests a new time-synchronous PIN regularly or whenever the timing between a token and a server 'drifts.' If the drift is more than 3 minutes, then the Server requests the user to enter the next authentication code generated by the token in the next interval to verify the possession of the token. If the next authentication mode has the same clock drift, then token is assumed valid by the Server.

RSA SecurID Agent

This authentication is similar to the standard username-passcode authentication, but the passcode is not a single word. It is a numeric combination of the authentication code in the token and the PIN known to the user.

The RSA SecurID can be achieved two ways:

- EAP-RSA based authentication - implemented currently
- Native SecurID Authentication - not in use at this time

Configure RSA SecurID

Communication between an RSA server and a controller is the same as communication between a controller and any other RADIUS server (IAS or Free RADIUS). The only difference is in the way the client authenticates to the RSA Server, by means of two factor authentication in which Fortinet does not interfere. Configure an RSA server on a controller using the CLI command radius-profile. For example:

```
default# configure terminal
   default(config)# radius-profile <RSA>
   default(config-radius)# ip-address <IP of the RSA server>
   default(config-radius)# key secure-secret
   default(config-radius)# exit
```

Configure Multiple PSK

The Multiple Pre-shared key (PSK) is a shared secret method added to the Temporal Key Integrity Protocol (TKIP) and Advanced Encryption Standard (AES) encryption methods for WPA/WPA2/WPA3 authentication. The multiple PSK feature of FortiWLC allows generation of unique pre-shared encryption keys for each wireless user (the valid range for the number of clients is 0-10. A value of 0 means that a single PSK can be used by an unlimited number of users/devices.). The clients are authenticated and allowed access to the network based on the verification of these keys.

Multiple keys can be generated, distributed, and managed across different clients. A maximum of 256 multiple PSK profiles and 2048 groups can be created with a maximum of 16k keys. These keys can be generated for one profile or be distributed across profiles. Only one PSK profile is associated with one ESS profile. Each PSK profile is created based on the key generation method, whether manual or automatic. Once the authentication key is generated, e mails can be triggered to send the PSK information to the user. Note that e mails can be triggered successfully only when the DNS Server and SMTP are configured at *Configuration* > *Devices* > *System Settings*.

VLAN support is available for multiple PSK in both bridge and tunnel modes.

These keys are valid till their configured timeout period. You can create multiple groups and the groups can be assigned to different PSK keys within the same profile. The PSK character limit is 8-10 for PSK profiles with automatic key generation and 8-66 characters for PSK profiles with manual key generation.

Configure the PSK profile in the Security profile to link it to the ESS profile. Once created, the PSK profile can be edited to assign VLAN groups and configure the **Key Generation Type** (selected while creating the PSK profile).

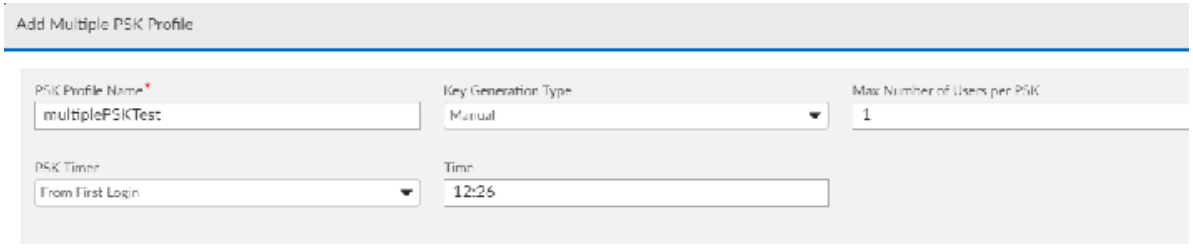
Field	Description
Psk Profile Name	A unique name for the multiple PSK profile.
Key Generation Type	The method of key generation, whether Manual or Automatic.
Max Number of Users per psk	Maximum number of clients per PSK. A value of 0 means that a single PSK can be used by any number of users.
PSK Timer Type	The timer for the expiry of a PSK profile. The timer can be Absolute (From First Login) or Periodic (Start/End). None indicates an infinite time period for the PSK profile.
Start Time/End Time	The start and end time for the PSK profile validity.
Time	The expiry time for the PSK profile.
Owner	The owner of the PSK profile; controller or the nms-server (FortiWLM) based on where the profile is created. The created profile can be modified and deleted only from the owner. If the FortiWLM where the profile is created is not connected to the controller, then the profile can be deleted from the controller.

Adding a Multiple PSK Profile

Navigate to **Configuration > Security > Multiple PSK > Add**.

Click **Add** to create a PSK profile and provide the following configuration details and click **Save**.

Figure 52: *Creating a Multiple PSK profiles*



Parameter	Description
Psk Profile Name	A unique name for the PSK profile. Valid range is 1-32 characters.
Key Generation Type	The method of key generation, whether **Manual** or **Automatic**.
Max Number of Users per psk	Maximum number of clients per PSK. Valid range is 0-10 clients.
PSK Timer Type	The timer for the expiry of a PSK profile. The timer can be Absolute (**From First Login**) or Periodic (**Start/End**). An absolute timer sets a single expiry time and starts immediately after the PSK profile creation. A periodic timer sets a start and end time for the PSK profile. The PSK profile is valid only till the timeout.
Start Time/End Time	The start and end time for the PSK profile validity.
Time	The expiry time for the PSK profile.

Editing Multiple PSK Profile

Select an existing PSK profile and click the edit icon. A PSK profile can be modified based on these parameters.

Figure 53: *Edit - Basic configuration*

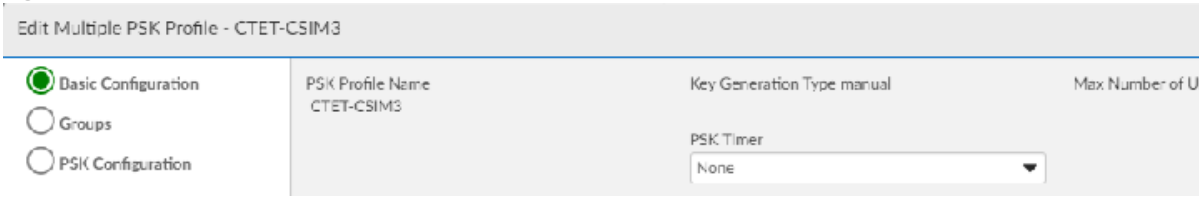


Figure 54: *Edit - Group configuration*

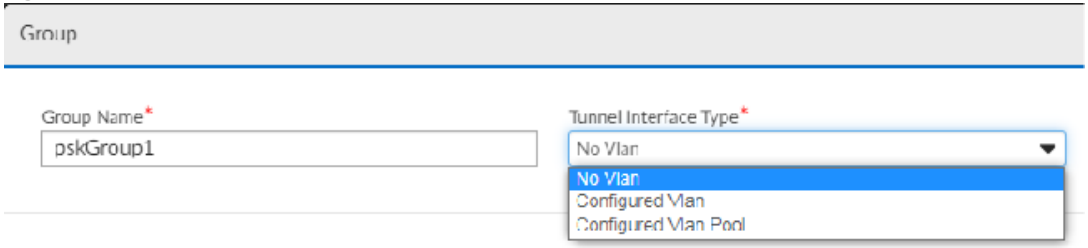
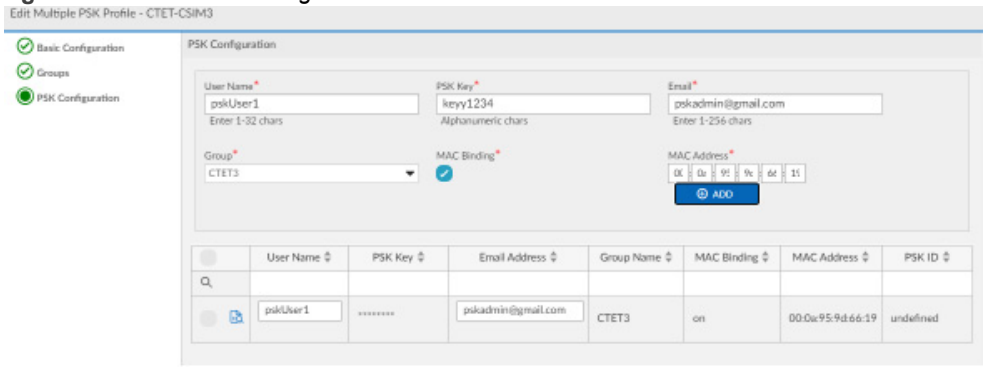


Figure 55: *Edit - PSK Configuration*



Tab	Description
Basic Configuration	Displays the PSK profile configurations. Update the **PSK Timer Type**, if required.

Groups	To add a new VLAN group, click **Add** and specify the following:
	• **Group Name** – A unique name for the group.
	• **Tunnel Interface Type** – Select the following:
	  • **No VLAN** – No VLAN is associated with this group.
	  • **Configured VLAN** – A configured VLAN is associated with this group. Specify the VLAN profile tag in **PSK VLAN TAG**.
	  • **Configured VLAN Pool** – A configured VLAN pool is associated with this group. Specify the **VLAN Pool Name**.

PSK Configuration	Based on the key generation method specified while creating the profile, configure the PSK key. If manual key is to be created, enter the following details: • **User Name** – A unique user name. Valid range is 1-24 characters. • **PSK key** – A unique authentication key. Valid length is 8-10 alphanumeric characters. • **Email** – The e mail ID to receive the notification for the generated key. • **MAC Binding** – Enables MAC-IP address binding for the client. Specify the **MAC Address**. If automatic key is configured, enter the following details: • **User Prefix** – A unique user name. Valid range is 1-24 characters. • **No of PSKs** – The number of PSK keys to be generated. Valid range is 1-16K. • **PSK length** – The length of the PSK key to be generated. The valid range is 8-10 alphanumeric characters. • **Email** – The e mail ID to receive the notification for the generated key. **Note**: A unique **PskId** is generated for each PSK. Assign one or more groups to the PSK profile. Click **Generate PSK**.

To delete an existing PSK profile, select it and click the delete icon. The PSK profile is deleted.

RADIUS Accounting

For each PSK you can view the start time, end time, and PSK ID in the configured RADIUS sever. This is a sample of messages viewed on the RADIUS server.

ACCOUNTING START

Ready to process requests
(0) Received Accounting-Request Id 87 from 10.33.94.97:59207 to 10.33.92.16:1813 length 259
(0) Acct-Status-Type = Start
(0) Acct-Session-Id = "5BB13F12-00000008"
...
(0) **Mpsk-Start-Time = "01-10-2018 03:26:28"**
(0) **Mpsk-Psk-Id = "4ee8f7ea1de894bf03d4af7007e48d99"**

ACCOUNTING INTERIM UPDATE

Ready to process requests
(1) Received Accounting-Request Id 88 from 10.33.94.97:59207 to 10.33.92.16:1813 length 262
(1) Acct-Status-Type = Interim-Update
...
(1) **Mpsk-Psk-Id = "4ee8f7ea1de894bf03d4af7007e48d99"**

ACCOUNTING STOP

Ready to process requests
(7) Received Accounting-Request Id 94 from 10.33.94.97:59207 to 10.33.92.16:1813 length 301
(7) Acct-Status-Type = Stop
...
(7) **Mpsk-End-Time = "01-10-2018 03:31:52"**
(7) **Mpsk-Psk-Id = "4ee8f7ea1de894bf03d4af7007e48d99"**

Export/Import PSK Profile

You can export the multiple PSK profiles to your local system and import profile information into FortiWLC. Click **Export** to export all existing PSK profiles' information in the *.csv* format on your system. The multiple PSK profile information can be imported in the *.csv* or *.txt* format. The following fields are required to import the profile information.

Note: Insert an empty row after every table so that the configuration is exported and applied correctly.

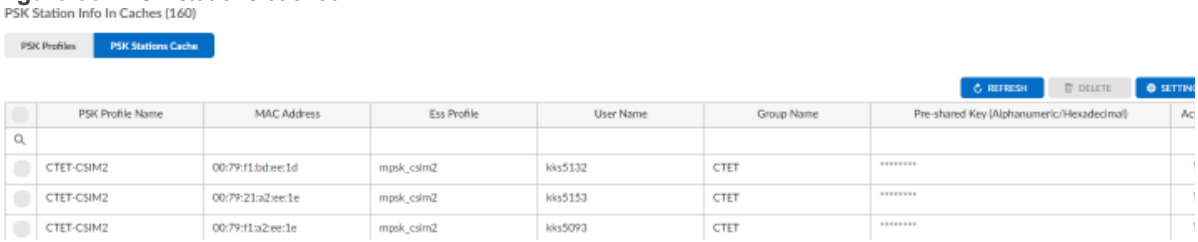
- Basic Configuration
  - PSK Profile Name
  - Key Generation Type
  - Max Number of Users per psk
  - PSK Timer Type
  - Start Time
  - End Time
  - Time
  - Timer Profile Interval State
  - Owner

- Groups
  - PSK Profile Name
  - Group Name
  - Tunnel Interface Type
  - VLAN Pool Name
  - PSK VLAN Tag
  - Owner
- PSK Configuration
  - PSK Profile Name
  - User Name
  - Email Address
  - PSK Key
  - Group Name
  - MAC Binding
  - MAC Address

PSK Stations Cache

The users authenticated with a PSK, will have their details cached here. The associated client **MAC Address**, **ESS Profile**, **Pre-shared Key**, **Group Name**, and **User Name** with which the client got authenticated are displayed. If the PSK profile is removed from the Security Profile or is deleted, then the PSK profile cache is also deleted. The cache is not added for MAC bound PSK profile.

Figure 56: *PSK stations cached*



When a user inadvertently enables more than one wi-fi supplicant (for example, Windows wireless zero configuration and Intel utility) in the wireless client and if there is a password/PSK change to the ESSID which the utilities connect to; wireless connectivity issues will occur if the password/PSK is not updated in both the utilities.

As a workaround, do a Forget Network from both the utilities and try to connect with the new password/PSK.

Note: Fortinet recommends the use only one wireless utility.

Configure MAC Filtering

MAC filtering controls a user station's access to the WLAN by permitting or denying access based on specific MAC addresses. A MAC address is unique to each IEEE 802-compliant networking device. In 802.11 wireless networks, network access can be controlled by permitting or denying a specific station MAC address, assigned to its wireless NIC card, from attempting to access the WLAN.

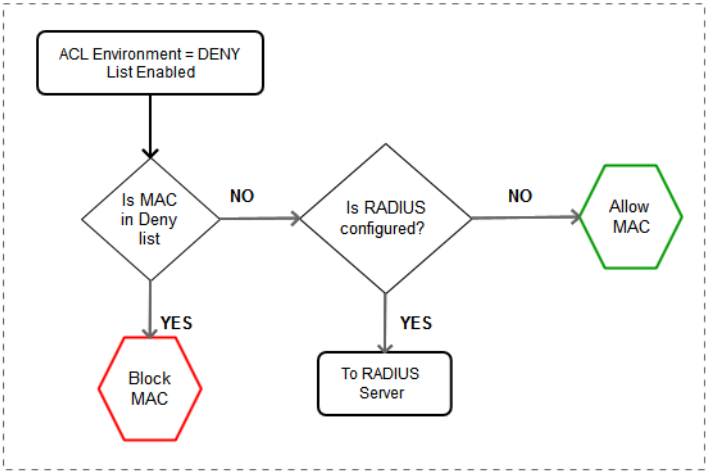
The Wireless LAN System provides MAC filtering using the following methods:

- Locally on the Controller, through the administration of an Access Control List (ACL) that permits or denies access for specific stations based on their unique MAC addresses. Two ACLs are available for MAC filtering:
  - Permit ACL, which limits access to only those MAC addresses on the permit list
  - Deny ACL, which specifically disallows access to those addresses (clients) on the deny list

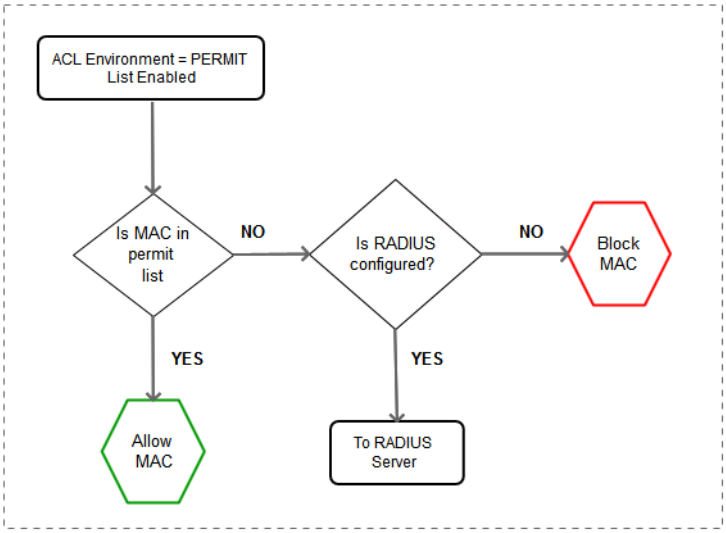
The following flowcharts illustrate how MAC filtering works:

MAC Filtering Behaviour

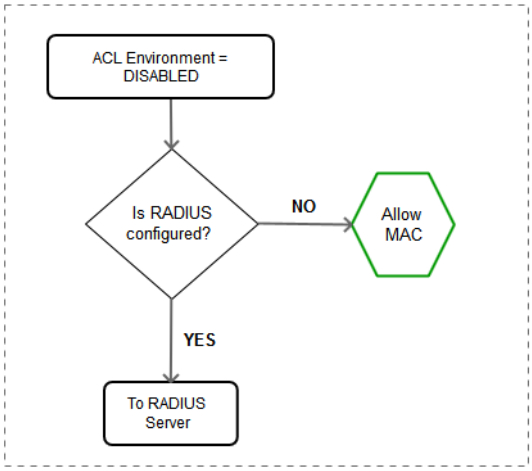
If ACL environment is Deny list



If ACL environment is Permit



If ACL environment is Disabled



Changes made to the local access/deny ACL are implemented in real time.

- Remotely, in conjunction with the RADIUS Server, which is configured to authorize access to a set of MAC addresses. The user authentication follows the procedure shown in **RADIUS Authentication**, but a MAC address is used for user validation.
  If the Controller Deny ACL is enabled, those addresses on the Deny list overrule MAC addresses on the

RADIUS Server. Changes made to the MAC addresses on the RADIUS Server are not implemented in real time.

- Per ESS, which allows MAC filtering to be enabled or disabled in the associated Security Profile, overriding the MAC filtering setting on the controller, or on the RADIUS server.

The state that is set for the MAC filtering option determines the type of access control in use, with the precedence in the order of ESS Security Profile setting, local MAC filtering list, and then the RADIUS Server state:

- For Controller ACL administration, the valid states are:
  - disabled: (default) both the permit and deny ACLs are inactive, even if they contain MAC addresses
  - permit: permit ACL is enabled and deny ACL (if it exists) is disabled
  - deny: deny ACL is enabled and permit ACL (if it exists) is disabled
- For remote RADIUS Server administration, the valid states are:
  - enabled
  - disabled

The following table summarizes the controller/RADIUS Server settings.

	RADIUS Server Setting `disabled`	`enabled`
MAC Filtering `disabled`	no MAC filtering	RADIUS MAC filtering only
Permit ACL `enabled`	allow client in Permit list only	check Permit list first; if not in Permit list, check RADIUS server
Deny ACL `enabled`	Deny list used only	if not in Deny list, check RADIUS server

Configure MAC Filtering

MAC filtering can be set up for both the controller and the RADIUS Server. By default, MAC filtering is disabled. Enable MAC filtering before adding MAC addresses. MAC filtering provides the following features:

- Enforced per security profile.
- Simultaneously use permit and deny list.
- Specify the same MAC address in both permit and deny list.
- Ability to simultaneously use global permit and deny list along with RADIUS based MAC-filtering per ESS level.

To change the state of MAC filtering so that the permit list is enabled, use the `mac-filter-state permit` command

Add addresses to a permit ACL list by specifying them as command arguments, or by importing them from a prepared list. To add one or more MAC addresses to the permit access control list along with a brief description, type the following:

```
controller(config)# access-list permit 00:40:96:51:eb:2b 00:40:96:51:eb:22
   controller(config-acl-permit)# descr MyClient
   controller(config-acl-permit)# end
```

To import a list of MAC addresses to permit, create a text file listing all the MAC addresses, and import the text file. When creating the text file to be imported, only include one MAC address, in hexadecimal format (***xx***:***xx***:***xx***:***xx***:***xx***:***xx***), per line. For example, the contents of a text file to be imported might look like the following:

```
00:04:23:87:89:71
   00:06:25:a7:e9:11
   00:07:e9:15:69:40
   00:0c:30:be:f8:19
   00:0c:e6:09:46:64
   00:0c:e6:12:07:41
```

After creating the text file, transfer the file to the controller's /images directory. Use the CLI copy command to transfer the file to the controller. Check that the file has been copied using the dir command. The following example shows the command to import a text file named ***acl*** that adds the MAC addresses to the permit ACL list:

```
controller(config)# access-list permit import acl

00:04:23:87:89:71
   00:06:25:a7:e9:11
   00:07:e9:15:69:40
   00:0c:30:be:f8:19
   00:0c:e6:09:46:64
   00:0c:e6:12:07:41
   00:0c:e6:bd:01:05

Successfully Added : 7
   Duplicate Entries  : 0
   Invalid Format     : 0
   Entries Processed  : 7
```

Starting with FortiWLC (SD) 7.0-4-0, the following commands are deprecated

- access-list state
- access-list radius-server

Configure a Deny MAC Filtering List

To set up a Deny MAC Filtering List, enable the ACL deny state and then either configure a Deny ACL or import a Deny ACL.

A Deny ACL takes precedence over RADIUS Server access, so you can use it to immediately deny access to a station or black-list certain clients (for example, if they have a virus or are attacking other devices).

By default, MAC filtering is disabled. To change the state of MAC filtering so that the deny list is enabled, use the `mac-filter-state deny` command.

Add client addresses to a deny ACL list by either specifying them as command arguments, or by importing them from a prepared list. This command specifies them as command arguments and enters a brief description:

```
controller(config)# access-list deny 00:40:96:51:eb:2b 00:40:96:51:eb:10
   controller(config-acl-deny)# descr DenyStation
   controller(config-acl-deny)# end
   controller(config)#
```

To import a list of MAC addresses to deny, create a text file listing all the MAC addresses, and import the text file. When creating the text file to be imported, only include one MAC address, in hexadecimal format (***xx***:***xx***:***xx***:***xx***:***xx***:***xx***), per line. For example, the contents of a text file to be imported might look like the following:

```
00:04:23:87:89:71
   00:06:25:a7:e9:11
   00:07:e9:15:69:40
   00:0c:30:be:f8:19
   00:0c:e6:09:46:64
   00:0c:e6:12:07:41
```

After creating a text file for import, transfer the file to the controller's /images directory using the CLI copy command. Ensure that the file has been copied using the dir command. Then, import the file.

The following example imports a text file named deny***acl*** that adds the MAC addresses to the deny ACL list:

```
controller(config)# access-list deny import denyacl
   00:04:23:87:89:71
   00:06:25:a7:e9:11
   00:07:e9:15:69:40
   00:0c:30:be:f8:19
   00:0c:e6:09:46:64
   00:0c:e6:12:07:41

Successfully Added : 6
   Duplicate Entries  : 0
```

```
Invalid Format     : 0
Entries Processed  : 6
```

Active connections do not get disconnected if the ACL environment is changed from Permit to Deny. However, during successive connection the MAC entry is filtered against deny or permit list.

Configure a Remote RADIUS Server for MAC Filtering

When RADIUS Server MAC filtering is enabled, station MAC addresses are set up and managed by a remote RADIUS Server. When a new station attempts to join the WLAN, the Controller queries the RADIUS server with the MAC address to determine whether the client is permitted. If the RADIUS server does not respond, or responds that the client is not authorized, the client is blocked from entering the WLAN.

RADIUS Server configuration with the CLI is performed using the `mac-filter-radius-server` command in the security profile where you specify the configuration profile for the primary (and optional secondary) RADIUS Server (includes IP address, secret key, port, and the delimiter used between MAC addresses in its authorization table).

This radius server is used only in one of the following conditions:

- If ACL environment is set to deny list and the MAC entry is not in the deny list then the packet is forward to the radius server.
- If ACL environment is set to permit list and the MAC entry is not in the permit list then the packet is forwarded to the radius server.

For more information on configuring a RADIUS profile, see *"Configure 802.1x RADIUS Security With the CLI"* ***on page 240***.

Configure an Security Profile for MAC Filtering

Control is provided per security profile via settings to turn off or on MAC Filtering settings. For example, if controller-based MAC filtering or if RADIUS Server MAC Filtering is enabled, the command no macfiltering disables those settings for the ESS. To enable global MAC filtering again, use the macfiltering command.

Security Certificates

Certificates provide security assurance validated by a Certificate Authority (CA). This chapter describes the process to obtain and use certificates. For a Custom Certificate to work properly, you must import not only the Server Certificate, but the entire chain of trust starting with the issuer certificate all the way up to the Root CA (see **Figure 58**).

Server certificates are generated based on a specific CSR (see **Figure 57**) and, along with the server certificate, you should get the entire chain of trust (see **Figure 58**).

Figure 57: *Sample CSR Sent to CA*

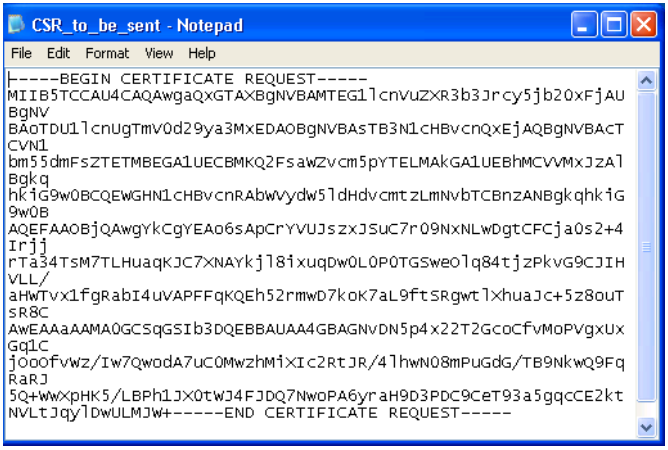


Figure 58: *Sample Certificates Returned by CA (Server, Intermediate, and Root)*

Generate Certificate Signing Requests (CSR) directly on the controller using the Web UI.

Generate a CSR on a Controller

To create a Certificate Request, follow these steps from the controller that needs a certificate:

1. Click Configuration > Certificates > Controller Certificates. The Controller Certificate window displays.
2. Click Add. The Certificate Add window displays.
3. Provide the requested information in this window.
4. Click Apply.
5. The CSR is generated and appears in a window.
6. Either copy this Certificate PEM for pasting into a submittal form or click Save to save the CSR as a file.

7. Click Close.
8. Send the CSR to the Certificate issuer to be processed. If the CA asks for the operating system type, select Open SSL (if available) or Other.

When requesting a certificate, the user type must be set to **Web User**, and not *admin*. Specifying the incorrect user type will result in an unusable certificate.

The Certificate entry now displays in the Server Certificates page under “Pending CSR.” This entry will be matched to the certificates when they arrive and imported, ensuring that the controller that requested certificates is the only one to use those certificates.

Generate a Wildcard Certificate

The SD support wildcard certificate for both tunnel and bridge mode captive portal. To create a Wildcard Certificate Request, follow these steps:

1. Click Configuration > Certificates > Controller Certificates. The Controller Certificate window displays.
2. Click Add. The Certificate Add window displays.
3. Enter the details in the General section.
4. Enter the Common Name as *.name in Distinguished Name (DN) section. For example *.Fortinetworks.com.

This creates a wild-card certificate. The * will be replaced by the system with the controller’s hostname.

5. Click Apply.
6. The CSR is generated and appears in a window.
7. Either copy this Certificate PEM for pasting into a submittal form or click Save to save the CSR as a file.
8. Click Close.
9. Send the CSR to the Certificate issuer to be processed. If the CA asks for the operating system type, select Open SSL (if available) or Other.

When requesting a certificate, the user type must be set to **Web User**, and not *admin*. Specifying the incorrect user type will result in an unusable certificate.

The Certificate entry now displays in the Server Certificates page under “Pending CSR.” This entry will be matched to the certificates when they arrive and imported, ensuring that the controller that requested certificates is the only one to use those certificates.

Import the Certificate

Remember that you MUST add the Root Certificate and ALL Intermediate Certificates in the chain of trust before you install the signed Server Certificate; if you don't install in order, you get an error.

To import a Trusted Root CA and the entire chain of trust that you receive from a CA, follow these steps:

1. Click Configuration > Certificates> Trusted Root CA.
2. Click Import.
3. Browse to the Root CA file and select it.
4. Click Open and give the Certificate an appropriate alias name.
   You can also open the certificate in any text editor and copy/paste the Certificate's PEM text into the "Certificate PEM" blank text area shown below.
5. Click Import.
   You should see a message indicating that the import was successful.
6. Click OK > Close.
7. Repeat steps 2 - 6 for all certificates.
   You should now see all certificates imported into the controller
8. Import the Server Certificate by clicking Configuration > Certificates > Controller Certificates > Pending CSR > Import.
9. Browse to the server certificate, select it and click Import > Open > Import.
10. Click OK > Close > Close.
11. Restart the web server by navigating to Maintenance > Reboot System and checking the Reboot Controller box located towards the top of the window. Click Reboot to perform the action.

You are finished importing the certificates.

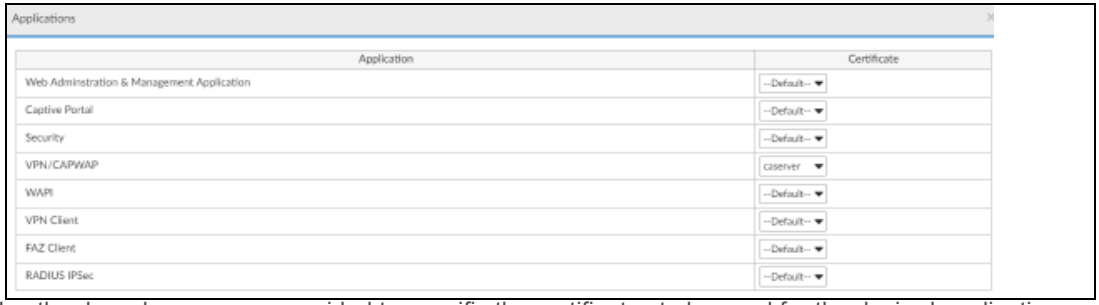
Assign a Server Certificate to an Application

Certificates can be used for security purposes (i.e., for RADIUS termination) as well as by Captive Portal or Web Administration tools. To assign the Server Certificate:

1. Select the certificate in the Controller Certificates table.
2. Click Applications. The Applications dialog displays.

Figure 59: *Applications to Use Certificate*

a



3. Use the drop-down menus provided to specific the certificates to be used for the desired applications.
4. Click Apply.
5. Click Close.
6. To ensure that the certificate is applied and activated correctly, use the reload-security command from the system's CLI.

The Apache Web Server needs to be restarted after successfully assigning a certificate to be used by Captive Portal and/or Management Applications.

AP Certificates

VPN applications require a security certificate to be installed on both the AP and the controller before secure communication between the two can proceed. Follow the instructions provided in the following sections in order to properly set up an AP for VPN connectivity.

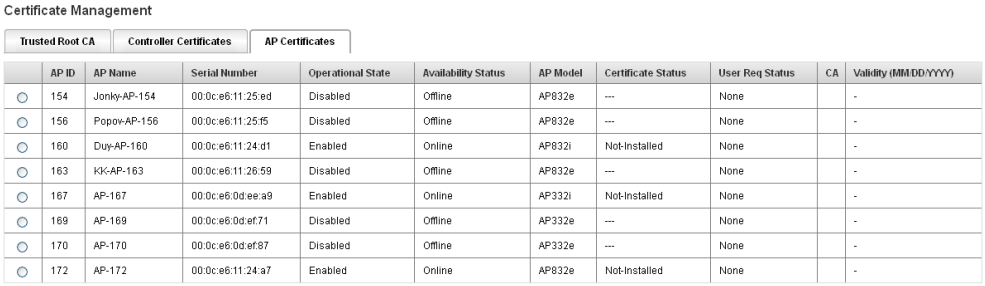
Some AP models come with the certificate pre-installed and therefore do not need one to be generated for them. If your AP already shows "Certificate Installed" in the VPN AP table (see *"Adding OpenVPN APs"* ***on page 273***), you do not need to go through this process.

Generating an AP CSR

Prior to installing an AP certificate, a Certificate Signing Request (CSR) specific to the desired AP must be generated via the FortiWLC (SD) WebUI. Perform the following steps to create and submit a CSR for a specific AP.

1. From the WebUI, navigate to Configuration > Certificates > AP Certificates. The AP Certificates table appears.

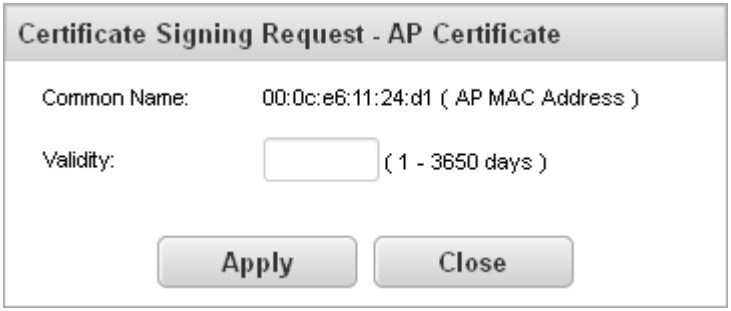
Figure 60: *AP Certificates Table*



	AP ID	AP Name	Serial Number	Operational State	Availability Status	AP Model	Certificate Status	User Req Status	CA	Validity (MM/DD/YYYY)
○	154	Jonky-AP-154	00:0c:e6:11:25:ed	Disabled	Offline	AP832e	---	None		-
○	156	Popov-AP-156	00:0c:e6:11:25:f5	Disabled	Offline	AP832e	---	None		-
○	160	Duy-AP-160	00:0c:e6:11:24:d1	Enabled	Online	AP832i	Not-Installed	None		-
○	163	KK-AP-163	00:0c:e6:11:26:59	Disabled	Offline	AP832e	---	None		-
○	167	AP-167	00:0c:e6:0d:ee:a9	Enabled	Online	AP332i	Not-Installed	None		-
○	169	AP-169	00:0c:e6:0d:ef:71	Disabled	Offline	AP332e	---	None		-
○	170	AP-170	00:0c:e6:0d:ef:87	Disabled	Offline	AP332e	---	None		-
○	172	AP-172	00:0c:e6:11:24:a7	Enabled	Online	AP832e	Not-Installed	None		-

2. Select the desired AP in the AP table and click Create CSR. The CSR dialog appears.

Figure 61: *CSR Configuration*



3. In the resulting dialog, the “Valid Till” field specifies the duration of the certificate. Enter the number of days for which the certificate should be valid and click Apply.
The AP table will refresh a few times as the CSR generation proceeds. The “User Req Status” column will display its progress, ranging from “CSR Generation in Progress” to “CSR Generated”. If the column doesn’t refresh, click Refresh.

4. Once you see “CSR Generated”, you are ready to proceed to export the CSR so that it may be submitted to a Certificate Authority.

Exporting the CSR

After the CSR has been generated, it can be exported into an individual file so that it may be provided to a Certificate Authority server for verification.

1. From the AP Certificates table, click the desired AP (if not already selected) and click Export.

2. Download the resulting exported file to your local machine.

3. Upload the exported file to your Certificate Authority server. The server should provide two files in return:

- An AP certificate generated using the CSR

- A Root CA certificate

When requesting a certificate, the user type must be set to **Web User**, and not *admin*. Specifying the incorrect user type will result in an unusable certificate.

If you have not already installed the Certificate Authority's Trusted Root CA certificate on the system, do so by following the steps detailed in *"Import the Certificate"* ***on page 265*** earlier in this chapter. Note that this must be done prior to installing the certificate on the AP.

Installing the AP Certificate

Once all the previous steps are completed, you are ready to install the certificate on the AP itself.

1. From the AP Certificates table (Configuration > Certificates > AP Certificates), select the desired AP and click Import.
2. In the resulting pop-up window, enter the certificate alias name in the field provided.
3. Click Choose File and browse to the AP certificate provided by the Certificate Authority.
4. Click Save. After a few seconds, a message displays stating "Certificate imported successfully" and the "Certificate Status" column will show "Cert Installed". If these messages don't seem to display properly, click Refresh to update the table.

The AP is now certified and ready for use.

It is recommended that all AP certificates be installed on their APs prior to configuring and deploying them for VPN use. Once all certificates have been installed, refer to *"Configuring the VPN"* ***on page 272*** for instructions.

Troubleshooting Certificates

.The following errors can occur during the certificate process.

Error Message	Why It Appeared	How to Correct Problem
Certificate file is not a valid x.509 certificate	Certificate file is corrupt or not a X.509 certificate (PEM/DER) file.	Navigate to a valid X.509 certificate file.
Certificate has expired or not yet valid	Certificates are valid for a specified number of days with Start Date (Valid From) and End Date (Valid To). This certificate is not valid at this time.	Make sure that the Certificates Start Date (Valid From) and End Date (Valid To) range is current. If the certificate Start Date is in future, then wait till that time to import the certificate. If the certificate has expired, then get another certificate issued by the CA.
Certificate alias name already exists	Another certificate with same alias name has already been imported.	Use a different alias name.
Certificate already exists (with either same alias name or different alias name)	Certificate has already been imported.	Do nothing.
Certificate Public key verification failed	You selected an alias name that is different from the certificate's CSR alias name.	Select the alias name that you used when creating the CSR for this certificate.
Certificate's Issuers verification failed	The Issuers certificates (complete chain-of-trust) is not available in Trusted Root CA's list. The most common cause is that you tried to import an intermediate or server certificate first.	Import the Trusted Root CA certificates chain of trust first. Then import the Server Certificate.

WAPI Configuration

The WLAN Authentication and Privacy Infrastructure (WAPI) is a Chinese national standard for WLANs. There are two authentication models used for WAPI functionality: certificate-based and PSK-based. For WAPI certificate configurations, the controller must have the IP and port communication details for the central Authentication Service Unit (ASU), which will verify that the wireless communication is permitted.

FortiWLC (SD) implements WAPI configurations in release 5.2 and later.

Specifying WAPI Authentication Mode

As mentioned above, users can specify whether the deployment will use certificate-based or PSK-based WAPI authentication. This is done via the Security Profile configuration.

1. From the WebUI, navigate to Configuration > Security > Profile.
2. Create a new profile by clicking the Add button.
3. In the L2 Modes Allowed section, specify the desired WAPI option:
   - WAI: for certificate-based models
   - WAI-PSK: for PSK models

Note that the **WPI-SMS4** option for the *Data Encrypt* field automatically gets selected when using either WAI option.

4. Make the remaining selections as desired. If using the PSK option, be sure to set an appropriate entry in the Pre-shared Key field.

If your deployment is making use of the WAI option (certificate-based), you will need to configure a WAPI server and import a WAPI certificate as well. Proceed to the following sections for these details.

Importing a WAPI Certificate

In order to properly authenticate WAPI communications, a certificate must be imported into the system. Follow the instructions below.

1. From the WebUI, navigate to Configuration > Certificates > Controller Certificates.
2. Click WAPI Cert Import.
3. Browse to the location of the WAPI certificate and click Import. Note that the system only supports one WAPI certificate to be configured at any given time.
4. After the certificate is imported, click the WebTerm link to open a CLI console.
5. Log into the console and execute the reload-wapi command to reload WAPI service.
6. Proceed to the next section in order to configure communication with the WAPI Authentication Service Unit.

Configuring a WAPI Server

The WAPI server needs to be configured only when using certificate-based WAI authentication. This configuration is used to authenticate the WAPI certificate after it has been imported into the system.

To configure the WAPI Server:

1. From the WebUI, navigate to Configuration > Security > WAPI Server.
2. Enter the following information:
   - WAPI Server IP—The IP address for the Authentication Service Unit.

- WAPI Server Port—Enter the port number used for WAPI communication (default: 3810).

Integration with Palo Alto Networks Firewall

FortiWLC (SD) supports syslog based integration with User ID Agent solution of the Palo Alto Networks Firewall solution. This allows for setting up firewall rules on the Palo Alto Firewall when a user login into the network.

Configuring VPN Connections

In System Directer version 5.2 and later, users have the ability to configure supported APs to connect to the corporate controller via VPN connections, allowing a secure remote wireless signal. This can be of particular use in telecommuting applications, as a user can simply take an AP that has been configured for VPN access to another Internet-accessible location and quickly set up a secure line back to the corporate network. In the VPN implementation, the controller acts as a TLS/SSL VPN server while the APs act as TLS/SSL VPN clients.

In order to configure an AP for VPN access, it must first be connected to the corporate network so that it can be populated into the controller AP table. The AP's secure VPN connection requires the use of a security certificate, which for some modes comes pre-installed, while others require it to be installed by the user. The following sections provide instructions on how to configure a VPN connection and add APs for VPN access.

Activating Controller Certificates for VPN

If a certificate has already been installed on the controller (i.e., for Captive Portal access—see *"Sample Certificates Returned by CA (Server, Intermediate, and Root) Generate a CSR on a Controller"* ***on page 263***), the same certificate can be used for VPN access; however, it must be configured for this use before it will allow VPN connections.

To enable a certificate for VPN use:

3. From the WebUI, navigate to Configuration > Certificates > Controller Certificates. The Controller Certificates table appears.
4. Select the desired certificate and click Used By…. A list of applications will appear.
5. Click VPN to enable the certificate for VPN use.
6. A dialog message will appear stating that you need to execute a command from the CLI to load the changes. Execute the command by performing the following:
   - Click the WebTerm link in the upper-right portion of the WebUI.
   - Log in using your controller credentials.

- Type reload-vpn and press Enter. The VPN service will relaunch.

Now that the controller certificate has been added, it is recommended that you add and install all required AP security certificates as well. Following this sequence of events will provide best VPN results. See *"AP Certificates"* ***on page 266*** for instructions on installing AP certificates.

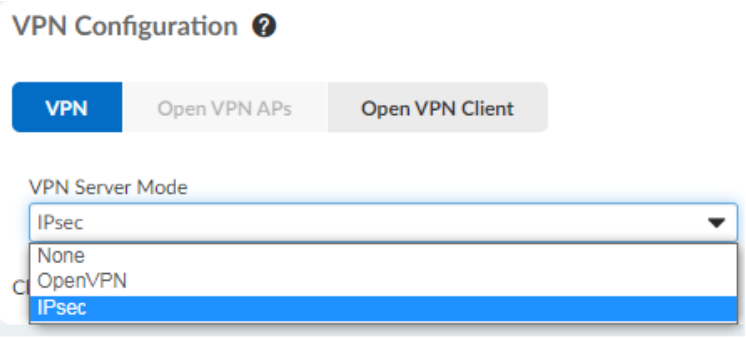
Configuring the VPN

Prior to configuring specific APs, the system administrator must first configure the VPN connection settings on the controller.

To configure the VPN:

1. From the WebUI, navigate to Configuration > Security > VPN. The VPN Configuration screen appears.

Figure 62: *Configuring the VPN*



Select the VPN server mode, **None, IPsec** or **OpenVPN**. If you select OpenVPN, update the following configurations.

Note: IPsec is supported only on 11ac access points.

Field	Description
VPN Server IP/Name	Enter an IP address or DNS name to be used by the VPN server.
VPN Server Port	Enter the port to be used for VPN communications. By default, the value is set to 1194.

Field	Description
IP Pool	Enter the IP range that can be used by the VPN server (in standard 255.255.255.255 notation). Note: Be sure that the IP from which you are accessing the controller (i.e., your current machine's IP address) is not included in this range. If it is, your local connection will be terminated once VPN is enabled. Note: The IP address 192.168.1.12 is reserved by the controller and cannot fall within the VPN range specified.
Netmask	Enter the netmask for the VPN server (in standard 255.255.255.255 notation).

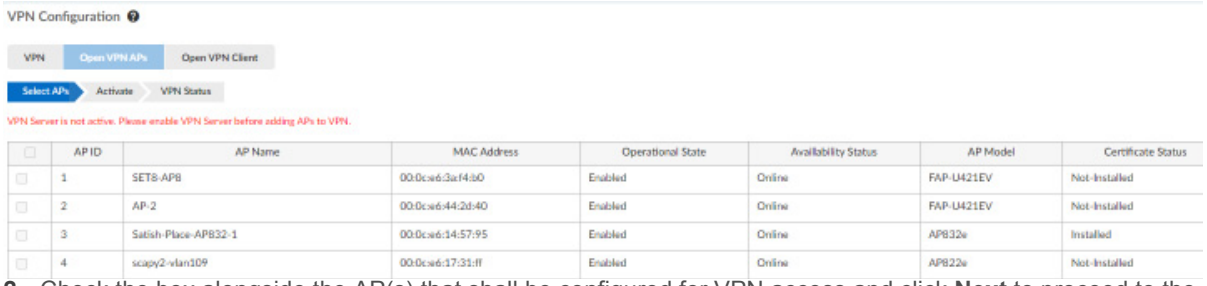
2. Click **OK** to save the changes. The controller is now configured for VPN service.

Adding OpenVPN APs

Once the OpenVPN server is configured, APs can be added for VPN access. To do so, follow the steps below.

1. From the VPN screen (Configuration > Security > VPN), click the **OpenVPN APs** tab. The screen refreshes.

Figure 63: *Selecting VPN APs*



2. Check the box alongside the AP(s) that shall be configured for VPN access and click **Next** to proceed to the Activate tab.
   The new table displays the VPN-readiness of the selected APs. If your AP already has a security certificate installed, the table will indicate that no further action is required. However, if any of the selected APs require a certificate to be installed, the Action Required column will provide a link that navigates automatically to the Certificates screen where you can install one for it.

For instructions on installing an AP certificate, refer to *"AP Certificates"* ***on page 266*** earlier in this chapter.

3. When all APs have “No Action Required” in the Action Required column, you are ready to activate the VPN devices. Click Activate to proceed to the VPN Status tab. The APs should automatically appear and are now ready to be deployed.

The **show vpn-ap** CLI command can be used to view the APs currently configured for VPN access. This command can be executed from the WebTerm link in the upper-right portion of the WebUI.

Configuring OpenVPN Client Connections

In addition to allowing VPN AP connections, FortiWLC can be configured to use VPN connectivity to its FortiWLM as well. In this configuration, the FortiWLM appliance acts as a VPN server and the controller acts as a client. Note that this must also be configured on the NFortiWLM appliance for full VPN communication.

To configure VPN configuration screen, click the **OpenVPN Client** tab.

1. Use the **State** drop-down and select **Enable** to activate the VPN client.
2. In the **VPN Server IP** address field, enter the IP of your Network Manager appliance.
   Note: The VPN must be configured on FortiWLC prior to attempting to associate VPN controllers with it.
3. In the **VPN Server Port** field, enter the port used for VPN service. By default, this is 1194.
4. Select the **Protocol** for the VPN client from the drop-down list. The options are TCP and UDP.
5. The **Connectivity** displays the VPN Client status with the VPN Server.
6. Click **Ok** to save the changes.

10 Authentication

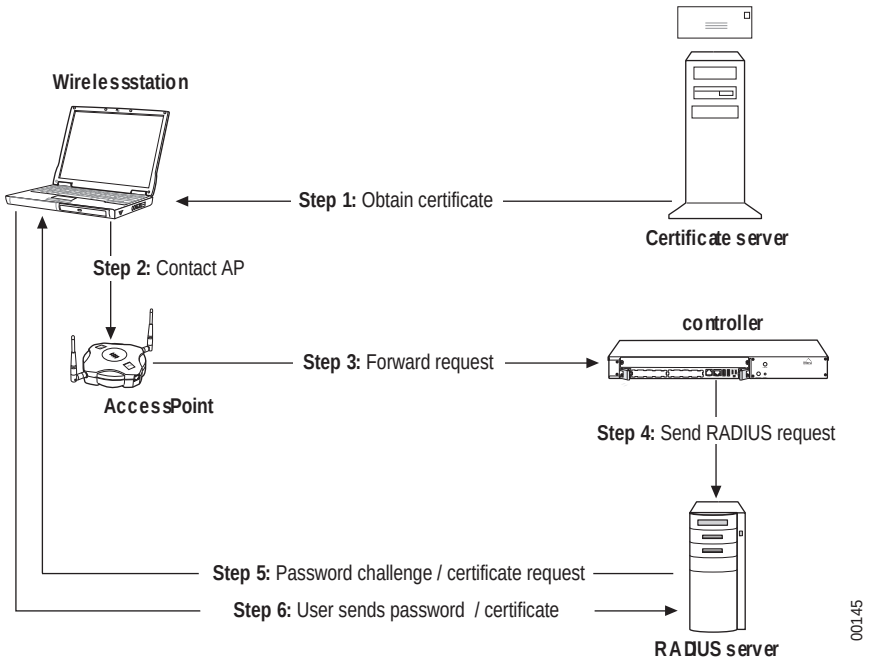
There are three authentication methods available for administrators and two methods available for users. Administrators can be authenticated with RADIUS, TACACS+ or Local authentication. Users can be authenticated with RADIUS or Local authentication.

RADIUS Authentication

Conceptual 802.1X Model for RADIUS Authentication

The conceptual model for 802.1X authentication looks like this:

Figure 64: *Conceptual Model for 802.1X RADIUS Server Authentication*



802.1X RADIUS authentication works like this:

1. Depending on the EAP type, you may first need to obtain a digital certificate from the Certificate Server.
2. Using EAP as end user, contact the AP in order to be authenticated.
3. The AP forwards the request to the controller.
4. The controller acts as a RADIUS client and sends the request to the RADIUS server.
5. Depending on the EAP type, the RADIUS server may challenge the end user for a password, or the user may present a digital certificate that they have previously obtained from a Certificate Server.
6. The RADIUS server authenticates the end user and the access point, and opens a port to accept the data from the end user.

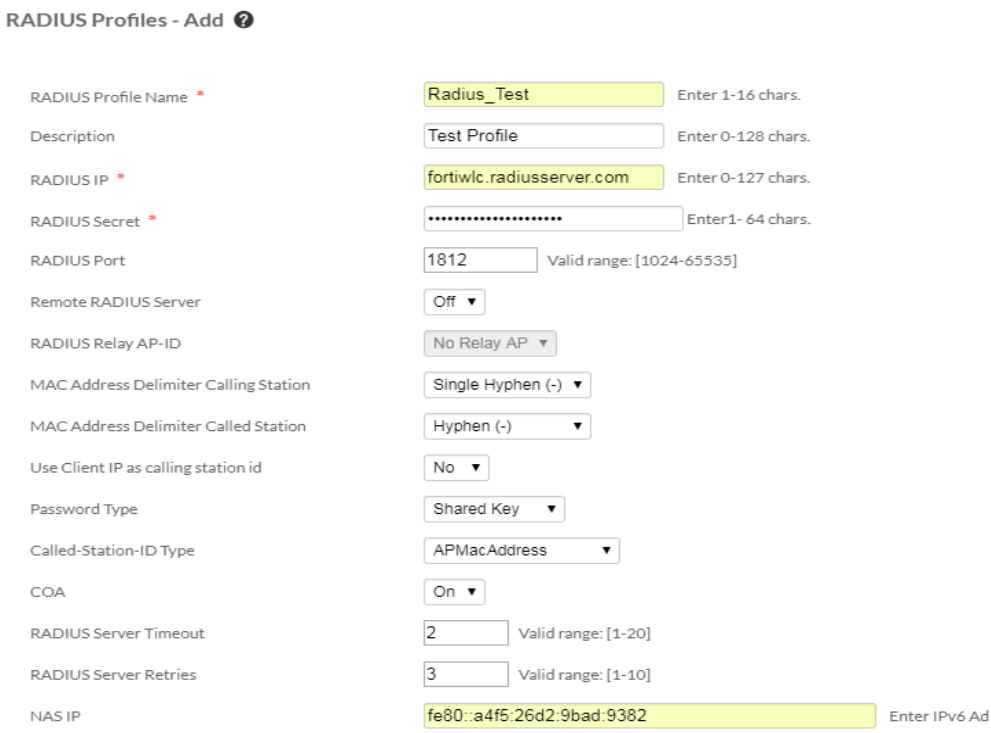
Configure RADIUS Authentication for Users With the Web UI

Note: RADIUS Authentication requires Level 10 permission.

To use RADIUS authentication for guests and employees on the network,

1. Add the controller IP address and shared secret in the RADIUS server.
2. Create a RADIUS Profile (use the same shared secret as in step 1).
3. Include that RADIUS Profile in a Security Profile.
4. Include the Security Profile in an ESS Profile.

Configuring RADIUS authentication for administrators is a different, simpler process. Follow these steps to add a RADIUS profile.



1. Click Configuration > Security > RADIUS.
2. Provide a unique **RADIUS Profile Name** (1-16 characters), **Description** (0-128 characters), **RADIUS IP** or FQDN (IPv4/IPv6), **RADIUS Secret** (1-64 characters) and **RADIUS Port** (1812 is default).
3. To configure this as a remote RADIUS server, enable **Remote RADIUS Server** and select **RADIUS Relay AP-ID**. *FQDN is not supported for remote RADIUS configuration and only L3 enabled 11ac AP are allowed as relay APs*.
   - The relay AP is used for communicating between the RADIUS server (in the remote site) and the controller in the head-quarters.
   - An AP is set as a relay AP only when it is assigned in the RAIDUS profile. Once an AP is assigned as a relay AP It is recommended that you do not overload the relay AP with client WLAN traffic. This can result in communication issues between the relay AP and DC. For regular client WLAN services, we recommend the use of a different access point.
   - For a remote RAIDUS profile, you cannot configure a secondary relay AP. However, for resilience purposes, we recommend configuring an alternate (backup) RADIUS profile and assigning another AP as a relay AP to this backup RAIDUS profile. In the security profile, set this RADIUS profile as the secondary RADIUS server.

4. Select a **MAC Address Delimiter Calling Station** and **MAC Address Delimiter Called Station**.
   - **None**--No delimiter is used.
   - **Hyphen** (-)--A hyphen is used to delimit the fields (xx-yy-zz-aa-bb-cc)
   - **Single Hyphen** (-)--Only one hyphen is used to delimit fields (xxyyzz-aabbcc)
   - **Colon** (:)--A colon is used to delimit fields (xx:yy:zz:aa:bb:cc)
5. Enable **Use Client IP as calling station id** to configure the wireless client IP address as the calling station ID. When enabled the MAC address delimiter need not be specified.
6. Select a **Password Type** (Shared Key or MAC Address) from the list.
7. Select the **Called-Station-ID Type** determines the information that is sent to the RADIUS server in the Called-Station-ID attribute of the Access-Request message. The options are supported:
   - **Default**--This attribute stores the controller /WLAN MAC address.
   - **Mac Address**-This attribute stores the controller/WLAN MAC address.
   - **Mac Address : SSID--**This attribute stores the controller/WLAN MAC address and the SSID to which the client connects.
   - **APMACAddress**--This attribute stores the access point MAC address.
   - **APMACAddress:SSID**--This attribute stores the access point MAC address and the SSID to which the client connects.
   - **APName**--This attribute stores the name of the access point configured on the controller.
   - **APName:SSID**--This attribute stores the name of the access point configured on the controller and the SSID to which the client connects.
   - **APLocation**--This attribute stores the location details of the access point configured on the controller.
   - **APGroup**--This attribute stores the access point group details configured on the controller.
   - **AP IP**--This attribute stores the IP address of the access point.
   - **VLAN**--This attribute stores the VLAN tag associated with the ESSID from where the RADIUS request originates.
8. Enable **COA** to process CoA requests from this RADIUS server.
9. Configure the **RADIUS Server Timeout,** the time interval (in seconds) between which the RADIUS authentication with primary RADIUS server is retried.
10. Configure the **RADIUS Server Retries**, the number of attempts to reach the primary RADIUS server. After the retries limit is reached, the authentication workflow is sent to the secondary server. All new clients will be authenticated via the secondary RADIUS server.
11. **[IPv6 only]** Enter the NAS IP address to be used in RADIUS access requests. When configuring FortiWLC to use a RADIUS server, the FortiWLC interface has multiple IP

addresses, specify the IP address included in the RADIUS configuration. However, if the NAS IP is not specified, any of the FortiWLC IPv6 interface addresses is used instead.

12. While creating a RADIUS security profile you can configure the Network Access Server Identifier (**NAS Identifier**) to report the source of the RADIUS access request. This allows the RADIUS server to select a policy for that request. You can configure the NAS identifier for each security profile.
    The controller sends the NAS ID to the RADIUS through an authentication request to classify users to different groups. This allows the RADIUS server to send a customized authentication response. The valid range is 0-128 characters.
    The following RADIUS IETF attributes are supported:
    - Acct-Session-Id (including authentication requests)
    - Acct-Input-Gigawords
    - Acct-Output-Gigawords
    - Operator-Name
13. Click **OK**.

CoA requests from Cisco ISE on port 1700 is automatically supported.

Indicate when the RADIUS server should be used. There are two ways to do this. One way is a two-step process that creates a Security Profile to call the RADIUS Profile, and then creates an ESS Profile to call the Security Profile.

14. Click Configuration > Security > Profile. Here you see all security profiles that have been created on this controller. You can either modify an existing security profile to use the RADIUS server or you can add a new security profile. Either way, the security profile includes a drop-down list for Primary RADIUS Profile Name and Secondary RADIUS Profile Name; all configured RADIUS servers are listed and you can select one from the list.

Indicate which ESS Profile should use the Security Profile.

15. Click Configuration > Wireless > ESS. Here you see all ESS profiles that have been created on this controller. You can either modify an existing ESS profile to use the Security Profile or you can add a new ESS Profile. Either way, there is a drop-down list for Security Profile Name; all configured Security Profiles are listed and you can select one from the list.

You can select the Primary RADIUS Profile Name and Secondary RADIUS Profile Name directly from the ESS.

COA Support

FortiWLC (SD) provides the following support for change of authorization messages:

- Controller responds to COA requests involving re-use of identifiers from the RADIUS server.
- Only 1x and Captive Portal user sessions supported.
- Both Primary/Secondary RADIUS Profiles supported.
- Controller listens to COA messages on UDP port 3799
- User sessions in a COA messages can be identified using MAC-address and/or username.
- Disconnect or CoA requests can be sent from any configured RADIUS server in the controller.
- CoA requests on UDP 1700, to enable Cisco ISE Interoperability.
- For Disconnect Message, only station mac-address is required. When disconnected, the client is completely disconnected from the network and its session data, 1x, PMK Cache is also cleared. In case of captive portal session, session aging timer is also cleared. After a disconnect, the client must be go through complete authentication sequence to reconnect.
- While sending a CoA message, only the change of Filter-ID is supported.
- RADIUS based filter-ID and CoA for filter-ID change for MAC authenticated (RADIUS) clients is supported.
- CoA disconnection requests are honoured when a user maps a security profile which is configured for WPA-PSK with MAC filtering enabled, to an ESS profile is implemented.
- CoA disconnect requests for Captive Portal Bypass and MAC filtering enabled stations have the stations go through the complete MAC and CP authentication while re-connecting.
- If you create more than one RADIUS profile using the same server IP address, ensure that the shared secret is the same across profiles.

RADIUS Disconnect Message and Filter-ID Support

	802.1x	MAC Auth	Captive Portal
RADIUS Disconnect	Y	Y	Y
CoA (Filter-ID)	Y	x	Y

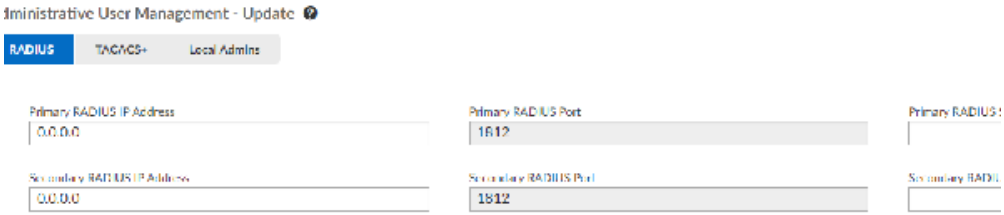
Configure RADIUS Authentication for Administrators With the Web UI

Configure RADIUS authentication for all administrators by following these steps:

1. Click Configuration > User Management.
2. Select RADIUS for Authentication Type at the top of the screen.

3. There are three tabs for admin authentication (see m), RADIUS, Tacacs+ and Local Admins. The RADIUS tab is the default.

Figure 65: *Configure a User for RADIUS Authentication*



4. Provide the IP address (IPv4/IPv6) of the primary RADIUS server.
5. Provide a primary RADIUS port number; the default is 1812.
6. Provide the secret key for RADIUS server access.
7. Optionally repeat steps 4, 5 and 6 for a secondary RADIUS server.
8. Click OK.
9. Add administrators on the RADIUS server using these three levels.

1	**Operator** is the lowest authentication level and also the default. Operators can see statistics and results but cannot make any configuration changes.
10	**Administrators** can also do general configuration changes, but cannot upgrade APs or controllers, nor can they upgrade FortiWLC (SD) versions using Telnet. The cannot configure an NMS server, NTP server, change the system password, date or time (all CLI). They cannot create admins nor can they set the authentication mode for a controller (GUI and CLI). Administrators cannot add or remove licensing.
15	**SuperUser** administrators can perform all configurations on the controller. They are the only ones who can upgrade APs or controllers and they can upgrade FortiWLC (SD) versions using Telnet. The can configure an NMS server, NTP server, system password, date and time (all CLI). They can also create admins and set the authentication mode for a controller (GUI and CLI). Superusers can add and remove licensing.

Configure RADIUS Authentication for Administrators With the CLI

Commands to configure all controller administrators for RADIUS authentication mode:

- authentication mode global
- primary-radius-ip
- primary-radius-port

- primary-radius-secret
- authentication type radius
- secondary-radius-ip
- secondary-radius-port
- secondary-radius-secret
- called-station-id-type
- mac-delimiter-called-station
- mac-delimiter-calling-station
- nas-ip-address

For command details, see the ***FortiWLC (SD) Command Reference***.

CLI Example for Setting Authentication Mode to RADIUS

```
ramcntrl(0)# configure terminal
   ramcntrl(0)(config)# authentication-mode global
   ramcntrl(0)(config-auth-mode)# authentication-type radius
   ramcntrl(0)(config-auth-mode)# primary-radius-
   primary-radius-ip      primary-radius-port    primary-radius-secret
   ramcntrl(0)(config-auth-mode)# primary-radius-ip 172.18.1.3
   ramcntrl(0)(config-auth-mode)# primary-radius-secret RadiusP
   ramcntrl(0)(config-auth-mode)# secondary-radius-
   secondary-radius-ip      secondary-radius-port    secondary-radius-secret
   ramcntrl(0)(config-auth-mode)# secondary-radius-ip 172.18.1.7
   ramcntrl(0)(config-auth-mode)# secondary-radius-secret RadiusS
   ramcntrl(0)(config-auth-mode)# exit
   ramcntrl(0)(config)# exit

   ramcntrl(0)# sh authentication-mode
   Administrative User Management
   AuthenticationType           : radius
   Primary RADIUS IP Address    : 172.18.1.3
   Primary RADIUS Port          : 1812
   Primary RADIUS Secret Key    : *****
   Secondary RADIUS IP Address  : 172.18.1.7
   Secondary RADIUS Port        : 1812
   Secondary RADIUS Secret Key  : *****
   Primary TACACS+ IP Address   : 0.0.0.0
   Primary TACACS+ Port         : 49
   Primary TACACS+ Secret Key   : *****
   Secondary TACACS+ IP Address : 0.0.0.0
   Secondary TACACS+ Port       : 49
   Secondary TACACS+ Secret Key : *****
   ramcntrl(0)#
```

RADIUS Authentication Attributes

Attributes for 802.1X

The RADIUS 802.1X message attributes are:

MESSAGE: Access-Request

ATTRIBUTES:

- User-Name(1)
- NAS-IP-Adress(4)
- NAS-Port(5)
- Called-Station-Id(30) = <mac of Controller>:<ssid string>
- Calling-Station-Id(31)
- Framed-MTU(12)
- NAS-Port-Type(61) = Wireless-802.11(19)
- Connect-Info(77)
- Message-Authenticator(80)

OPTIONAL ATTRIBUTES (depends on EAP type):

- EAP-Message(79)
- State(24)

OPTIONAL ATTRIBUTES (depends on RADIUS based User Management)

- Service-Type(6) = Value:Login(1)
- User-Password(2) = Value:<password string>

MESSAGE: Access-Accept

ATTRIBUTES:

- Framed-Protocol(7) = PPP(1)
- Service-Type(6) = Framed-User(2)
- Class(25)
- Message-Authenticator(80)

OPTIONAL ATTRIBUTES (depends on EAP type):

- EAP-Message(79)
- OPTIONAL ATTRIBUTES (required for RADIUS-assigned VLAN):
- Tunnel-Medium-Type(65) = 802(6)

- Tunnel-Type(64) = VLAN(13)
- Tunnel-Private-Group-Id (81) = <the VLAN ID>

OPTIONAL ATTRIBUTES (depends on RADIUS based User Management)

- Filter-Id(11) = Value:<Privilege Level>:<1-15>

RADIUS Accounting for Clients

If you have a RADIUS accounting server in your network, you can configure the controller to act as a RADIUS client, allowing the controller to send accounting records to the RADIUS accounting server. The controller sends accounting records either for clients who enter the wireless network as 802.1X authorized users or for the clients that are Captive Portal authenticated.

When using RADIUS accounting, set up a separate RADIUS profile for the RADIUS accounting server and point the ESS profile to that RADIUS profile. So, for example, you could have a RADIUS profile called radiusprofile1 that uses UDP port 1645 or 1812 (the two standard ports for RADIUS authentication) and your security profiles would point to radiusprofile1. To support RADIUS accounting, configure a new RADIUS profile (like radiusprofile1_acct) even if the RADIUS accounting server is the same as the RADIUS authentication server. Set its IP and key appropriately and set its port to the correct RADIUS accounting port (1646, 1813 for example). Then point ESS profiles) to this new RADIUS profile radiusprofile1_acct.

Accounting records are sent for the duration of a client session, which is identified by a unique session ID. You can configure a RADIUS profile for the primary RADIUS accounting server and another profile for a secondary RADIUS accounting server, which serves as a backup should the primary server be offline. The switch to the backup RADIUS server works as follows. After 30 seconds of unsuccessful Primary RADIUS server access, the secondary RADIUS server becomes the default. The actual attempt that made it switch is discarded and the next RADIUS access that occurs goes to the Secondary RADIUS server. After about fifteen minutes, access reverts to the Primary RADIUS Server.

In every RADIUS message (Start, Interim Update and Stop), the following attributes are included:

TABLE 14: *RADIUS Accounting Attributes*

RADIUS Attribute	Description
Session-ID	Client IP Address-Current Time - The session time returned from the RADIUS server has priority. If the RADIUS server doesn't return the session time, the configured value is used.
Status Type	Accounting Start/Accounting Stop/Interim-Update

TABLE 14: *RADIUS Accounting Attributes*

RADIUS Attribute	Description
Authentication	RADIUS authentication
User-Name	Username
User-Name	Station Mac Address (station info)
NAS-IP Address	Controller IP Address
NASPort	Unique value (system generated)
Called Station-ID	Controller MAC Address
Called Station-ID	Controller MAC Address:ESSID Name (Used to enforce what ESS a station can connect to)
Calling Station-ID	Station MAC address
Connect Info	Radio Band of Station
Class	Class Attribute
NAS-Identifier	Any string to identify controller (self) in Access Request Packet. Min value 3 chars.
Acct-Input-Octets*	Number of octets received on this port (interface) and sent in Accounting-Request when Accounting status type is STOP
Acct-Input-Packets*	Number of packets received on this port (interface) and sent in Accounting-Request when Accounting status type is STOP
Acct-Output-Packets*	Number of packets sent on this port (interface) and sent in Accounting-Request when Accounting status type is STOP
Acct-Output-Octets*	Number of octets sent on this port (interface) and sent in Accounting-Request when Accounting status type is STOP
Acct-Terminate-Cause	Used to get the reason for session termination and sent in Accounting-Request when Accounting status type is STOP
Acct-Delay-Time	Sent to indicate the number of seconds we have been waiting to send this record.
AP ID	Vendor specific info: the AP ID to which client connected. Sent when accounting starts

TABLE 14: *RADIUS Accounting Attributes*

RADIUS Attribute	Description
AP ID	Vendor specific info: the AP ID from which client disconnected from. Sent when accounting stops
AP Name	Vendor specific info: The AP Name to which client connected. Sent when accounting starts
AP Name	Vendor specific info: the AP ID from which client disconnected from. Sent when accounting stops
Session-Time	Number of seconds between start and stop of session

TABLE 15: *RADIUS Authentication Attributes*

RADIUS Attribute	Description
User-Name	Username
NAS-IP-Address	Controller IP Address
NAS-Port	Unique value = essid << 11 | Sta AID
NAS-Port-Type	Type of the physical port used for authentication = 19
Called-Station-Id	Own MAC Address: ESSID Name
Called-Station-Id	Own MAC Address
Calling-Station-Id	STA MAC Address
Framed-MTU	Max RADIUS MTU = 1250
Connect-Info	Radio Band of Station
VLAN ID	Vlan Id of the ESS profile to which client is trying to connect. Only available for 802.1x clients and is sent only if its configured on the controller
Service-Type	Send the types of service requested = 8 (Authenticate Only)
Service-Type	Send the types of service requested = 1 (Login)
User-Password	User Password

TABLE 15: *RADIUS Authentication Attributes*

RADIUS Attribute	Description
Session-Timer	Number of seconds the user must be allowed to remain in the network
Class	Returned by RADIUS Server and to be sent in Accounting Request message
Vlan-Id	The Vlan ID returned by the RADIUS server
Filter-Id	Used with Per User Firewall (PEM); privilege level (1, 10, 15) sent as filter id in RADIUS response
Message-Authenticator	Returned by RADIUS server
EAP Message	Returned by RADIUS server
Tunnel-Medium-Type	Indicates the transport medium like ipv4, ipv6. In CP, valid only if VPN is set. Also sent in Access-Request in case of CP.
Tunnel-Type	The type of tunnel, in our case should be VLAN i.e. 13. If anything else is received, treat as ACCESS-REJECT. In CP, valid only if VPN is set. Also sent in Access-Request in case of CP.
Tunnel-Private-Group	Receives the Vlan ID from this attribute (Does not apply for Captive Portal)
Framed-Compression	Indicates the compression protocol that is being used. In our case, NONE
Idle-Timeout	Use this to calculate client idle time and knock the client off.

Configure RADIUS Accounting for Captive Portal

See *"Configure RADIUS Accounting for Captive Portal"* ***on page 287***.

RADIUS-Based ESS Profile Restriction

This feature gives a controller the capability to restrict wireless clients attempting connection through RADIUS based ESS profiles; the clients can connect only to certain SSIDs as returned in a RADIUS Accept message.

With this system, there is one RADIUS server and multiple ESS profiles with 802.1X security using this RADIUS Server. In absence of the RSSID feature, all wireless clients provisioned in the RADIUS Server have access to all ESS profiles and hence all associated VLANS. With SSID restriction, the RADIUS server can be further configured for each of these wireless clients specifying the SSIDs they can connect with.

You can use a RADIUS server to restrict SSID connection using VSA in the RADIUS Accept message. There are three possible conditions for an SSID:

RADIUS Server Sends	Results in:
No list of acceptable SSIDs	Connection is accepted
A list of acceptable SSIDs that includes the ID	Connection is accepted
A list of acceptable SSIDs that does not include the ID	Connection is not accepted

The RADIUS server should return the allowed SSID(s) in a Vendor-specific attribute (VSA) with Vendor code 9 and attribute number 1 in the Access-Accept message. The attribute value should be string format.

The string should say ssid=<ssid-string> where <ssid-string> is replaced by the actual SSID (also known as the ESSID).

If a list of multiple allowed SSIDs is used, put each SSID in a separate instance of the attribute. The order of the attributes does not matter. If the SSID to which the station is trying to connect is not among the SSIDs returned by the RADIUS server, the station will be denied access.This feature has no CLI or Web UI commands associated with it. If the RADIUS responds with a list of allowed SSIDs, the list is used to process and limit the user.

Remote RADIUS Server

Network deployments with remote sites that are physically away from their head-quarter (or master data center -DC) can use remote RADIUS server in each of the remote sites for local authentication purposes.

In a typical scenario, a RADIUS server is usually co-located in the DC. Remote sites that required AAA services to authenticate their local clients use the RADIUS server in the DC. This in most cases introduces among other issues high latency between the remote site and its DC. Deploying a RADIUS server within a remote site alleviates this problem and allows remotes sites or branches to use their local AAA services (RADIUS) and not rely on the DC.

Before you Begin

Points to note before you begin deploying a remote RADIUS server:

1. Ensure that the Controller and site AP communication time is less than RADIUS timeout.
2. Provision for at least one AP that can be configured as a relay AP.
3. In case of WAN survivability, no new 802.1x radius clients will be able to join, until relay AP rediscovers the controller.

How It Works

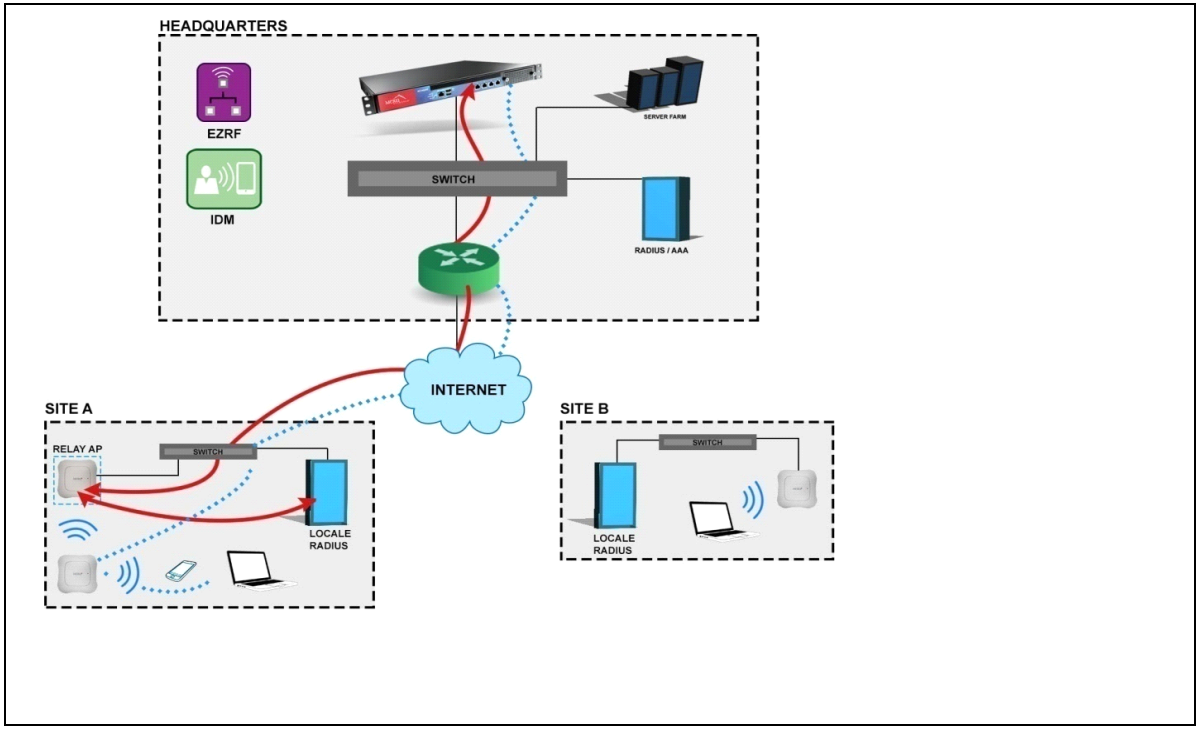
This feature provides local authentication (.1x, Captive Profile, and mac-filtering) services using a RADIUS server set up in the remote site. In addition to the RADIUS server, the remote site must also configure a Fortinet 11ac AP as a relay AP. The remote RADIUS profile can be created per ESS profile using the controller's WebUI (Configuration > RADIUS) or CLI. A remote RADIUS profile works like a regular profile and can be used as primary and secondary RADIUS auth and accounting servers.

High latency between the remote site and DC can cause client disconnections and sluggish network experience.

About Relay AP

- The relay AP primarily is used for communicating between the RADIUS server (in the remote site) and the controller in the head-quarters.
- An AP is set as a relay AP only when it is assigned in the RAIDUS profile. Once an AP is assigned as a relay AP It is recommended that you do not overload the relay AP with client WLAN services. This can result in communication issues between the relay AP and DC. For regular client WLAN services, we recommend the use of a different Fortinet access point.
- For a remote RAIDUS profile, you cannot configure a secondary relay AP. However, for resilience purposes, we recommend configuring an alternate (backup) RADIUS profile and assigning another AP as a relay AP to this backup RAIDUS profile. In the security profile, set this RADIUS profile as the secondary RADIUS server.

The following figure illustrates a simple scenario with local RADIUS deployment.

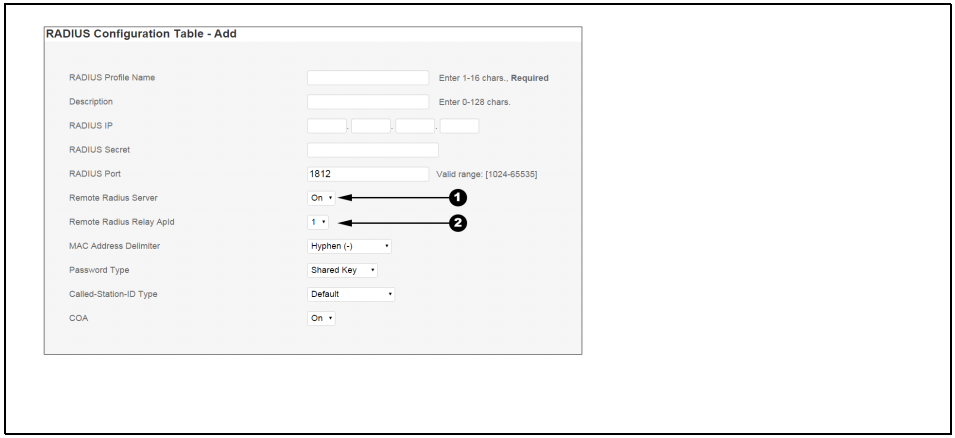


Configuring Using WebUI

To configure remote RADIUS via WebUI,

In the Configuration > RADIUS > RADIUS Configuration Table - ADD page, set Remote Radius Server to ON (see 1 in Figure 2).

Select the AP (Remote Radius Relay ApId) to be used as the relay AP (see 2 in Figure 2).



Configuring Using CLI

```
# configure terminal

(config)# radius-profile RemoteRadius

(config-radius)# remote-radius-server on

(config-radius)# radius-relay-apid XXX

XXX is the AP ID of the relay AP in the remote site.

# configure terminal

(config)# radius-profile RemoteRadius

(config-radius)# no remote-radius-server

# show radius-profile <remoteRadius-profile-name>
```

EXAMPLE

```
# show radius-profile site-a

RADIUS Configuration Table

RADIUS Profile Name      : site-a

Description              : Remote radius profile for Site-A

RADIUS IP                : 172.18.1.8

RADIUS Secret            : *****

RADIUS Port              : 1812
```

```
Remote Radius Server     : on
Remote Radius Relay ApId : 2
MAC Address Delimiter    : hyphen
Password Type            : shared-secret
Called-Station-ID Type   : default
Owner                    : controller
COA                      : on
```

TACACS+ Authentication

Terminal Access Controller Access-Control System Plus (TACACS+) is a remote authentication protocol that runs on a TACACS+ server on the network and is similar to RADIUS authentication. There are some differences between the two, however. RADIUS combines authentication and authorization in one user profile, while TACACS+ separates the two operations. Another difference is that TACACS+ uses TCP port 49 while RADIUS uses UDP port 1812. FortiWLC (SD) supports TACACS+ authentication but not accounting; FortiWLC (SD) supports both RADIUS authentication and accounting. Only the Cisco ACS server is supported for Tacacs+ authentication.

The TACACS+ level required, 15 (superuser), 10 - 14 (admin), and 1 - 9 (user), for the activity on the current GUI window is listed in the Help. Click Help on any GUI window of FortiWLC (SD). In the CLI, all command lists also include the required authentication level, which is also now used for both RADIUS and local admin authentication in Release 5.1. TACACS+ actually provides eight levels, but Fortinet only uses the three authentication levels described here.

The three levels used are described below:

1	**Operator** is the lowest authentication level and also the default. Operators can see statistics and results but cannot make any configuration changes.

10	**Administrators** can also do general configuration changes, but cannot upgrade APs or controllers, nor can they upgrade FortiWLC (SD) versions using Telnet. The cannot configure an NMS server, NTP server, change the system password, date or time (all CLI). They cannot create admin accounts nor can they set the authentication mode for a controller (GUI and CLI). Administrators cannot add or remove licensing.
15	**SuperUser** administrators can perform all configurations on the controller. They are the only ones who can upgrade APs or controllers and they can upgrade FortiWLC (SD) versions using Telnet. The can configure an NMS server, NTP server, system password, date and time (all CLI). They can also create admins and set the authentication mode for a controller (GUI and CLI). Superusers can add and remove licensing.

Configure TACACS+ Authentication Mode with the CLI

New commands to configure TACACS+ authentication mode for all administrators on a Cisco ACS server were introduced in FortiWLC (SD) 4.1:

- authentication mode global
- primary-tacacs-ip
- primary-tacacs-port
- primary-tacacs-secret
- authentication type tacacs+
- secondary-tacacs-ip
- secondary-tacacs-port
- secondary-tacacs-secret

For command details, see the ***FortiWLC (SD) Command Reference***.

CLI Example for Setting Authentication Mode to TACACS+

```
ramcntrl(0)# configure terminal
   ramcntrl(0)(config)# authentication-mode global
   ramcntrl(0)(config-auth-mode)# authentication-type tacacs+
   ramcntrl(0)(config-auth-mode)# primary-tacacs-
   primary-tacacs-ip      primary-tacacs-port    primary-tacacs-secret
   ramcntrl(0)(config-auth-mode)# primary-tacacs-ip 172.18.1.5
   ramcntrl(0)(config-auth-mode)# primary-tacacs-secret TacacsP
   ramcntrl(0)(config-auth-mode)# secondary-tacacs-
   secondary-tacacs-ip      secondary-tacacs-port    secondary-tacacs-secret
   ramcntrl(0)(config-auth-mode)# secondary-tacacs-ip 172.18.1.10
   ramcntrl(0)(config-auth-mode)# secondary-tacacs-secret TacacsS
   ramcntrl(0)(config-auth-mode)# exit
```

```
ramcntrl(0)(config)# exit
ramcntrl(0)# sh authentication-mode
Administrative User Management
AuthenticationType           : tacacs+
Primary RADIUS IP Address    : 172.18.1.3
Primary RADIUS Port          : 1812
Primary RADIUS Secret Key    : *****
Secondary RADIUS IP Address  : 172.18.1.7
Secondary RADIUS Port        : 1812
Secondary RADIUS Secret Key  : *****
Primary TACACS+ IP Address   : 172.18.1.5
Primary TACACS+ Port         : 49
Primary TACACS+ Secret Key   : *****
Secondary TACACS+ IP Address : 172.18.1.10
Secondary TACACS+ Port       : 49
Secondary TACACS+ Secret Key : *****
ramcntrl(0)#
```

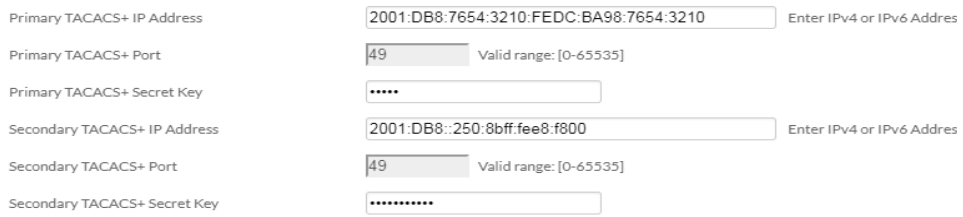
For command details, see the ***FortiWLC (SD) Command Reference***.

Configure TACACS+ Authentication Mode with the Web UI

To configure TACACS+ authentication on a Cisco ACS server for all admins, follow these steps:

1. Click Configuration > User Management.
2. Select the Authentication Type Tacacs+ at the top of the screen.
3. There are three tabs for admin authentication (see **Figure 66**), RADIUS, Tacacs+ and Local Admins. Click the Tacacs+ tab.

Figure 66: *Setting Authentication for Admins*



4. Provide the IP address (IPv4/IPv6) of the primary TACACS+ server.
5. Provide a primary TACACS+ port number; the default is 49.
6. Provide the secret key for TACACS+ server access.
7. Optionally repeat steps 4, 5 and 6 for a secondary TACACS+ server.
8. Click OK.

9. Add administrators on the TACACS+ server using these three levels.

1	Operator is the lowest authentication level and also the default. Operators can see statistics and results but cannot make any configuration changes.
10	Administrators can also do general configuration changes, but cannot upgrade APs or controllers, nor can they upgrade FortiWLC (SD) versions using Telnet. The cannot configure an NMS server, NTP server, change the system password, date or time (all CLI). They cannot create admins nor can they set the authentication mode for a controller (GUI and CLI). Administrators cannot add or remove licensing.
15	SuperUser administrators can perform all configurations on the controller. They are the only ones who can upgrade APs or controllers and they can upgrade FortiWLC (SD) versions using Telnet. The can configure an NMS server, NTP server, system password, date and time (all CLI). They can also create admins and set the authentication mode for a controller (GUI and CLI). Superusers can add and remove licensing.

Local Admin Authentication

Local admin authentication takes place on the controller and uses the same three privilege levels as RADIUS and TACACS+, 15 (superuser), 10 (admin), and 1 (user). If administrators are using Local authentication, they cannot use RADIUS or TACACS+.

Configure an Admin for Local Authentication Mode With the CLI

Use these commands, new in release 4.1, to configure local administrators with the CLI:

- authentication-mode global
- authentication-type local
- local-admin
- password
- privilege-level
- show local admins

For command details, see the ***FortiWLC (SD) Command Reference***.

CLI Example for Configuring a Local Admin

```
ramcntrl(0)# configure terminal
   ramcntrl(0)(config)# authentication-mode global
   ramcntrl(0)(config-auth-mode)# authentication-type local
   ramcntrl(0)(config-auth-mode)# exit
```

```
ramcntrl(0)(config)# exit
ramcntrl(0)# sh authentication-mode
Administrative User Management
AuthenticationType           : local
Primary RADIUS IP Address    : 0.0.0.0
Primary RADIUS Port          : 1812
Primary RADIUS Secret Key    : *****
Secondary RADIUS IP Address  : 0.0.0.0
Secondary RADIUS Port        : 1812
Secondary RADIUS Secret Key  : *****
Primary TACACS+ IP Address   : 0.0.0.0
Primary TACACS+ Port         : 49
Primary TACACS+ Secret Key   : *****
Secondary TACACS+ IP Address : 0.0.0.0
Secondary TACACS+ Port       : 49
Secondary TACACS+ Secret Key : *****
ramcntrl(0)#
ramcntrl(0)(config)# local-admin LocalUser
ramcntrl(0)(config-local-admin)# privilege-level 15
ramcntrl(0)(config-local-admin)# password LocalUser
ramcntrl(0)(config-local-admin)# exit
ramcntrl(0)(config)# exit
ramcntrl(0)
```

Configure Local Authentication and Add an Admin with the Web UI

To configure Local authentication for admins and optionally add a local administrator, follow these steps:

1. Click Configuration > User Management.
2. Select the Local radio button at the top of the screen.

To actually add a local administrator, continue with Step 3.

3. There are three tabs for admin authentication (see **Figure 66**), RADIUS, Tacacs+ and Local Admins. Click the Local Admin tab.
4. Click Add. The Local Admins - Add window displays - see **Figure 67**.

Figure 67: *Setting Local Authentication for Admins*

5. Provide the user name for a local administrator.

6. Provide a password for that local administrator.
7. Enter a privilege level, 15 (Superuser), 10 (Admin), or 1 (Operator); see the descriptions for each level below.
8. Click OK.

802.1X Authentication

Authentication in the 802.11 standard is focused more on wireless LAN connectivity than on verifying user or station identity. For enterprise wireless security to scale to hundreds or thousands of users, an authentication framework that supports centralized user authentication must be used in addition to the WEP type specified by 802.11, or by using WPA/WPA2, which incorporates TKIP/CCMP-AES and 802.1X authentication.

The use of IEEE 802.1X offers an effective framework for authenticating and controlling user traffic to a protected network, as well as dynamically varying encryption keys if WPA/WPA2 is configured. 802.1X ties a protocol called EAP (Extensible Authentication Protocol) to both the wired and wireless LAN media and supports multiple authentication methods, such as token cards, Kerberos, one-time passwords, certificates, and public key authentication.

802.1X Components

There are three basic pieces to 802.1X authentication:

1. Supplicant—a software client running on the wireless station
2. Authenticator—the access point and the controller
3. Authentication Server—an authentication database, traditionally a RADIUS server such as Cisco ACS, Steel Belt RADIUS server (Juniper), or Microsoft IAS.

Extensible Authentication Protocol (EAP) is used to pass the authentication information between the supplicant (the wireless station) and the authentication server (RADIUS, MS IAS, or other). The actual authentication is defined and handled by the EAP type. The access point (and the controller in the configuration) acts as the authenticator. The authenticator is a client of the server that allows the supplicant and the authentication server to communicate.

You can configure the FAP-U42xEV, FAP-U422EV, and FAP-U32xEV access points as an 802.1X supplicant for port based authentication from FortiWLC 8.6 onwards. The 802.1X supplicant access point is authenticated by an external RADIUS server based on the configured credentials (user name and password). The switch is the authenticator between the supplicant access point and the external RADIUS server.

Note: This feature is tested in a setup of 15 access points.

This feature is disabled by default and is enabled using the FortiWLC CLI or GUI. To enable and configure this feature while configuring an AP:

- ? Run the **1x_auth state enable username <username> password <password>** command. To disable, run the **1x_auth state disable** command.
  OR
- ? Create an initialization script. Navigate to **Maintenance > File Management** on the FortiWLC GUI.

Note: Change in the username and password for 802.1X authentication takes effect only after the AP is rebooted.

About the EAP Types

The EAP type you choose, and whether you choose to implement authentication in your organization, depends on the level of security you require. Some of the most commonly deployed EAP authentication types include the following, all of which are supported by the controller:

- EAP-TLS
- EAP-PEAP
- EAP-TTLS
- Cisco LEAP

EAP-TLS

EAP-TLS (Transport Layer Security) provides certificate-based mutual authentication between the client and the network. It relies on client and server certificates to provide authentication and can be used to dynamically generate user-based and session-based encryption keys to secure subsequent communications between the WLAN client and the access point. This type of authentication mechanism requires the administrator install a Certificate Server to store and distribute user and computer certificates. Each client will need the certificate to be downloaded and installed on the wireless client before attempting to use the WLAN. For a large WLAN installation, this can be a cumbersome task.

EAP-TTLS (Tunneled Transport Layer Security)

EAP-TTLS (Tunneled Transport Layer Security) was developed by Funk Software and Certicom, as an extension of EAP-TLS. This security method provides for certificate-based, mutual authentication of the client and network through an encrypted channel (or tunnel), as well as a means to derive dynamic, per-user, per-session encryption keys. Unlike EAP-TLS, EAP-TTLS requires only server-side certificates.

LEAP (Lightweight Extensible Authentication Protocol)

LEAP (Lightweight Extensible Authentication Protocol), is an EAP authentication type used primarily in Cisco Aironet WLANs. It encrypts data transmissions using dynamically generated WEP keys, and supports mutual authentication. Cisco has recently licensed LEAP to a variety of other manufacturers enabling the usage of other than Cisco adapters with LEAP.

PEAP (Protected Extensible Authentication Protocol)

PEAP (Protected Extensible Authentication Protocol) provides a method to securely transport authentication data, including legacy password-based protocols, via 802.11 wireless networks. PEAP accomplishes this by using tunneling between PEAP clients and an authentication server. Like the competing standard Tunneled Transport Layer Security (TTLS), PEAP authenticates wireless LAN clients using only server-side certificates, thus simplifying the implementation and administration of a secure wireless LAN. Microsoft, Cisco and RSA Security developed PEAP. Note that Cisco's LEAP authentication server, ACS, recently added support for PEAP.

802.1X EAP Types Feature/Benefit	MD5	TLS	TTLS	PEAP	LEAP
Client certificate required	no	yes	no	no	no
Server certificate required	no	yes	yes	yes	no
WEP key management	no	yes	yes	yes	yes
Provider	Microsoft	Microsoft	Funk	MS	Cisco
Authentication Attributes	One way	Mutual	Mutual	Mutual	Mutual
Deployment Difficulty	Easy	Difficult	Moderate	Moderate	Moderate
Wireless Security	Poorest	Highest	High	High	High

The following notes apply to the authentication mechanisms above:

1. MD5 is not typically used as it only provides one-way authentication. MD5 does not support automatic distribution and rotation of WEP keys and therefore does nothing to relieve the administrative burden of manual WEP key maintenance.
2. TLS, although very secure, requires the administrator to install client certificates on each wireless station. Maintaining a PKI infrastructure adds additional time and effort for the network administrator.
3. TTLS addresses the certificate issue by tunneling TLS, and thus eliminates the need for a certificate on the client side. This often makes TTLS the preferred option. Funk Software primarily promotes TTLS and there is a charge for supplicant and authentication server software.
4. LEAP has the longest history. Although previously proprietary to Cisco, Cisco now licenses the software. Other vendors are now beginning to support LEAP in their wireless LAN adapters.
5. The more recent PEAP works similar to EAP-TTLS in that it does not require a certificate on the client side. PEAP is backed by Cisco and Microsoft and is available at no additional cost from Microsoft. If you want to transition from LEAP to PEAP, Cisco's ACS authentication server runs both.

11 Captive Portals

If you want to give limited wireless access to a group of users, use Captive Portal. Captive Portal is a feature designed to isolate temporary users on a network, for example guests in a company or students using a library. If Captive Portal is enabled, the HTTP protocol over Secure Socket Layer (SSL, also known as HTTPS) provides an encrypted login interchange with the RADIUS server until the user is authenticated and authorized. During this interchange, all traffic with the Client station except DHCP, ARP, and DNS packets is dropped until access is granted. If access is not granted, the user is unable to leave the Captive Portal login page. If access is granted, the user is released from the Captive Portal page and is allowed to enter the WLAN. This section provides instructions to both implement Captive Portal and customize the GUI pages for Fortinet Captive Portal. Guest Login is disabled by default and requires privilege level 1 (lowest level). You can either *"Configuring Fortinet Captive Portal"* ***on page 301*** or use *"Captive Portal (CP) Authentication for Wired Clients"* ***on page 314***.

For details on Captive Portal in Bridged mode refer to "CP bridged_2013-04_v2" located in the Fortinet Support Portal.

The RADIUS attributes for Dynamic VLAN assignment (Tunnel-Type, Tunnel-Medium-Type, and Tunnel-Private-Group-ID, see the command vlan support) are not supported and are ignored if returned as part of the RADIUS exchange.

Security logging must be set to on before passthrough will work. Also, security logging has to be toggled of/on for any new settings to take effect.

It is recommended not to use internal Captive Portal in production and scale deployments. High CPU usage for Xems and Apache process might be noticed in case of high concurrent internal Captive Portal requests.

Configuring Fortinet Captive Portal

To implement the built-in Captive Portal feature, complete the following tasks:

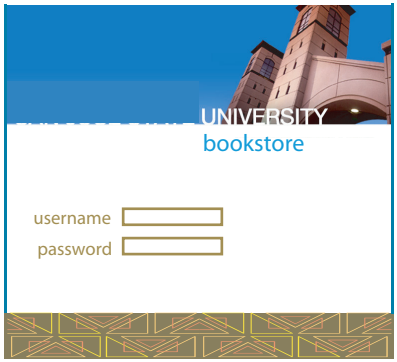
- *"Configure Captive Portal with the CLI"* ***on page 308***
- For authentication, either *"Configure a RADIUS Server for Captive Portal Authentication"* ***on page 318*** or *"Create Captive Portal Guest User IDs Locally"* ***on page 309***
- *"Optionally Customize and Use Your Own HTML Pages"* ***on page 302***
- *"Optionally Configure Pre-Authentication Captive Portal Bypass"* ***on page 311***

Optionally Customize and Use Your Own HTML Pages

If you want to create custom Captive Portal login and success pages with your own logos and credentials, complete the directions in this section. You do not need to do this if you plan to use all of the default Captive Portal pages provided by Fortinet Networks (see login example in *Figure 68 on* ***page 302***). If you do want to create custom HTML pages, you can create up to four sets of Captive Portal custom login pages; these are referred to as Captive Portal 1 through 4. Each set has 6 files, but you can only create customized pages for the main login page and the authentication successful page. The remaining four HTML pages are always the default pages. If you create multiple custom files, they must both use the same authentication (RADIUS or Local) with up to 300 local users (the users can be different for each custom portal).

Figure 68: *Default Captive Portal Login Page*

Figure 69: *Customized Captive Portal Login Page*



All Custom Portal pages (HTML, CSS, JS, and graphics) for the default pages and up to four sets of Custom Portal 2 pages that you create are all located in the same folder. This makes it imperative that you use unique names for all custom files. It also means that you can share a file such as a CSS file used for both CP1 and CP2 custom pages. This is also how and why any pages that you do not customize will use default HTML files. Here are the locations for the custom web portal files:

/opt/meru/etc/ws/html.vpn.custom

/opt/meru/etc/ws/Styles.vpn.custom

/opt/meru/etc/ws/Images.vpn.custom

Create Custom Pages

The easiest way to create your own set of custom pages is to download Fortinet default files and use the two customizable ones (Login page and Success page) as templates, giving the two altered HTML pages new names. To do this, follow these steps:

1. Get the template files. Click Maintenance > Captive Portal > Customization > Get Files.
   A zip file called zip.tar.gz is downloaded to your computer. When the zip.tar.gz file is unzipped, you see the folder html.vpn that contains these six default files:
   - Login page can be customized (default filename is loginformWebAuth.html)
   - Successful login page can be customized (default filename is auth_web_ok.html)
   - Your login failed - try again page (default filename is loginformWebAuthRetry.html)
   - Web authentication succeeded; do you want to log off? (default filename is logoff User.html)
   - You are now logged off page (default filename is loggedoff.html)
   - Your logoff failed - try again page (default filename is logoffUserFailed.html)
2. You can only create two custom files per Captive Portal interface: a replacement for the Login page loginformWebAuth.html and a replacement for the Successful Login page auth_web_ok.html. Locate the two customizable HTML files on your computer and use them as templates to create your own custom HTML files. Use a program such as Notepad, make your changes, and then save the files with unique names.
   - CSS, JavaScript, and HTML are supported.

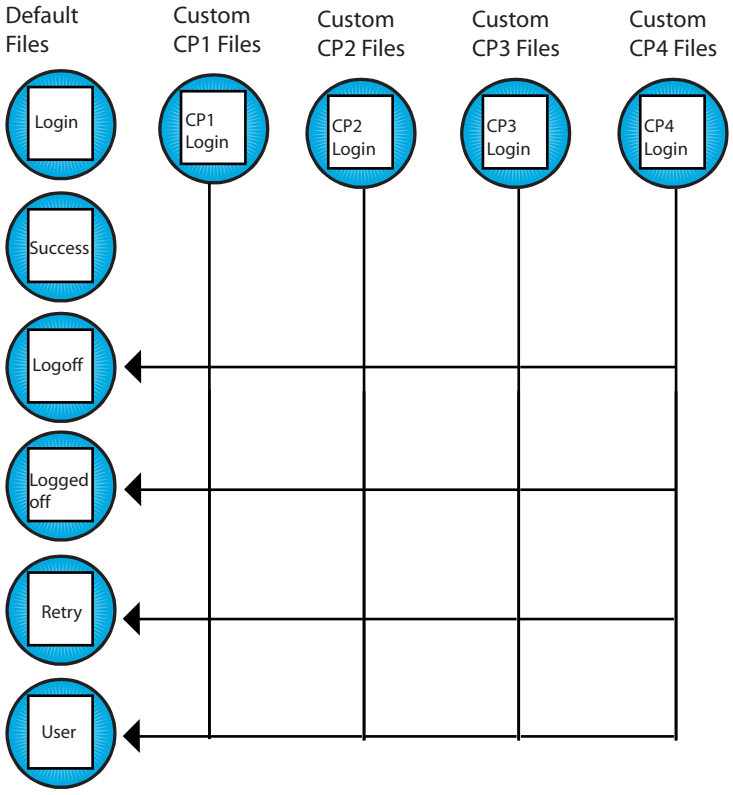
- You can upload graphics up to 50K each in the formats .html .gif, .jpg, .png, .bmp .css, .js.
  To replace the first Fortinet logo graphic, look for the line that reads:
  src="Images.vpn/img_merulogo.gif" width=133 border=0></A></TD>
  Change the text "Images.vpn/img_merulogo.gif" to "Images.vpn.custom/your_image.gif" (Note that you are specifying a new directory for the .gif file, which is Images.vpn.custom).
  To replace the second graphic (the mountain), look for the line that reads:
  src="Images.vpn/img_aboutmeru.jpg" width=326 border=0></TD></TR>
  Change the text "Images.vpn/img_aboutmeru.jpg" to "Images.vpn.custom/your_image2.gif" (Note that you are specifying a new directory for the .gif file, which is Images.vpn.custom).
- You can insert *.js* and *.css* file formats based on the following examples:
  - <script src="Jscript.vpn.custom/.js"</script>
  - <link href="Styles.vpn.custom/.css" rel="stylesheet">
- Possible edits include changing logos, text, and formatting. The only lines that cannot be altered are the login communication process between the controller and the RADIUS server in the file loginformWeb-Auth.html.

3. Import all new Captive Portal files (HTML, CSS, JS, and graphics) to the controller one by one. Click Maintenance > Captive Portal > Import File > enter the location/file in the text box > Import File. Be sure that the files have unique names; they will all be placed in the same directory.
   Tell the controller to use custom pages. Click Configuration > Captive Portal and select the radio button Customization.

The custom HTML, CSS, JS, and graphic files are now on the controller.

4. If you want to remove the word Fortinet or make any other changes in the four remaining files loginformWeb-AuthRetry.html, logoff User.html, loggedoff.html, or logoffUserFailed.html, alter the default files that you downloaded in Step 1 and import them as you did in Step 3. All five sets of Portal pages (default, CP1, CP2, CP3, and CP4) will then use the default files that you altered. These four files have only one version. See **Figure 70**.

Figure 70: *Captive Portal HTML Pages (maximum)*



Next, tell FortiWLC (SD) which custom files to use under what circumstances. Either **Implement New Custom HTML Files Using the CLI** or **Global Captive Portal Settings**.

Implement New Custom HTML Files Using the CLI

Implement custom Captive Portal pages with the CLI by indicating which subset of users should see the new login and success pages; when a user logs in from this subnet, they will see the corresponding custom pages. You can implement up to two sets of Captive Portal pages at a time. For example, students in a library might see the Custom Captive Portal 1 login and success pages while visitors to the football stadium see the Custom Captive Portal 2 login and success pages. See **Figure 70**.

Determine who will see which pages. Point to two custom Captive Portal pages with the CLI command web custom CaptivePortal[1|2] landing-file-name <landing.html> success-file-name <success.html>. Then, point to the network or subnet for the custom captive portal pages with web custom CaptivePortal[1|2] subnet <x.x.x.x> mask <x.x.x.x>. For example:

```
controller-1# configure terminal
   controller-1(config)# web custom ?
   CaptivePortal1         Custom configuration for captive portal 1
   CaptivePortal2         (10) Custom configurations for captive portal2.
   CaptivePortal3         (10) Custom configurations for captive portal3.
   CaptivePortal4         (10) Custom configurations for captive portal4.controller-1(config)#
   web custom captiveportal2 ?
   landing-file-name subnet
   controller-1(config)# web custom CaptivePortal1 landing-file-name landing.html success-file-
   name success.html
   controller-1 (config) web custom CaptivePortal1 subnet 1.1.1.0 mask 255.255.255.0
   controller-1(config)# exit
   controller-1# show web ?
   custom                 Displays IP range for captive portal custom mode.
   custom-area            Lists the files in the custom area for web-auth and captive portal.
   login-page             Displays the type of login page used for web-auth and captive portal.
   controller-1# show web custom-area
   Html Files
   total 16
   -rw-rw-rw-    1 root     root         2607 Jul 13 16:26 page2OK.html
   -rw-rw-rw-    1 root     root         4412 Jul 13 16:26 page2LOGIN.html
   -rwx------    1 root     root         2607 Jul 13 16:04 auth_web_ok.html
   -rw-rw-rw-    1 root     root         4412 Jul 13 16:04 loginformWebAuth.html
   -rwx------    1 root     root            0 Jun 30 00:31 empty.html
   Image Files
   total 9
   -rwx------    1 root     root            0 Jun 30 00:31 empty.gif
   -rw-rw-rw-    1 root     root         8574 Oct 29  2008 Sample.jpg
   controller-1# show web login-page
   custom
```

Global Captive Portal Settings

To configure the global settings for Captive Portal, navigate to Configuration > Security > Captive Portal > Global Settings and configure the following:

Server Port-Traffic received on this port will direct users to the Captive Portal Login Page. The TCP port number range is 1024 through 65,535 and the default port is 10101.

Protocol-Name of the protocol used to authenticate the user, HTTP or HTTPS.

Certificate (HTTPS only)-Server Certificate name if one is configured; otherwise, the field is blank

WLC-FQDN (HTTP only)-Specify the host name/controller FQDN. This is displayed in the internal captive portal URL (if the configured DNS server can resolve it). This is configured in the CLI using the *captive-portal-redirection-url* attribute of the *captive-portal-global-settings* command.

Implement New Custom HTML Files Using the GUI

Implement custom Captive Portal pages with Web UI by first directing Captive Portal to use custom HTML files; those HTML files will then reference the CSS, JS and graphic files you imported. Second, indicate which subset of users should see the new login and success pages by providing a subnet and a mask; when a user logs in from this subnet, they will see the corresponding custom pages. For example, students in a library might see the Custom Captive Portal 1 login page while visitors to the football stadium see the Custom Captive Portal 2 login page.

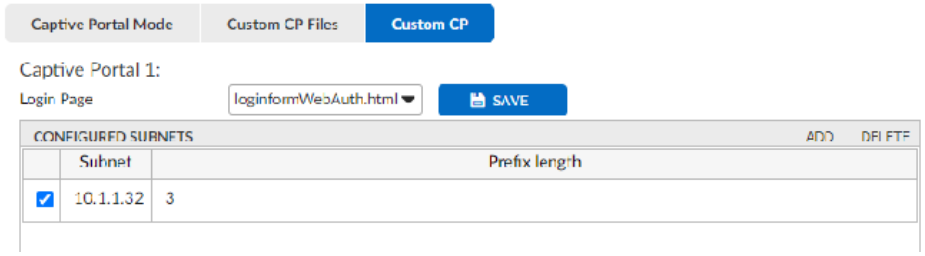
Direct Captive Portal to use custom HTML files by following these steps:

1. Click Maintenance > Customization > select a controller > Change Mode
2. Scroll down and select Customized.

indicate which subset of users should see the custom pages by following these steps:

1. Make sure that security logging is set to on by clicking Configuration > Security > Profile and then selecting a security profile from the list. The security logging setting is near the bottom of the Security Profile Table. This setting must be set to on for Captive Portal configuration to work.
2. Click Maintenance > Captive Portal > Custom CP.
   The Custom Captive Portal page is displayed.

Figure 71: *Custom Captive Portal Page*



3. Provide the names of the new HTML Login Page and Success Page for CP1. Since they are on the controller now, you do not have to indicate a location. Click Save Page Info.
4. Provide at least one subnet location by clicking Add, providing a Subnet IP (IPv4/IPv6) and a Network Mask, then clicking OK. Users logging in from this subnet will see these custom pages.
5. Create a corresponding Security Profile for this portal by clicking Configuration > Security > Profile > Add. Be sure that the setting for Captive Portal is set to webauth in this profile, then save it.
6. Click Configuration > Security > Captive Portal. In this window, identify the RADIUS server, whether or not to adjust the session, and idle timeouts. Session timeout and idle timeout are indicated in minutes.

The L3 User Session Timeout field is used for specific clients that have issues in which they get de-authenticated upon entering sleep mode. This field specifies that the controller will retain these clients in memory for the specified number of minutes before the client is dropped from the captive portal authentication state.

7. Click OK.

The custom HTML files are now configured. You can configure up to four sets of custom files, Captive Portal 1, Captive Portal 2, Captive Portal 3, and Captive Portal 4; or, you can use the default files. See **Figure 70**.

Configure Captive Portal with the CLI

- radius-profile defines the primary and secondary Captive Portal authentication servers.
- accounting-radius-profile defines the primary and secondary Captive Portal accounting servers.
- captive-portal > activity-timeout determines one timeout value. If a client is idle for this many minutes, the client is asked to reauthenticate.
- captive-portal > session-timeout determines one timeout value. If a client session lasts this long (minutes), the client is asked to reauthenticate.
- change_mac_state
- ssl-server captive-portal-external-URL directs Captive Portal to use a third-party solution located at the named URL.
- captive-portal-auth-method sets authentication to internal (default for Fortinet) or external for third-party solutions.

Captive Portal CLI Examples

This example configures Captive Portal with the CLI by completing these tasks:

- Create a guest user ID (Guest) and password.
- Enter the service start time (01/01/2010 00:00:00).
- Enter the service end time (01/01/2011 00:00:00).
- Show the Captive Portal.

```
controller-1(config)# guest-user ?
  <guestname> Enter the name of the guest user.
  controller-1(config)# guest-user Guest ?
  <password> Enter the password of the guest user.
  controller-1(config)# guest-user Guest XXXXX ?
  <start-time> Enter the service start-time (mm/dd/yyyy hh:mm:ss) in double quotes.
  controller-1(config)# guest-user Guest XXXXX "01/01/2010 00:00:00" ?
  <end-time> Enter service end-time (mm/dd/yyyy hh:mm:ss) in double quotes.
  controller-1(config)# guest-user Guest XXXXX "01/01/2010 00:00:00" "01/01/2011 00:00:00" ?
  <CR>
  controller-1(config)# guest-user Guest XXXXX "01/01/2010 00:00:00" "01/01/2011 00:00:00"
  controller-1(config)# exit
  controller-1#
  controller-1# show guest-user
  Guest User  Name Service Start Time              Service End Time
  Guest 01/01/2010 00:00:00             01/01/2011 00:00:00
          Guest User Table(1 entry)
```

The commands in this section show how to configure Captive Portal. The RADIUS server user configuration is performed separately, and is vendor-specific. (Check the Customer Service website for applicable Application Notes.) The Microsoft Internet Explorer and Netscape 7 browsers are both supported for the client application.

1. Create the Security Profile for the WebAuth Captive Portal:

```
default# configure terminal
   default(config)# security-profile web_auth
   default(config-security)# captive-portal webauth
   default(config-security)# exit
   default(config)# exit
```

2. Bind the web_auth Security Profile to an ESSID:

```
default# configure terminal
   default(config)# essid WebAuth-fortinet-WIFI
   default(config-essid)# security-profile web_auth
   default(config-essid)# exit
```

3. Set the SSL server to use the primary RADIUS authentication server profile:

```
default(config)# ssl-server radius-profile primary main-auth
   default(config)# end
```

4. Save the configuration:

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

When users are authenticated, they can be moved into a corporate VLAN, and can have QosRules applied to their session. Each user will have a supplied default session timeout, which if nothing is supplied, will be the default of 33 minutes. If a user disconnects and connects back to same SSID on the same controller within 60 seconds, no re-authentication will be required.The session time returned from the RADIUS server takes priority. If the RADIUS server doesn't return the session time, configured values are used.

Create Captive Portal Guest User IDs Locally

For authentication purposes, you can set up guest user IDs instead of using RADIUS authentication. (This is also a backup for RADIUS authentication; if RADIUS fails, this list is then used.) Releases 3.6 and later support user IDs. Be sure that the field Captive Portal Authentication is set as Local when using Guest IDs (click Configuration > Security > Captive Portal).

The guest user features of both releases are as follows.

Guest User Feature	Supported
Number of users	300
Add/delete users	yes

Guest User Feature	Supported
Change user's password	yes
Time of day login	yes
Day of month login	yes
Assigned to local administrators	yes

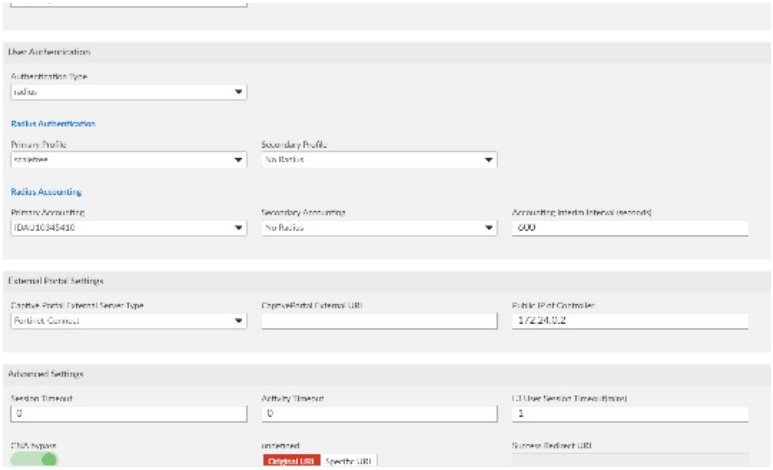
CLI Example - Create Guest User ID

This CLI example creates the guest user named Guest:

```
Default-1 configure terminal
   Default-1(config)# guest-user ?
   <guestname>            Enter the name of the guest user.
   Default-1(config)# guest-user Guest ?
   <password>             Enter the password of the guest user.
   Default-1(config)# guest-user Guest XXXXX ?
   <start-time>           Enter the service start-time (mm/dd/yyyy hh:mm:ss) in double quotes.
   Default-1(config)# guest-user Guest XXXXX "01/01/2010 00:00:00" ?
   <end-time>             Enter service end-time (mm/dd/yyyy hh:mm:ss) in double quotes.
   Default-1(config)# guest-user Guest XXXXX "01/01/2010 00:00:00" "01/01/2011 00:00:00" ?
   <CR>
   Default-1(config)# guest-user Guest XXXXX "01/01/2010 00:00:00" "01/01/2011 00:00:00"
   Default-1(config)# exit
   Default-1#
   Default-1# show guest-user
   Guest User Name Service Start TimeService End Time

Guest 01/01/2010 00:00:00 01/01/2011 00:00:00

         Guest User Table(1 entry)
   Default-1#
```

There is an additional option for Local Authentication so that when local authentication for a Captive Portal user fails, RADIUS authentication is automatically checked; this option is called Local and RADIUS. From the Web UI, configure this by clicking Configuration > Security > Captive Portal.

Figure 72: *Local Captive Portal Authentication Has Two Options*



The corresponding CLI command ssl-server captive-portal authentication-type configures the controller to use both local and RADIUS authentication.

```
Controller(config)# ssl-server captive-portal authentication-type ?
   local                  Set Authentication Type to local.
   local-radius           Set Authentication Type to Local and RADIUS.
   radius                 Set Authentication Type to RADIUS.
```

Optionally Configure Pre-Authentication Captive Portal Bypass

Not all users or traffic types need to be authorized and authenticated by Captive Portal; users of VPN software can pass through the portal without authentication. To enable this passthrough firewall filter ID, follow these steps:

1. Click Configuration > Security > Profile.
2. Enter the name of the Passthrough Firewall Filter ID.
3. Click Configuration > QoS > System Settings to see the QosRule section of the Configuration menu (a license for PPF is required to enter the passthrough rules).
4. Add a rule. Remember that rules are stored in the order they are entered and can not be modified once they are entered.
5. At the bottom of the screen enter the QoS Filter ID.
   The last entry in the filter should be a rule that drops all other traffic, so that traffic other than the passthrough will not be allowed to transverse the Captive Portal without authentication.

Bypass Apple Captive Network Assistant (CNA)

You can bypass or disable the CNA. When enabled, the auto-login pop-up is not displayed in a captive portal authentication (in tunneled mode) using an Apple device or Android devices running Android 5.0 or later.

Using GUI

To enable CNA bypass, Go to **Configuration** > **Captive Portal** > **Advanced Settings** section and select ON for Bypass Apple CNA.

Using CLI

Use the **cna-bypass** option in the **ssl-server** command to enable or disable CNA bypass.

```
Default(15)# configure terminal

master(15)(config)# ssl-server cna-bypass on

master(15)(config)# exit

master(15)# sh ssl-server

Captive Portal


Name                                    : Captive Portal

Server Port                             : 10101

User Authentication Protocol            : None

Server Lifetime                         : 100

Server IP                               : 172.18.34.177

Certificate                             :

Authentication Type                     : radius

Primary Profile                         :

Secondary Profile                       :

Primary Profile                         :

Secondary Profile                       :

Accounting Interim Interval (seconds)   : 60

CaptivePortalSessionTimeout             : 0

CaptivePortalActivityTimeout            : 0
```

```
Protocol                                    : https
Portal URL                                  :
CaptivePortal External URL                  :
CaptivePortal External IP                   : 172.18.34.177
L3 User Session Timeout(mins)               : 1
Apple Captive Network Assistant (CNA) Bypass : on
```

Captive Portal With N+1

Captive Portal changes are propagated in an Nplus1 environment as follows. When a slave takes over a master, it uses the master's Captive Portal pages. If changes are made on that active slave, that change is not automatically propagated to the master.

Troubleshooting Captive Portal

- The same subnet should not be entered for both CaptivePortal1 and CaptivePortal2. If you do this, only the CaptivePortal1 configured splash page will be displayed.
- Custom pages have to imported properly before making use of this feature. See *"Optionally Customize and Use Your Own HTML Pages"* ***on page 302***.
- To check if the pages and images have been properly imported into the controller use the command show web custom-area
- To check if the imported page is coming up properly use the CLI https://<controller ip>/vpn/<page Name>
- To ensure that Captive Portal authentication is taking place, look at the access-accept message from the RADIUS server during Captive Portal authentication.
- Even when using custom CP pages, four default HTML files are used; only two are actually customized. The only way to change this is to alter the four default files which are used for both CP1 and CP2.

Captive Portal Profiles

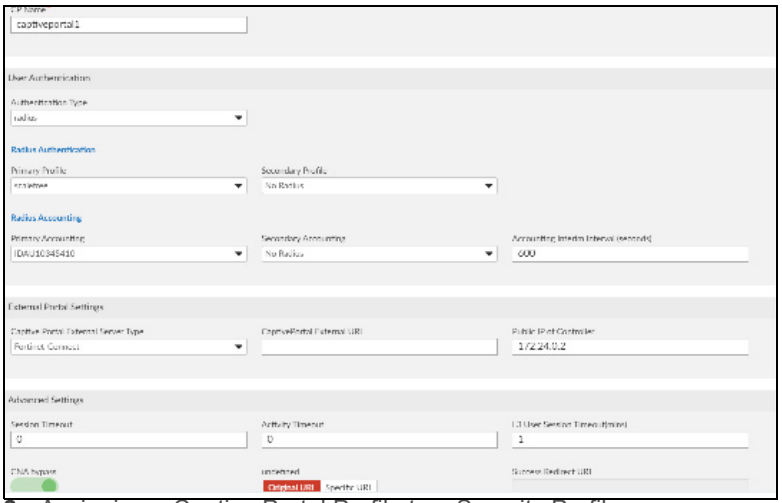
Captive portal profiles feature that allows you to create individual captive portal profiles with distinct configuration settings. Such captive portal profiles can be mapped to security profiles for fine control over captive portal user access.

A captive portal profile is created from the **Configuration** > **Security** > **Captive Portal** page. The Captive Portal Profile tab is used to specify the captive portal profile settings. Once created, this captive profile can be enabled

in a security profile. The following screen-shots illustrate the process to create and assign a captive profile.

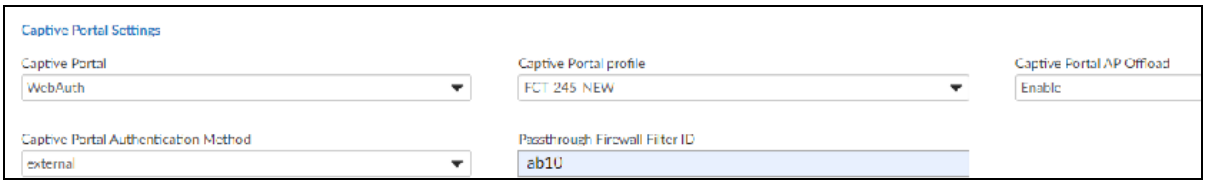
Maximum of 8 Captive profiles can be created.

1. Creating a Captive Portal Profile



2. Assigning a Captive Portal Profile to a Security Profile

   Configuring the external captive portal supports both an IPv4 and IPv6 address for the controller. Also, the external captive portal URL supports both IPv4 and IPv6 address. This is an example for IPv6, *https://[2001:470:ecfb:457:20c:29ff:fe3f:beff]/portal/2001:470:ecfb:45a::123fortiInitialRedirect*



Captive Portal (CP) Authentication for Wired Clients

Wired clients connected via port profile (tunnelled and bridged) will require CP authentication to pass external traffic. Wired Clients can have CP Authentication with Security Profile configured with L2 mode in Clear profile or L2 mode in 802.1X Clear profile.

To allow wired clients to pass external traffic, do the following:

1. Create a captive portal (CP)profile
2. In the security profile, map the CP profile to the security profile. In the security profile ensure that at least one of the (802.1x, WebAuth, Mac Authentication, or CP Bypass) security option is enabled.
3. In the port profile, map the security profile to port profile

NOTES

- CP authentication is available only when VLAN trunk is disabled.
- Dynamic VLAN is not supported.\
- Wired clients connected to a leaf AP should be in bridge mode port profile.
- Re-authentication will fail, If the Ethernet cable is disconnected and reconnected from the wired client's port.

Station log for wired client

```
2019-06-25 08:02:49.056279 | 00:40:96:ad:d4:3c | 00:0c:e6:9d:4f:be | 4 | Station Assign | wired Assign to <AP_ID=10>(v0)
```

CP Bypass for MAC Authenticated Clients

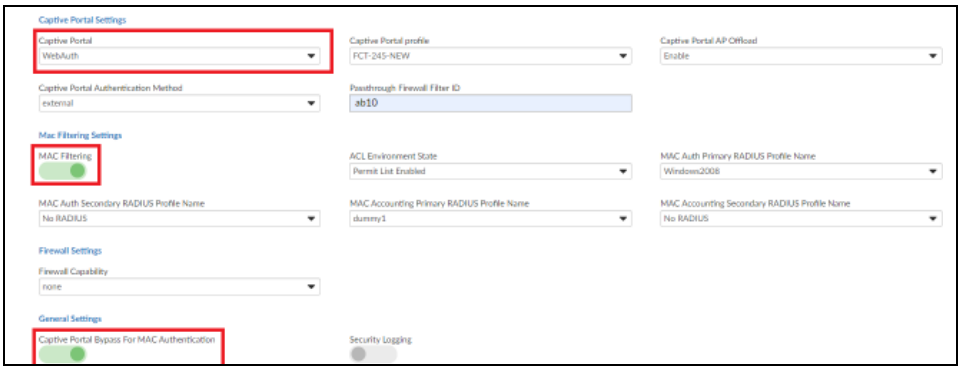
Wired and wireless clients that are successfully authenticated by their MAC address (MAC Filtering) are considered as captive portal authenticated clients. Both RADIUS-based MAC filtering and local MAC filtering is supported for CP bypass. However, to intentionally block a client, add its MAC address only to the local ACL deny list.

To bypass CP authentication, do the following in a security profile:

1. Enable Captive Portal and MAC Filtering in the same security profile.
2. Enable the "Captive Portal Bypass For MAC Authentication"
3. Use this security profile for the ESSID.

NOTES

- Captive Portal must be enabled.
- If MAC-filtering authentication fails then the client is redirected for Web Authentication



Configuring using CLI

Use the **captive-portal-bypass-mac** command to enable or disable this functionality.

The following station logs provide information on client status:

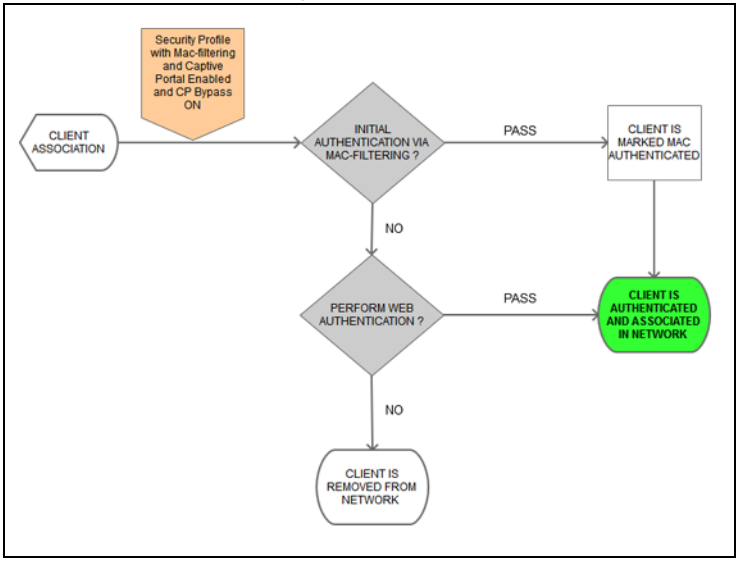
Wireless Station: MAC-filtering Success and CP is bypassed:

```
2019-06-25 08:02:49.056279 | 00:40:96:ad:d4:3c | 00:00:00:00:00:00 | 0 | Mac Filtering |
Mac in permit list - accept client

2019-06-25 08:02:49.056279 | 00:40:96:ad:d4:3c | 00:00:00:00:00:00 | 0 | Mac Filtering |
Mac-Filtering is Success and Captive Portal is Bypassed for Wireless Client
<00:40:96:ad:d4:3c>
```

Wired Station: MAC-filtering Success and CP is bypassed:

```
2019-06-25 08:02:49.056279 | 00:40:96:ad:d4:3c | 00:00:00:00:00:00 | 0 | Mac Filtering |
Mac in permit list - accept client

2019-06-25 08:02:49.056279 | 00:40:96:ad:d4:3c | 00:00:00:00:00:00 | 0 | Mac Filtering |
Mac-Filtering is Success and Captive Portal is Bypassed for Wired Client
<00:40:96:ad:d4:3c>
```

The following flowchart illustrates the flow of CP bypass for MAC authenticated clients.



Third-Party Captive Portal Solutions

Instead of using the Fortinet Captive Portal solution, you can use a third-party solution; you cannot use both. Companies such as Bradford, Avenda, and CloudPath all provide Captive Portal solutions that work with Forti-WLC (SD) 4.1 and later. There are two places that you need to indicate a third-party captive portal solution, in the corresponding Security Profile and in the Captive Portal configuration.

Configure Third-Party Captive Portal With the Web UI

Indicate that a third-party Captive Portal solution will be used in the Security Profile by setting Captive Portal Authentication Method to external. For complete directions, see **Configure a Security Profile With the Web UI**.

Indicate that a third-party Captive Portal solution will be used in the Captive Portal configuration by setting Captive Portal External URL to the URL of the Captive Portal box:

1. Click Configuration > Security > Captive Portal.
2. Change the value for CaptivePortal External URL to the URL of the third-party box.
3. Click OK.

Configure Third-Party Captive Portal With the CLI

Configure an SSL server before configuring third-party captive portal in the security profile. For example, example of SSL server configuration:

```
controller1# show ssl-server
   Captive Portal

Name                                          : Captive Portal
   Server Port                                  : 10101
   User Authentication Protocol                 : None
   Server Lifetime                              : 100
   Server IP                                    : 172.18.37.223
   Certificate                                  :
   Authentication Type                          : radius
   Primary Profile                              : IDAU1721946201
   Secondary Profile                            :
   Primary Profile                              : IDAC1721946201
   Secondary Profile                            :

Accounting Interim Interval (seconds)         : 60
   CaptivePortalSessionTimeout                  : 0
   CaptivePortalActivityTimeout                 : 0
   Protocol                                     : https
   Portal URL                                   :
   CaptivePortal External URL                   : https://172.19.46.201/portal/
   172.18.37.223?FortiInitialRedirect
   CaptivePortal External IP                    : 172.18.37.223
   L3 User Session Timeout(mins)                : 1
   Apple Captive Network Assistant (CNA) Bypass : on
```

Example of configuring SSID with external captive portal:

```
controller1# configure terminal
   controller1(config)# security-profile CPExternal
   controller1(config-security)# captive-portal-auth-method external
   controller1(config-security)# passthrough-firewall-filter-id IDMAUTH
   controller1(config)# essid CaptivePortal-External
   controller1(config-essid)# security-profile CaptivePortal-External
   controller1(config-essid)# end
```

Configure a RADIUS Server for Captive Portal Authentication

Configure a RADIUS Server with Web UI for Captive Portal Authentication

You can, for authentication purposes, set up the identity and secret for the RADIUS server. This takes precedence over any configured User IDs but if RADIUS accounting fails over, the local authentication guest user IDs are used. To do this, follow these steps:

1. Click Configuration > Security > RADIUS to access the RADIUS Profile Table.
2. Click Add.
3. Provide the RADIUS server information.
4. Save the configuration by clicking OK.
5. Enable a security profile for use with a Captive Portal login page by clicking Configuration > Security > RADIUS > Add.
6. Provide the required information, such as the name of the RADIUS profile. L2MODE must be clear to use Captive Portal. Set the Captive Portal to WebAuth and adjust any other parameters as required.

The identity and secret are now configured.

Configure a RADIUS Server with CLI for Captive Portal Authentication

The CLI command ssl-server captive-portal authentication-type configures the controller to use either local authentication, RADIUS authentication, or both. If both is selected, local authentication is tried first; if that doesn't work, RADIUS authentication is attempted.

```
Controller(config)# ssl-server captive-portal authentication-type ?
   local                  Set Authentication Type to local.
   local-radius           Set Authentication Type to Local and RADIUS.
   radius                 Set Authentication Type to RADIUS.
```

The following example configures an authentication RADIUS profile named radius-auth-pri.

```
/* RADIUS PROFILE FOR AUTHENTICATION */
   default# configure terminal
   default(config)# radius-profile radius-auth-pri
   default(config-radius)# ip-address 172.27.172.3
   default(config-radius)# key sept20002
   default(config-radius)# mac-delimiter hyphen
   default(config-radius)# password-type shared-secret
   default(config-radius)# port 1812
   default(config-radius)# end
   default#
   default# sh radius-profile radius-auth-pri
   RADIUS Profile Table
   RADIUS Profile Name   : radius-auth-pri
   Description           :
   RADIUS IP             : 172.27.172.3
   RADIUS Secret         : *****
   RADIUS Port           : 1812
   MAC Address Delimiter : hyphen
   Password Type         : shared-secret
```

The following example configures a security RADIUS profile named radius-auth-sec.

```
default# configure terminal
   default(config)# radius-profile radius-auth-sec
   default(config-radius)# ip-address 172.27.172.4
   default(config-radius)# key sept20002
   default(config-radius)# mac-delimiter hyphen
   default(config-radius)# password-type shared-secret
   default(config-radius)# port 1812
   default(config-radius)# end
   default#
   default# sh radius-profile radius-auth-sec
   RADIUS Profile Table
   RADIUS Profile Name   : radius-auth-pri
   Description           :
   RADIUS IP             : 172.27.172.4
   RADIUS Secret         : *****
   RADIUS Port           : 1812
   MAC Address Delimiter : hyphen
   Password Type         : shared-secret
```

OAuth Authentication Support

FortiWLC (SD) along with Fortinet Connect (MCT) 14.10.0.2 supports OAuth authentication for captive portal users. In a typical scenario if a user (for example: a hotel guest) tries to access an external web site, they are re-directed to a captive portal page for authentication. In the captive portal page, the user must register with a user-name, password, e-mail etc and complete the authentication process after receiving confirmation from the hotel captive portal.

- OAuth support must be enabled in the Fortinet Connect
- Only wireless clients that access SSL3 enabled (HTTPS) destination can use this feature
- If the wireless client uses a proxy server located on the wired network, then the client will be granted access to the internet till the login timeout expires.
- Supported only for ESS profiles in tunneled mode.
- Supported only for IPv4 clients.

By enabling OAuth, users can use any of the social media (Facebook, Google, Twitter, OpenID, etc) login credentials that support OAuth for captive portal authentication. For your users, this alleviates the need to spend time to register or remember passwords for repeated authentication.

For details on configuring OAuth in MCT and registering with OAuth service provides, see the Fortinet Connect 14.10.0.2 Release Notes.

Social Authentication Support

The captive portal authentication process now supports Fortinet Presence as an external CP authentication server that allows users to authentication using social media accounts like Facebook or Gmail OAuth.

Before proceeding, note the following:

- Enable location service in the controller (See *FortiWLC CLI Reference Guide* for more details).
- Assign the AP in the data analytics store.
- Not supported in "Bridge mode".

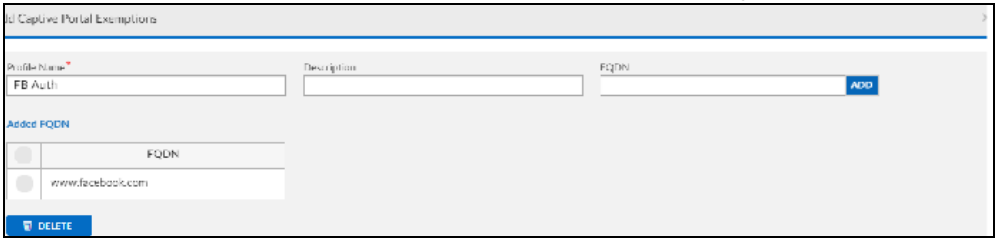
To enable social authentication support, do the following:

1. Create captive portal exemptions profile
2. Configure captive portal profile to use Fortinet Presence
3. Enable this captive portal profile in security profile and add this security profile in the ESS profile.

Create Captive Portal Exemptions Profile

To enable social login, create a profile with the list of exempted URLs and in the captive portal profile and select FortiPresence as the external authentication server.

1. Go to Configuration > Security > Captive Portal > Captive Portal Exemptions.
2. Click the Add button to create a profile with the list of URLs that will be allowed for social authentications. To add multiple URLs to a profile, enter a space after each URL entry. You can add up to 32 URLs



For each profile, ensure that you add socialwifi.fortipresence.com (inclusive of the 32 URLs) as part of the FQDN list. This is mandatory for clients to access the social Wi-Fi login page.

Configure Captive Portal Profile to use Fortinet Presence

1. Go to Configuration > Security > Captive Portal > Captive Portal Profiles page
2. Create a captive portal profile with local or radius as authentication type.
   - If Authentication type is Local, then create a guest user with the following credentials:

- username: gooduser
- password:good.

- If Authentication type is RADIUS, then in that RADIUS server, create a user with the following credentials:
  - username: gooduser
  - password:good.

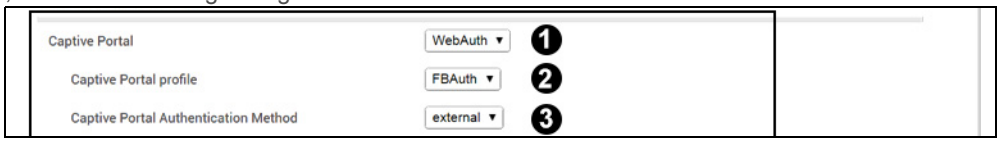
3. Make the following changes to External Portal Settings:

1. Select Fortinet-Presence as the external server (1).
2. Select the profile (2) created with the exempted URLs.
3. Enter http://socialwifi.fortipresence.com/wifi.html?login as URL (3) in the external portal URL.

For Fortinet Presence server configuration and account, see the FortiPresence configuration guide: http://docs.fortinet.com/d/fortipresence-analytics-configuration-guide

Enable this captive portal profile in security and ESS profiles

Enable the captive portal profile in the security profile and map the security profile in the ESS Profile. In the security profile, make the following changes to the CAPTIVE PORTAL SETTINGS section:



1. Set Captive Portal to Webauth.
2. Select the captive portal created for enabling social wifi login.
3. Set Captive Portal Authentication Method as External.

In the ESS-Profile set Dataplane mode to Tunnel Mode.

12 Rogue AP Detection and Mitigation

Rogue APs are unauthorized wireless access points. These rogues can be physically connected to the wired network or they can be outside the building in a neighbor's network or they can be in a hacker’s parked car. Valid network users should not be allowed to connect to the rogue APs because rogues pose a security risk to the corporate network. Rogue APs can appear in an enterprise network for reasons as innocent as users experimenting with WLAN technology, or reasons as dangerous as a malicious attack against an otherwise secure network. Physical security of the building, which is sufficient for wired networks with the correct application of VPN and firewall technologies, is not enough to secure the WLAN. RF propagation inherent in WLANs enables unauthorized users in near proximity of the targeted WLAN (for example, in a parking lot) to gain network access as if they were inside the building.

Regardless of why a rogue AP exists on a WLAN, it is not subject to the security policies of the rest of the WLAN and is the weak link in an overall security architecture. Even if the person who introduced the rogue AP had no malicious intent, malicious activity can eventually occur. Such malicious activity includes posing as an authorized access point to collect security information that can be used to further exploit the network. Network security mechanisms typically protect the network from unauthorized users but provide no means for users to validate the authenticity of the network itself. A security breach of this type can lead to the collection of personal information, protected file access, attacks to degrade network performance, and attacks to the management of the network.

To prevent clients of unauthorized APs from accessing your network, enable the options for both scanning for the presence of rogue APs and mitigating the client traffic originating from them. These features are set globally from either the CLI or Web UI, with the controller managing the lists of allowable and blocked WLAN BSSIDs and coordinating the set of APs (the mitigating APs) that perform mitigation when a rogue AP is detected.

As a result of the channel scan, a list of rogue APs is compiled and sent by the controller to a number of mitigating APs that are closest to the rogue AP. Mitigating APs send mitigation (deauth) frames to the rogue AP where clients are associated to remove those clients from the network. This presence of the rogue AP generates alarms that are noted on the Web UI monitoring dashboard and via syslog alarm messages so the administrator is aware of the situation and can then remove the offending AP or update the configuration list.

Rogue Scanning can be configured so that it is a dedicated function of a radio on a dual radio AP or a part time function of the same radio that also serves clients. When rogue AP scanning (detection) is enabled, for any given period, an AP spends part of the time scanning channels and part of the time performing normal AP WLAN operations on the home channel. This cycle of scan/operate, which occurs on a designated AP or an AP interface without assigned stations, ensures there is no network operation degradation.

For the AP, each radio is dual band (supports both 2.4GHz and 5.0GHz) and capable of scanning for all channels and all bands when configured as a dedicated scanning radio. As access points are discovered, their BSSID is compared to an AP access control list of BSSIDs. An access point might be known, blocked, or nonexistent on the access control list. A “known” AP is considered authorized because that particular BSSID was entered into the list by the system administrator. A “selected” AP is blocked by the Wireless LAN System as an unauthorized AP. The Fortinet WLAN also reports other APs that are not on the access control list; these APs trigger alerts to the admin console until the AP is designated as known or selected in the access control list. For example, a third party BSS is detected as a rogue unless it is added to the access control list.

Fortinet APs also detect rogue APs by observing traffic either from the access point or from a wireless station associated to a rogue. This enables the system to discover a rogue AP when the rogue is out of range, but one or more of the wireless stations associated to it are within range.

The following topics are covered in this chapter:

Configuring Rogue AP Mitigation with Web UI

To prevent clients of unauthorized APs from accessing your network, enable the options for both scanning for the presence of rogue APs and mitigating the client traffic originating from them. These features are set globally, with the controller managing the lists of allowable and blocked WLAN BSSIDs and coordinating the set of APs (the Mitigating APs) that perform mitigation when a rogue AP is detected.

You can create a white-list of APs that will perform rogue detection. Other APs that are not added to this white-list will not scan for rogue AP/clients.

When rogue AP scanning (detection) is enabled, for any given period, the AP spends part of the time scanning channels (determined by the setting Scanning time in ms), and part of the time performing normal AP WLAN operations on the home channel (determined by the setting

Operational time in ms). This cycle of scan/operate repeats so quickly that both tasks are performed without noticeable network operation degradation.

The channels that are scanned by a particular AP are determined by the model of the AP. As a result of the channel scan, a list of rogue APs is compiled and sent by the controller to a number of Mitigating APs that are closest to the rogue AP. Mitigating APs send mitigation (deauth) frames to the rogue AP where clients are associated to remove those clients from the network. This presence of the rogue AP generates alarms that are noted on the Web UI monitoring dashboard and via syslog alarm messages so the administrator is aware of the situation and can then remove the offending AP or update the configuration list.

As well, if a rogue device seen on the wired interface of the AP and if the device is in the AP's discovered list of stations a wired rogue notification will be sent via the Web UI monitoring dashboard and syslog alarm message. If the rogue client is associated with the AP, that client is also classified as a rogue.

Alter the List of Allowed APs with the Web UI

To change the list of allowed APs, follow these steps:

1. From the Web UI, Enable rogue detection from Configuration > WIPS > Rogue APs > Global Settings page.

To add an AP to scan for rogues, click the Add button and select an AP from the list:

Alter the List of Blocked APs with the Web UI

To change the list of allowed APs, follow these steps:

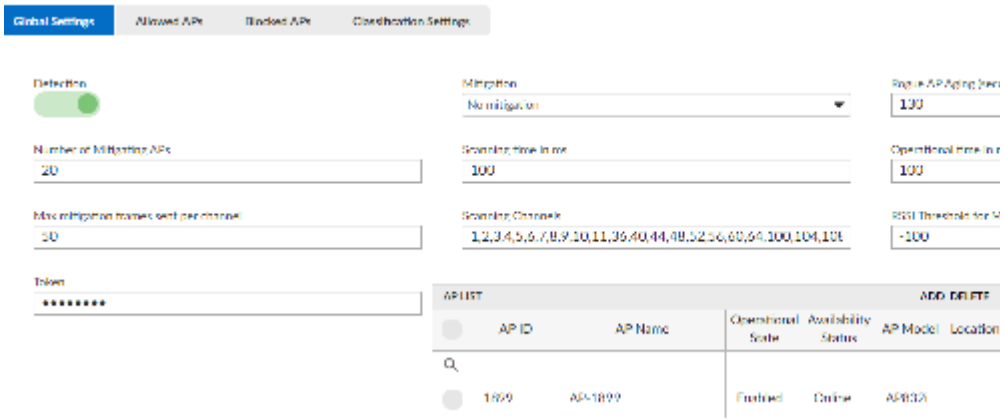
1. From the Web UI click Configuration > Security > Rogue APs > Blocked APs. The table shows information about access points listed as blocked BSSIDs in the access control list (ACL).
2. To see an updated list of the APs blocked in the WLAN, click Refresh.
3. To add an AP to the blocked list, click Add.
   - In the BSSID box, type the BSSID, in hexadecimal format, of the access point.
   - Add the BSSID to the ACL, by clicking OK.
4. The blocked BSSID now appears on the list with the following information:
   - BSSID The access point's BSSID.
   - Creation Time The timestamp of when the blocked AP entry was created.
   - Last Reported Time The time the AP was last discovered. If this field is blank, the AP has not been discovered yet.
5. To remove a blocked BSSID from the ACL, select the checkbox of the blocked AP entry you want to delete, click Delete, and then click OK.

Configure Scanning and Mitigation Settings with the Web UI

To configure rogue AP scanning and mitigation settings, follow these steps:

1. From the Web UI click Configuration > Security > Rogue APs > Global Settings. The Rogue AP screen appears with the Global Settings tab selected. See **Figure 73**.

Figure 73: *Web UI Rogue AP Global Settings*



2. In the Detection list, select one of the following:
   - On: Enables scanning for rogue APs.
   - Off: Disables rogue detection.
3. In the Mitigation list, select one of the following:
   - No mitigation: No rogue AP mitigation is performed.
   - Block all BSSIDs that are not in the ACL: Enables rogue AP mitigation of all detected BSSIDs that are not specified as authorized in the Allowed APs list.
   - Block only BSSIDs in blocked list: Enables rogue AP mitigation only for the BSSIDs that are listed in the Blocked APs list.
   - Block Clients seen on the wire: Enables rogue mitigation for any rogue station detected on the wired side of the AP (the corporate network, in many cases). When Block clients seen on the wire is selected, clients seen on the corporate network are mitigated. When Block clients seen on the wire is selected and the BSSID of the wired rogue client is entered in the blocked list (see *"Alter the List of Blocked APs with the Web UI"* ***on page 325***) only listed clients are mitigated.
4. In the Rogue AP Aging box, type the amount of time that passes before the rogue AP alarm is cleared if the controller no longer detects the rogue. The value can be from 60 through 86,400 seconds.
5. In the Number of Mitigating APs text box, enter the number of APs (from 1 to 20) that will perform scanning and mitigation of rogue APs.

6. In the Scanning time in ms text box, enter the amount of time Mitigating APs will scan the scanning channels for rogue APs. This can be from 100 to 500 milliseconds.
7. In the Operational time in ms text box, enter the amount of time Mitigating APs will spend in operational mode on the home channel. This can be from 100 to 5000 milliseconds.
8. In the Max mitigation frames sent per channel text box, enter the maximum number of mitigation frames that will be sent to the detected rogue AP. This can be from 1 to 50 deauth frames.
9. In the Scanning Channels text box, enter the list of channels that will be scanned for rogue APs. Use a comma separated list from 0 to 256 characters. The complete set of default channels are 1,2,3,4,5,6,7,8,9,10,11,36,40,44,48,52,56,60,64,149,153,157,161,165.
10. In the RSSI Threshold for Mitigation text box, enter the minimum threshold level over which stations are mitigated. The range of valid values is from to -100 to 0.
11. In the Token text box, enter a unique token string broadcast as a part of the beacons for identification of rogue and friendly APs. The valid range is 1 – 64 characters.
12. Click OK.

Configuring Rogue AP Detection Using the CLI

These CLI commands configure rogue detection; for a complete explanation of the commands, see the ***FortiWLC (SD) Command Reference***.

Adding APs to Scan List

```
default(15)# configure terminal

default(15)(config)# rogue-ap detection-ap 1

default(15)(config)# rogue-ap detection-ap 3

default(15)(config)# exit
```

Show Output

```
default(15)# sh rogue-ap detection-ap-list

AP ID

1

3

        Rogue Device Detecting APs(2)
```

Deleting APs from Scan list

```
default(15)# configure terminal

default(15)(config)# no rogue-ap detection-ap 1

default(15)(config)# no rogue-ap detection-ap 3

default(15)(config)# end
```

Show Output

```
default(15)# show rogue-ap detection-ap-list

AP ID

        Rogue Device Detecting APs(No entries)
```

Configuring the AP Access and Block Lists with the CLI

The feature uses an Access Control List (ACL) containing a list of allowed BSSIDs and a list of Blocked BSSIDs. By default, all Fortinet ESS BSSIDs in the WLAN are automatically included in the allowed ACL. A BSSID cannot appear in both lists.

To add an access point with a BSSID of 00:0e:cd:cb:cb:cb to the access control list as an authorized access point, type the following:

```
controller (config)# rogue-ap acl 00:0e:cd:cb:cb:cb
   controller (config)#
```

To see a listing of all BSSIDs on the authorized list, type the following:

```
controller# show rogue-ap acl
   Allowed APs
   BSSID
   00:0c:e6:cd:cd:cd
   00:0e:cd:cb:cb:cb
```

A BSSID cannot be on both the blocked list and the access list for rogue AP detection at the same time. Suppose 00:0c:e6:cd:cd:cd is to be placed on the blocked list. If this BSSID is already on the authorized list, you must remove the BSSID from the authorized list, and then add the BSSID to the blocked list, as follows:

```
controller (config)# no rogue-ap acl 00:0c:e6:cd:cd:cd
   controller (config)#
   controller (config)# rogue-ap blocked 00:0c:e6:cd:cd:cd
   controller (config)# exit
   controller# show rogue-ap acl
   Allowed APs
   BSSID
```

```
   00:0e:cd:cb:cb:cb
   controller# show rogue-ap blocked
   BssId               Creation Date   Last Reported
   -----------------   -------------   -------------
   00:0c:e6:cd:cd:cd   11/02 01:05:54   11/02 01:06:20
```

The commands to enable and confirm the rogue AP detection state are as follows:

```
controller (config)# rogue-ap detection
   controller# show rogue-ap globals
   Global Settings
   Detection                              : on
   Mitigation                             : none
   Rogue AP Aging (seconds)               : 60
   Number of Candidate APs                : 3
   Number of Mitigating APs               : 5
   Scanning time in ms                    : 100
   Operational time in ms                 : 400
   Max mitigation frames sent per channel : 10
   Scanning Channels                      :
   1,2,3,4,5,6,7,8,9,10,11,36,40,44,48,52,56,60,64,149,153,157,161,165
   RSSI Threshold for Mitigation          : -100
```

Use the CLI command show rogue-ap-list to display all rogue clients and APs in the network.

Rogue Mitigation Example

Rogue AP mitigation for APs in the blocked list is enabled and confirmed as follows:

```
controller# configure terminal
   controller (config)# rogue-ap detection
   controller (config)# rogue-ap mitigation selected
   controller (config)# exit
   controller# show rogue-ap globals
   Global Settings
   Detection                              : on
   Mitigation                             : selected
   Rogue AP Aging (seconds)               : 60
   Number of Candidate APs                : 3
   Number of Mitigating APs               : 5
   Scanning time in ms                    : 100
   Operational time in ms                 : 400
   Max mitigation frames sent per channel : 10
   Scanning Channels                      :
   1,2,3,4,5,6,7,8,9,10,11,36,40,44,48,52,56,60,64,149,153,157,161,165
   RSSI Threshold for Mitigation          : -100
```

Modifying Detection and Mitigation CLI Settings

The default settings that are configured for the rogue AP detection and mitigation features are adequate for most situations. However, many default settings can be changed if your network requires lighter or heavier scanning and/or mitigation services. The following is the list of rogue-ap commands:

```
controller (config)# rogue-ap ?
   acl                    Add a new rogue AP ACL entry.
   aging                  Sets the aging of alarms for rogue APs.
   assigned-aps           Number of APs assigned for mitigation.
   blocked                Add a new rogue AP blocked entry.
   detection              Turn on rogue AP detection.
   min-rssi               Sets RSSI Threshold for Mitigation.
   mitigation             Set the rogue AP mitigation parameters.
   mitigation-frames      Sets the maximum number of mitigation frames sent out
   per channel.
   operational-time       Sets the APs time on the home channel during scanning.
   scanning-channels      Sets the global Rogue AP scanning channels.
   scanning-time          Sets the APs per channel scanning time
```

As a general rule, unless the AP is in dedicated scanning mode, the more time that is spent scanning and mitigating, the less time is spent by the AP in normal WLAN operating services. Some rules determine how service is provided:

- The controller picks the APs that will scan and mitigate; those that mitigate are dependant on their proximity to the rogue AP and the number of mitigating APs that have been set.
- To preserve operational performance, APs will mitigate only the home channel if they have clients that are associated.
- Settings are administered globally; there is no way to set a particular AP to mitigate.
- Mitigation is performed only on clients associated to rogue APs; the rogue APs themselves are not mitigated. It is the network administrator's responsibility to remove the rogue APs from the network.
- AP mitigation frames are prioritized below QoS frames, but above Best Effort frames.
- To reduce network traffic, you may configure the scanning channels list that contains only the home channels

Changing the Number of Mitigating APs with the CLI

By default, three Mitigating APs are selected by the controller to perform scanning and mitigation. This number can be set to a high of 20 APs or down to 1 AP, depending on the needs of your network. To change the number of mitigating APs to 5:

controller (config)# rogue-ap assigned-aps 5

Changing the Scanning and Mitigation Settings with the CLI

When rogue AP scanning is enabled, for any given period, the AP spends part of the time scanning channels, and part of the time performing normal AP WLAN operations on the home channel. This cycle of scan/operate repeats so quickly that both tasks are performed without noticeable network operation degradation.

If scanning is enabled, the rogue-ap operational-time command sets the number of milliseconds that are spent in operational time, performing normal wireless services, on the home channel. This command is related to the rogue-ap scanning-time command. The channels that are scanned are determined by the rogue-ap scanning channels command. The complete set of default channels are 1,2,3,4,5,6,7,8,9,10,11,36,40,44,48,52,56,60,64,149,153,157,161,165.

The following command changes the operational time from the default 400 to 2500 milliseconds:

```
controller (config)# rogue-ap operational-time 2500
```

The following command changes the scanning time from the default 100 to 200 milliseconds:

```
controller (config)# rogue-ap scanning-time 200
```

The following command sets the scanning channels to 1, 6, 11, 36, 44, 52, 60:

```
controller (config)# rogue-ap scanning-channels 1,6,11,36,44,52,60
   controller (config)# exit
```

To verify the changes, use the show rogue-ap globals command:

```
controller# show rogue-ap globals
   Global Settings
   Detection                              : on
   Mitigation                             : selected
   Rogue AP Aging (seconds)               : 60
   Number of Candidate APs                : 5
   Number of Mitigating APs               :5
   Scanning time in ms                    : 200
   Operational time in ms                 : 2500
   Max mitigation frames sent per channel : 10
   Scanning Channels                      : 1,6,11,36,44,52,60
   RSSI Threshold for Mitigation          : -100
```

Changing the Minimum RSSI with the CLI

RSSI is the threshold for which APs attempt to mitigate rogues; if the signal is very week (distant AP), APs won't try to mitigate it.

The command to change the minimum RSSI (Received Signal Strength Indication) level, over which a station will be mitigated is rogue-ap min-rssi. A level range of 0 of -100 is supported, with -100 being the default setting.

The following command sets the minimum RSSI level to -80:

```
controller (config)# rogue-ap min-rssi -80
   controller (config)#
```

TABLE 16: *CLI Commands for Rogue Mitigation*

Rogue Mitigation Command	Action
rogue-ap mitigation all	Sets rogue mitigation for all rogue APs that are not on the access control list.
rogue-ap mitigation selected	Sets rogue mitigation for all rogue APs that are on the blocked list.
rogue-ap mitigation wiredrogue	Sets rogue mitigation for all wired-side rogue APs. If rogue clients on the wired side are added to the blocked ACL list, then only those listed wired-side rogue clients are blocked.
show rogue-ap globals	Displays current rogue data.
rogue-ap mitigation none	Turns off rogue mitigation.

Rogue Mitigation Example

Rogue AP mitigation for APs in the blocked list is enabled and confirmed as follows:

```
controller# configure terminal
   controller(config)# rogue-ap detection
   controller(config)# rogue-ap mitigation selected
   controller(config)# exit
   controller# show rogue-ap globals
   Global Settings
   Detection                              : on
   Mitigation                             : selected
   Rogue AP Aging (seconds)               : 60
   Number of Candidate APs                : 3
   Number of Mitigating APs               : 5
   Scanning time in ms                    : 100
   Operational time in ms                 : 400
   Max mitigation frames sent per channel : 10
   Scanning Channels                      :
   1,2,3,4,5,6,7,8,9,10,11,36,40,44,48,52,56,60,64,149,153,157,161,165
   RSSI Threshold for Mitigation          : -100
```

Modify Rogue Detection and Mitigation Settings with the CLI

The default settings that are configured for the rogue AP detection and mitigation features are adequate for most situations. However, many default settings can be changed if your network requires lighter or heavier scanning and/or mitigation services. The following is the list of rogue-ap commands:

```
controller(config)# rogue-ap ?
   acl                    Add a new rogue AP ACL entry.
   aging                  Sets the aging of alarms for rogue APs.
   assigned-aps           Number of APs assigned for mitigation.
   blocked                Add a new rogue AP blocked entry.
   detection              Turn on rogue AP detection.
   min-rssi               Sets RSSI Threshold for Mitigation.
   mitigation             Set the rogue AP mitigation parameters.
   mitigation-frames      Sets the maximum number of mitigation frames sent out
   per channel.
   operational-time       Sets the APs time on the home channel during scanning.
   scanning-channels      Sets the global Rogue AP scanning channels.
   scanning-time          Sets the APs per channel scanning time
```

As a general rule, unless the AP is in dedicated scanning mode, the more time that is spent scanning and mitigating, the less time is spent by the AP in normal WLAN operating services. Some rules determine how service is provided:

- The controller picks the APs that will scan and mitigate; those that mitigate are dependant on their proximity to the rogue AP and the number of mitigating APs that have been set.
- To preserve operational performance, APs will mitigate only the home channel if they have clients that are associated.
- Settings are administered globally; there is no way to set a particular AP to mitigate.
- Mitigation is performed only on clients associated to rogue APs; the rogue APs themselves are not mitigated. It is the network administrator's responsibility to remove the rogue APs from the network.
- AP mitigation frames are prioritized below QoS frames, but above Best Effort frames.
- To reduce network traffic, you can configure the scanning channels list that contains only the home channels.

Changing the Number of Mitigating APs with the CLI

By default, three mitigating APs are selected by the controller to perform scanning and mitigation. This number can be set to a high of 20 APs or down to 1 AP, depending on the needs of your network, although we do not recommend assigning a high number of APs for mitigation because they can interfere with each other while mitigating the rogue. To change the number of mitigating APs to 5:

```
controller(config)# rogue-ap assigned-aps 5
```

Changing the Scanning and Mitigation Settings with the CLI

When rogue AP scanning is enabled, for any given period, the AP spends part of the time scanning channels, and part of the time performing normal AP WLAN operations on the home channel. This cycle of scan/operate repeats so quickly that both tasks are performed without noticeable network operation degradation.

If scanning is enabled, the rogue-ap operational-time command sets the number of milliseconds that are spent in operational time, performing normal wireless services, on the home channel. This command is related to the rogue-ap scanning-time command. The channels that are scanned are determined by the rogue-ap scanning channels command. The complete set of default channels are 1,2,3,4,5,6,7,8,9,10,11,36,40,44,48,52,56,60,64,149,153,157,161,165.

The following command changes the operational time from the default 400 to 2500 milliseconds:

```
controller(config)# rogue-ap operational-time 2500
```

The following command changes the scanning time from the default 100 to 200 milliseconds:

```
controller(config)# rogue-ap scanning-time 200
```

The following command sets the scanning channels to 1, 6, 11, 36, 44, 52, 60:

```
controller(config)# rogue-ap scanning-channels 1,6,11,36,44,52,60
controller(config)# exit
```

To verify the changes, use the show rogue-ap globals command:

```
controller# show rogue-ap globals
   Global Settings
   Detection                                : on
   Mitigation                               : selected
   Rogue AP Aging (seconds)                 : 60
   Number of Candidate APs                  : 5
   Number of Mitigating APs                 : 5
   Scanning time in ms                      : 200
   Operational time in ms                   : 2500
   Max mitigation frames sent per channel : 10
   Scanning Channels                        : 1,6,11,36,44,52,60
   RSSI Threshold for Mitigation            : -100
```

Changing the Minimum RSSI with the CLI

RSSI is the threshold for which APs attempt to mitigate rogues; if the signal is very week (distant AP), APs won't try to mitigate it.

The command to change the minimum RSSI (Received Signal Strength Indication) level, over which a station will be mitigated is rogue-ap min-rssi. A level range of 0 of -100 is supported, with -100 being the default setting.

The following command sets the minimum RSSI level to -80:

```
controller(config)# rogue-ap min-rssi -80
   controller(config)#
```

Configure Rogue AP Mitigation with the Web UI

To prevent clients of unauthorized APs from accessing your network, enable the options for both scanning for the presence of rogue APs and mitigating the client traffic originating from them. These features are set globally, with the controller managing the lists of allowable and blocked WLAN BSSIDs and coordinating the set of APs (the Mitigating APs) that perform mitigation when a rogue AP is detected.

When rogue AP scanning (detection) is enabled, for any given period, the AP spends part of the time scanning channels (determined by the Scanning time in ms setting), and part of the time performing normal AP WLAN operations on the home channel (determined by the Operational time in ms setting). This cycle of scan/operate repeats so quickly that both tasks are performed without noticeable network operation degradation.

The channels that are scanned by a particular AP are determined by the model of AP. As a result of the channel scan, a list of rogue APs is compiled and sent by the controller to a number of Mitigating APs that are closest to the rogue AP. Mitigating APs send mitigation (deauth) frames to the rogue AP where clients are associated to remove those clients from the network. This presence of the rogue AP generates alarms that are noted on the Web UI monitoring dashboard and via syslog alarm messages so the administrator is aware of the situation and can then remove the offending AP or update the configuration list.

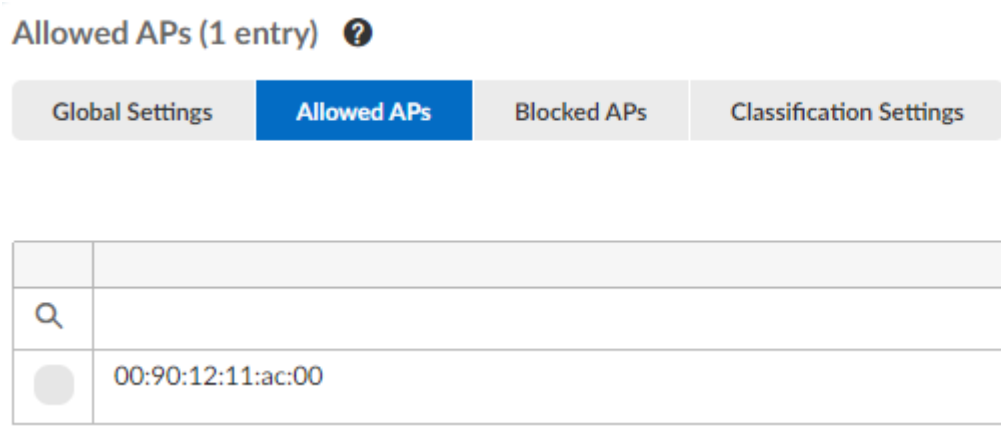
As well, if a rogue device seen on the wired interface of the AP and if the device is in the AP's discovered list of stations a wired rogue notification will be sent via the Web UI monitoring dashboard and syslog alarm message. If the rogue client is associated with the AP, that client is also classified as a rogue.

Alter the List of Allowed APs with the Web UI

To change the list of allowed APs, follow these steps:

1. From the Web UI, click Configure > Security > Rogue AP > Global settings.
   The Allowed APs screen appears. See **Figure** .

Figure 74: *Web UI List of Allowed APs*



2. To add a BSSID to the list, click Add.
   - In the BSSID boxes, type the BSSID, in hexadecimal format, of the permitted access point.
   - To add the BSSID to the ACL, click OK.
3. To delete a BSSID from the list, select the BSSID, click Delete, then OK.

Alter the List of Blocked APs with the Web UI

To change the list of allowed APs, follow these steps:

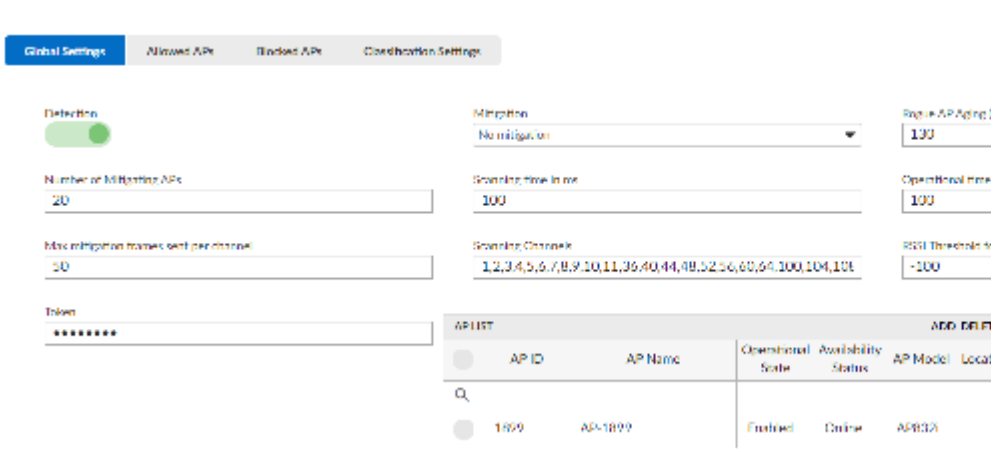
1. From the Web UI click Configure > Security > Rogue AP > Blocked APs. The table shows information about access points listed as blocked BSSIDs in the access control list (ACL).
2. To see an updated list of the APs blocked in the WLAN, click Refresh.
3. To add an AP to the blocked list, click Add.
   - In the BSSID box, type the BSSID, in hexadecimal format, of the access point.
   - Add the BSSID to the ACL, by clicking OK.
4. The blocked BSSID now appears on the list with the following information:
   - BSSID The access point's BSSID.
   - Creation Time The timestamp of when the blocked AP entry was created.
   - Last Reported Time The time the AP was last discovered. If this field is blank, the AP has not been discovered yet.
5. To remove a blocked BSSID from the ACL, select the checkbox of the blocked AP entry you want to delete, click Delete, and then click OK.

Configure Scanning and Mitigation Settings with the Web UI

To configure rogue AP scanning and mitigation settings, follow these steps:

1. From the Web UI click Configuration > Wireless IDS/IPS > Rogue APs.
   The Rogue AP screen appears with the Global Settings tab selected. See **Figure 73**.

Figure 75: *Web UI Rogue AP Global Settings*



2. In the Detection list, select one of the following:
   - On: Enables scanning for rogue APs.
   - Off: Disables rogue detection.
3. In the Mitigation list, select one of the following:
   - No mitigation: No rogue AP mitigation is performed.
   - Block all BSSIDs that are not in the ACL: Enables rogue AP mitigation of all detected BSSIDs that are not specified as authorized in the Allowed APs list.
   - Block only BSSIDs in blocked list: Enables rogue AP mitigation only for the BSSIDs that are listed in the Blocked APs list.
   - Block Clients seen on the wire: Enables rogue mitigation for any rogue station detected on the wired side of the AP (the corporate network, in many cases). When Block clients seen on the wire is selected, clients seen on the corporate network are mitigated. When Block clients seen on the wire is selected and the BSSID of the wired rogue client is entered in the blocked list (see *"Alter the List of Blocked APs with the Web UI"* ***on page 325***) only listed clients are mitigated.
4. In the Rogue AP Aging box, type the amount of time that passes before the rogue AP alarm is cleared if the controller no longer detects the rogue. The value can be from 60 through 86,400 seconds.
5. In the Number of Mitigating APs text box, enter the number of APs (from 1 to 20) that will perform scanning and mitigation of rogue APs.
6. In the Scanning time in ms text box, enter the amount of time Mitigating APs will scan the scanning channels for rogue APs. This can be from 100 to 500 milliseconds.

7. In the Operational time in ms text box, enter the amount of time Mitigating APs will spend in operational mode on the home channel. This can be from 100 to 5000 milliseconds.
8. In the Max mitigation frames sent per channel text box, enter the maximum number of mitigation frames that will be sent to the detected rogue AP. This can be from 1 to 50 deauth frames.
9. In the Scanning Channels text box, enter the list of channels that will be scanned for rogue APs. Use a comma separated list from 0 to 256 characters. The complete set of default channels are 1,2,3,4,5,6,7,8,9,10,11,36,40,44,48,52,56,60,64,149,153,157,161,165.
10. In the RSSI Threshold for Mitigation text box, enter the minimum threshold level over which stations are mitigated. The range of valid values is from to -100 to 0.
11. Click OK.

If a station that is already present in the discovered station database (learned wirelessly by the AP) is also discovered via DHCP broadcast on the APs wired interface, it implies that the station is connected to the same physical wired network as the AP. Such a station could potentially be a rogue device and is flagged by the controller as a wired rogue, indicating the rogue was identified as being present on the same wired network as the AP. If mitigation is enabled for wired rogue, mitigation action is performed accordingly on the rogue device.

Configure Rogue AP Classification

The rogue access points detected by the controller are categorized as rogue and friendly based on specific rules that you configure. You can configure multiple rules; these rules are assigned different priorities. When a rogue access point is detected its attributes (ESSID, RSSI, Security mode, and discovered by APs count) are matched against the configured rules and its classification type is defined by the matching rule with highest priority.

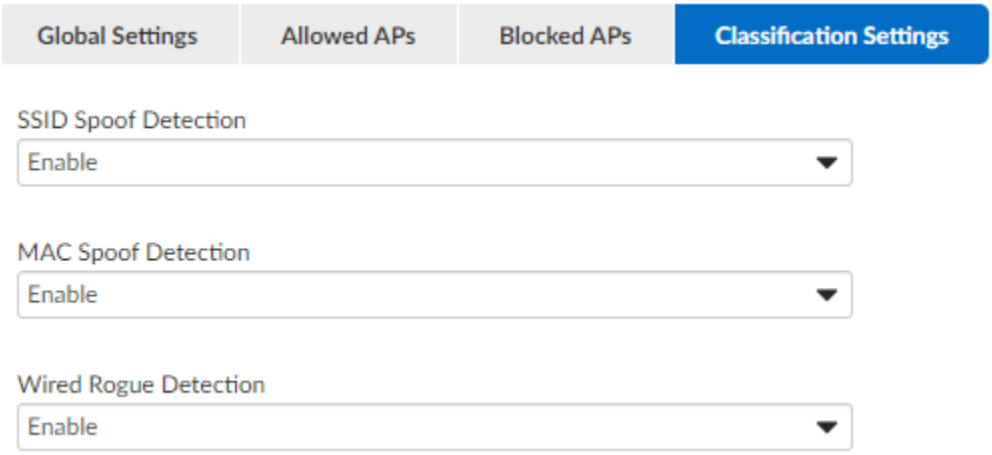
You can configure the following detection mechanisms for rogue APs.

- SSID Spoof Detection - SSID spoofing involves rogue access points beaconing same SSID name as a FortiWLC managed AP.
- MAC Spoof Detection - In a MAC spoofing attack, rogue access points beacon same BSSID as a known managed AP, attracting clients and resources to connect to the fake network/SSID for exploiting data.
  In the case of SSID and MAC spoofing events, clients connected to the rogue APs are deauthenticated and valid notifications are raised about the presence of rogue APs.

Note: SSID and MAC spoofing detection is only for wireless clients.

- Wired Rogue Detection - Rogue APs and stations connected to the wired network.

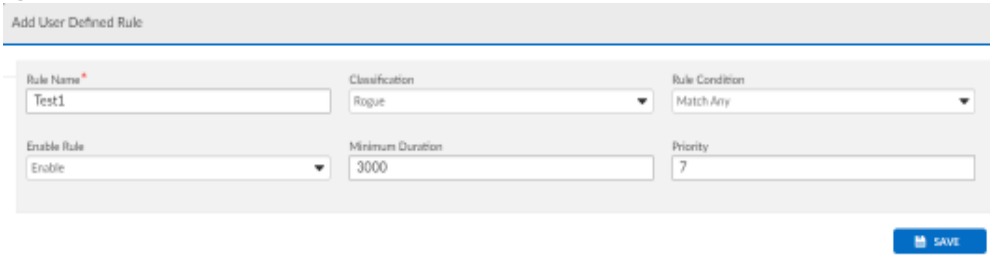
Figure 76: *Rogue classification settings*



Adding a User Defined Rule

The **Basic Configuration** for a user defined rule includes the following.

Figure 77: *Adding a rule*



1. In the **Classification Settings** tab, select **Add**. The **Add User Defined Rule** screen is displayed.
2. Provide the details for the following parameters. You can create multiple Rogue Classification rules.
   - **Rule Name** - Unique name for this rogue classification rule. The valid range is 1 – 32 characters.
   - **Classification** - The classification of the rogue access point, whether rogue and friendly, based on matching the configured rule.
   - **Rule Condition** - Select any of these conditions to apply.

- **Match Any** - If the rogue access point matches a single rule of the many configured rules, then the classification is successful and the access point is marked as per the classification type.
- **Match All** - If the rogue access point matches all the configured rules only then the classification is successful and the access point is marked as per the classification type.

- **Enable Rule** - To enable or disable the rogue classification rule.
- **Minimum Duration** - The minimum amount of time the AP is heard on air, for the rule to be applied. The valid range is 0-3600 seconds.
- **Priority** - Allows configuring the priority of the rogue classification rule. The valid range is 1 -255.

3. Click **Save**. The rogue classification rule is created.

Adding a Sub-Rule

Each rule can have multiple sub-rules. To create a sub-rule, click on the edit icon and the **User Defined Sub Rules** screen is displayed. Select **Add**; the **Sub Rul**e screen is displayed. Provide the details for the following parameters.

Sub Rule Type	Sub Rule Operator	Sub Rule Value (Examples)
ssid	• string contains • string matches • string is not • string starts-with	string contains – SSID containing forti is friendly.
rssi	• lesser than • greater than	greater than – Any unknown BSS with an RSSI greater than 50 is rogue.
discovered-ap-count	• lesser than • greater than	greater than – Any unknown BSS detected by more than 1 AP is rogue.
ssid-encryption	• Enabled • Disabled	Disabled – Any unknown SSID with encryption disabled is rogue.

Figure 78: *Adding a sub-rule*

You can perform the following additional operations on the configured rogue classification settings.

- **Delete** – Select the rule and click Delete or the delete icon.
- **Edit** - Select the rule and click the edit icon. You can modify the basic configuration and the sub rules.
- **Settings** – You can select the columns/details to display in the rules table.

Troubleshooting Rogue Mitigation

Check if the rogue AP is being displayed in the discovered list of stations on the AP or the rogue list on the controller.

If the system is taking too long to find a rogue, reduce the number of channels that need to be scanned.

13 Configuring VLANs

A virtual local area network (VLAN) is a broadcast domain that can span across wired or wireless LAN segments. Each VLAN is a separate logical network. Several VLANs can coexist within any given network, logically segmenting traffic by organization or function. In this way, all systems used by a given organization can be interconnected independent of physical location. This has the benefit of limiting the broadcast domain and increasing security. VLANs can be configured in software, which enhances their flexibility. VLANs operate at the data link layer (OSI Layer 2), however, they are often configured to map directly to an IP network, or subnet, at the network layer (OSI Layer 3). You can create up to 512 VLANs.

IEEE 802.1Q is the predominant protocol used to tag traffic with VLAN identifiers. VLAN1 is called the default or native VLAN. It cannot be deleted, and all traffic on it is untagged. A trunk port is a network connection that aggregates multiple VLANs or tags, and is typically used between two switches or between a switch and a router. VLAN membership can be port-based, MAC-based, protocol-based, or authentication-based when used in conjunction with the 802.1x protocol. Used in conjunction with multiple ESSIDs, VLANs support multiple wireless networks on a single Access Point using either a one-to-one mapping of ESSID to VLAN, or mapping multiple ESSIDs to one VLAN. By assigning a security profile to a VLAN, the security requirements can be fine-tuned based on the use of the VLAN, providing wire-like security or better on a wireless network.

VLAN assignment is done for RADIUS-based MAC filtering and authentication. VLAN assignment is not done in Captive Portal Authentication by any of the returned attributes. Because VLANs rely on a remote switch that must be configured to support trunking, also refer to the Fortinet Wi-Fi Technology Note WF107, “VLAN Configuration and Deployment.” This document contains the recommended configuration for switches as well as a comprehensive description of VLAN configuration and deployment.

- While deploying AP122 and AP822 in bridge mode, we recommend that you do not create static/RADIUS VLANs from 1 to 4.
- When VLAN is configured under ESSID and multiple PSK; ESSID takes precedence. This issue exists in both tunnel and bridge modes.

Configure and Deploy a VLAN

VLANs can be configured/owned either by E(z)RF Network Manager or by a controller. You can tell where a profile was configured by checking the read-only field Owner; the Owner is either nms-server or controller.

In order to map an ESSID to a VLAN, the VLAN must first be configured. To create a VLAN from the CLI, use the command vlan ***name*** tag ***id.*** The name can be up to 16 alphanumeric characters long and the tag i***d*** between 1 and 4,094.

For example, to create a VLAN named guest with a tag number of 1, enter the following in global configuration mode:

```
controller (config)# vlan guest tag 1
   controller (config-vlan)#
```

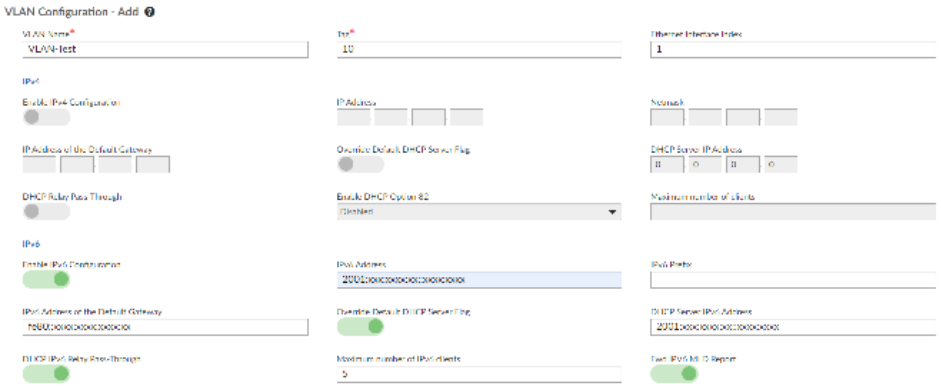
As shown by the change in the prompt above, you have entered VLAN configuration mode, where you can assign the VLAN interface IP address, default gateway, DHCP Pass-through or optional DHCP server (if specified, this DHCP server overrides the controller DHCP server configuration).

In the following example, the following parameters are set:

- VLAN interface IP address: 10.1.1.2 with a subnet mask of 255.255.255.0
- Default gateway: 10.1.1.1
- DHCP server: 10.1.1.254

```
controller (config-vlan)# ip address 10.1.1.2 255.255.255.0
   controller (config-vlan)# ip default-gateway 10.1.1.1
   controller (config-vlan)# ip dhcp-server 10.1.1.254
   controller (config-vlan)# exit
   controller (config)#
```

In the GUI, (Configuration > Wired > VLAN > Add) create a VLAN and configure its parameters if you want to segment traffic on the network. VLAN interfaces created on the controller acquire IPv6 addresses from router advertisements only.



1. In the VLAN Name box, type a name up to 32 alphanumeric characters long without spaces.
2. In the Tag box, type the VLAN tag. The VLAN tag is an integer in the range of 1 through 4,094. You must specify a VLAN tag.
3. In the FastEthernet Interface Index box, enter the number of the interface (1 or 2; the second interface is an optional configuration).
4. In the IP address field specify the IP address assigned to the controller from this VLAN?s IP subnet.
5. In the Netmask boxes, type the subnet mask of the IP address. The subnet mask must match the subnet mask of the default gateway configured in wireless clients.
6. In the IP address Default Gateway/IPv6 address Default Gateway field, specify the IPv4/IPv6 gateway the controller should use to forward packets from wireless stations using this VLAN. The Default Gateway IP address should match the default gateway IP address configured (via either DHCP or statically) on wireless stations using this VLAN.
7. In the Override Default DHCP Server Flag list, select one of the following:
   - **On**: Enable use of specified DHCP server (see step 8 rather than the global DHCP server configured for the controller.
   - **Off**: Disable usage of specified DHCP server and return to using global DHCP server configured for the controller.
8. In the DHCP Server IP Address/DHCP Server IPv6 Address boxes, type the IPv4/IPv6 address of the DHCP relay server.
9. In the DHCP Relay Pass-Through/DHCP IPv6 Relay Pass-Through list, select one of the following:
   - **On**: Enable use of the pass-through DHCP server feature (default setting).
   - **Off**: Disable usage of the pass-through DHCP server feature.
10. When DHCP option 82 is enabled, the controller acts as a DHCP relay agent to avoid DHCP client requests from untrusted sources. This secures the network where DHCP is

used to allocate network addresses. The controller adds the DHCP option 82 information to DHCP requests from clients before forwarding the requests to the DHCP server. By default, this option is disabled.
Note: DHCP relay pass-through should be disabled for the controller to act as the DHCP relay agent.

11. Select the DHCP option 82 remote ID field format as AP-MAC or AP-MAC-SSID.
If the DHCP server is set to the default IP address of 127.0.0.1, DHCP packets pass through without modification. No DHCP relay function is performed. Instead, the packet is copied as is. This mode of operation is the default for a fresh system.
12. Enter the **Maximum number of clients/Maximum number of IPv6 clients** that will be supported in this VLAN, if this VLAN tag is used in a VLANPOOL.
13. Select any of the following IPv6 address type.
    - Static IP: Configure the AP IP address manually.
    - DHCP: The IP address is procured from the DHCP server.
    - Autoconfig address: The IPv6 address acquisition is based on the flags set in the router advertisement.
14. **Enable IPv4 Configuration/Enable IPv6 Configuration** for the configured VLAN.
15. Enable **Fwd IPV6 MLD Report** to forward the Multicast Listener Discovery report.
16. Click **OK**.

Bridged APs in a VLAN

When creating an ESS, AP can be configured to bridge the traffic to the Ethernet interface. This is called bridged VLAN dataplane mode (per ESSID); it is also sometimes known as Remote AP mode. These two AP models also have the capability to tag the Ethernet frames when egressing the port, using 802.1Q VLAN tags, and setting the 802.1p priority bit. Bridging is configured setting the Dataplane Mode parameter in the ESS profile to Bridged (default is Tunneled).

In Tunneled mode, all traffic in an ESS is sent from the AP to the controller, and then forwarded from there. This is configured on a per ESS profile basis. In Bridged mode, client traffic is sent out to the local switch. Fortinet control and coordination traffic is still sent between the AP and the controller.

When configuring an ESS, the Dataplane Mode setting selects the type of AP/Controller configuration:

Bridged VLANs support:

- Non-Virtual Cell
- Virtual Port

- RADIUS profile for Mac Filtering/1x/WPA/WPA2
- Standard DSCP/802.1q to AC mapping defined in WMM
- RADIUS profile for Mac Filtering/1x/WPA/WPA2
- RADIUS assigned VLANs (even with 802.1x)
- QoS Rules

See the ESSID chapters in this guide for more information on configuring an ESSID.

VLAN Tagging in Bridge Mode for Wired Ports

You can enable VLAN tagging for wired ports in bridged mode. VLAN tagging for wired ports provide four VLAN policies:

- No VLAN
- Static VLAN: VLAN tag shall be configured for a valid range of 0-4094.

Configuring VLAN Tagging

Using CLI

In the port profile configuration, use the following commands to specify the policy and the VLAN tag.

- default (config-port-profile)# port-ap-vlan-policy
- default(config-port-profile)# port-ap-vlan-tag

Dynamic VLAN support in Bridge mode

Stations can receive IP dynamically when the AP is in tunneled and bridged mode with the RADIUS server dynamically assigning the VLAN's.

- Dynamic VLAN is not supported for Captive Portal.
- The switch port to which the AP is connected needs to be tagged with appropriate VLANs.

Delete a VLAN

You cannot delete a VLAN if it is currently assigned to an ESSID (see Chapter , “” on page 139). You cannot delete a VLAN created by E(z)RF Network Server; that must be done

from Network Server. To delete a VLAN created on a controller, use the following command in global configuration mode:

no vlan ***name***

For example, to delete the VLAN name vlan1, enter the following:

```
controller (config)# no vlan vlan1
  controller (config)#
```

More About VLANs

FortiWLC (SD) provides commands for configuring both virtual LAN (VLANs) and Generic Routing Encapsulation (GRE) tunnels to facilitate the separation of traffic using logical rather than physical constraints. As an alternative to VLANs, GRE Tunneling can be configured on the either Ethernet interface, as described in **Configure GRE Tunnels** in the Security chapter. VLANs and GRE tunnels can coexist within any given network, logically segmenting traffic by organization or function. In this way, all systems used by a given organization can be interconnected, independent of physical location. This has the benefit of limiting the broadcast domain and increasing security.

VLANs, when used in conjunction with multiple ESSIDs, as discussed in **Chapter , “,”** allow you to support multiple wireless networks on a single access point. You can create a one-to-one mapping of ESSID to VLAN or map multiple ESSIDs to one VLAN.

Customized security configuration by VLAN is also supported. By assigning a VLAN a Security Profile, you can fine-tune the security requirements based on the use of the VLAN (see **Chapter , “,”** for details).

VLAN Pooling

To reduce big broadcast or risking a chance of running out of address space, you can now enable VLAN pooling in an ESS profile.

VLAN pooling essentially allows administrators to create a named alias using a subset of VLANs thereby creating a pool of address. By enabling VLAN pool, you can now associate a client/device to a specific VLAN. This allows you to effectively manage your network by monitoring appropriate or specific VLANs pools.

Features

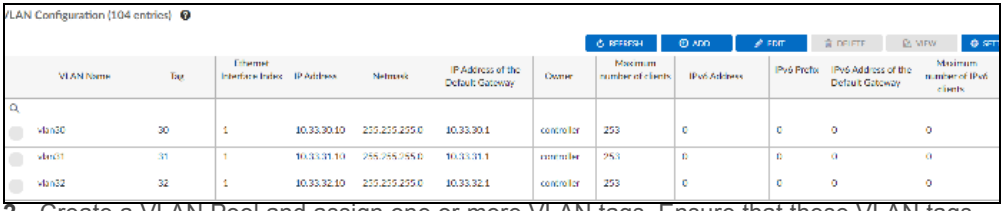
- You can associate up to 16 VLANs to a pool.
- You can create a maximum of 64 VLAN Pools.
- You can specify the maximum number of clients that can be associated to a VLAN.

- The client/device behaviour does not change after it is associates to a VLAN in a pool.
- If a VLAN is removed from a VLAN pool, clients/devices connected to the VLAN will continue to be associated to the VLAN. However, if the clients disconnect and reconnect the VLAN will change.

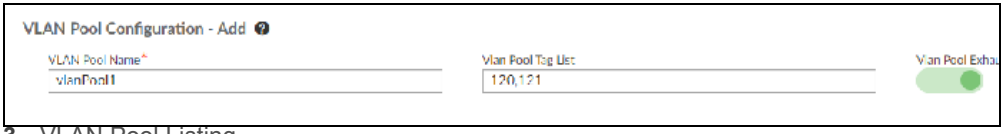
Configuration

Using WebUI

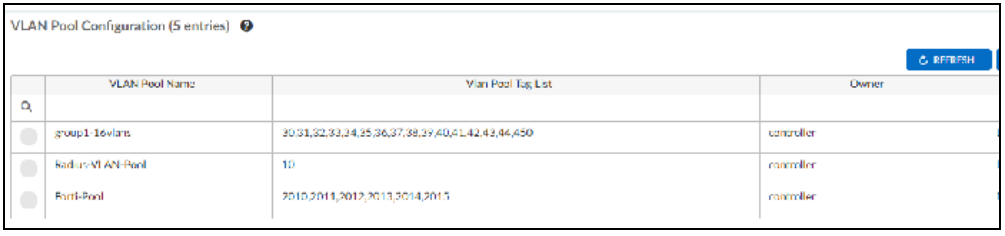
1. Create VLANs tags



2. Create a VLAN Pool and assign one or more VLAN tags. Ensure that these VLAN tags are not in use by another profile.



3. VLAN Pool Listing



Using CLI

1. Configure VLAN

```
default(config)# vlan vlan10 tag 10

default(config-vlan)# ip address 10.0.0.222 255.255.255.0

default(config-vlan)# ip default-gateway 10.0.0.1

default(config-vlan)# exit

default(config)# exit

default# sh vlan vlan10
```

```
VLAN Configuration
VLAN Name                              : vlan10
Tag                                    : 10
Ethernet Interface Index               : 1
IP Address                             : 10.0.0.222
Netmask                                : 255.255.255.0
IP Address of the Default Gateway      : 10.0.0.1
Override Default DHCP Server Flag      : off
DHCP Server IP Address                 : 0.0.0.0
DHCP Relay Pass-Through                : on
Owner                                  : controller
Maximum number of clients              : 253
```

2. Configure VLAN Pool

```
default(config)# vlan-pool vlangroup
default(config-vpool)# tag-list 10,36
default(config-vpool)# exit
default(config)# exit
default# sh vlan-pool
VLAN Pool Name           Vlan Pool Tag List
vlangroup                10,36
VLAN Pool Configuration(1 entry)
```

14 Configuring Access Points

This chapter includes instructions for the following:

Support for CAPWAP

FortiWLC supports Control and Provisioning of Wireless Access Points (CAPWAP) protocol to allow Fortinet access points to discover Fortinet WLAN controllers. In addition to controller discovery, APs can send keep-alive packets to controllers via CAPWAP.

The CAPWAP protocol implementation complies with the following RFCs:

- RFC5417: CAPWAP Access Controller DHCP Option
- RFC 5415: CAPWAP Protocol Specification **and** RFC 5416: CAPWAP Binding for 802.11 for the following:
  - Controller discovery (DTLS handshake)
  - Keep-alive packets (echo request and response)
  - AP image upgrade
  - Tunnelled client data packets between AP and controller

Legacy Discovery Process

There are three types of access point discovery:

- Layer 2 only-Access point is in the same subnet as controller.
- Layer 2 preferred-Access point sends broadcasts to find the controller by trying Layer 2 discovery first. If the access point gets no response, it tries Layer 3 discovery.
- Layer 3 preferred-Access point sends discovery message to the controller by trying Layer 3 discovery first. If the access point gets no response, it tries Layer 2 discovery.
- Layer 3 only-Access point sends discovery message to the controller by trying Layer 3 only.

For Layer 2 and Layer 3 discovery, the access point cycles between Layer 2, Layer 3, and Mesh (if mesh is enabled) until it finds the controller.

During each discovery cycle, the AP will send 5 probe requests at 2 seconds intervals.

An access point obtains its own IP address from DHCP (the default method), or you can assign a static IP address. After the access point has an IP address, it must find a controller's IP address. By default, when using Layer 3 discovery, the access point obtains the controller's IP address by using DNS and querying for hostname. The default hostname is "wlan-controller." This presumes the DNS server knows the domain name where the controller is located. The domain name can be entered via the AP configuration or it can be obtained from the DHCP server, but without it, an Layer 3-configured AP will fail to find a controller. Alternately, you can configure the AP to point to the controller's IP directly (if the controller has a static IP configuration).

After the access point obtains the controller IP address, it sends discovery messages using UDP port 9393. After the controller acknowledges the messages, a link is formed between the AP and the controller.

Discovery sequence for OAP832

Even if OAP832 is configured in the L3-only mode, the access points will be use L3 preferred mode to find controller. If the L3-preferred mode fails, they will fall back to L2 mode.

CAPWAP and Legacy Reference

Port Requirements

Activity	CAPWAP UDP Ports	L3 UDP Ports	Ethertype (L2)
Discovery	5246	9292	0x4003
Configuration and Keep-Alive	5246	5000	0x4001
Data Flow	5247	9393	0x4000

If Firewalls/packet filtering devices are used in your network, ensure the ports mentioned in this table are allowed.

Controller and AP Communication Ports

AP firmware version	Discovery Mode	Discovery Port / Ethertype	keep-alive ports / Ethertype	Configuration ports/ Ethertype	Data Flow Ports / Ethertype	Notes
Pre-8.3 (8.2, 8.1, 8.0, 7.0, etc.,)	L2	0x4003	0x4001	0x4001	0x4000	
	L3	9292	5000	5000	9393	After upgrade, UDP 5246 and 5247 is used for future discovery process and data flow respectively.
8.3.0	L2	0x4003	0x4001	0x4001	0x4000	
	L3	5246	5246	5000	5247	

CAPWAP Discovery

The CAPWAP protocol requires the UDP ports 5246 and 5247 to exchange control and data packets respectively

Discovery Sequence

The CAPWAP discovery supports the following sequence on port UDP 5246:

1. Unicast Options
   - Controller IP address: AP sends discovery request to a controller based on the configured IP address in the AP.
   - DHCP Option 138: AP sends discover request to the controller configured with DHCP option 138. Alternatively, option 43 is also available for discovering controller.
   - DNS: AP sends discovery request based on the DNS resolution of - **_capwap-control._udp.example.com**
2. Multicast: AP sends discovery request via multicast address - 224.0.1.140
3. Broadcast: AP sends discovery request via broadcast address on - 255.255.255.255

Discovery Process

1. In L3 discovery mode, the AP sends discovery request on both port 5246 and port 9292 to the controller.
2. If the controller is already upgraded to 8.3 release, it sends response on port 5246 to complete the AP association.
3. Further the keep-alive and image upgrade message exchange happens on port 5246.
4. Tunnelled client data are sent to controller on port 5247.

Upgrading from Pre-8.3 Release

If you have more than one controller in your network, we recommend that you disable multicast before you begin the upgrade process.

Using the `upgrade controller` command with `auto-ap-upgrade ON`

1. The controller is upgraded to 8.3 and will now listen on port 5246 and 9292 for discovery request from access points. During the controller upgrade process, the pre-8.3 access points will continue re-discovery of the controller using the legacy method.
   - Once the controller is upgraded, the pre-8.3 APs will associate with the controller using the legacy method.
2. Now, the access points begin the upgrade process. After the upgrade is complete, the access points will send discovery request on port 5246 and port 9292. The controller that is already upgraded to 8.3 will respond on port 5246 to complete AP association.

Using the `upgrade system` command

1. The APs are upgraded first to the 8.3 release. After upgrade the APs will send discovery request using a method sequence as mentioned in the Discovery Sequence section.
2. The controller is upgraded to 8.3 after the APs are upgraded. The 8.3 controller will respond to AP discovery request.

Post Upgrade

Ensure that UDP 5000 is open after the upgrade is complete.

Downgrading

When downgraded to a previous release, the discovery mechanism will switch back to the legacy discovery process. However, we recommend that you open the CAPWAP UDP ports, Kcom (L3) UDP ports, and Ethertypes.

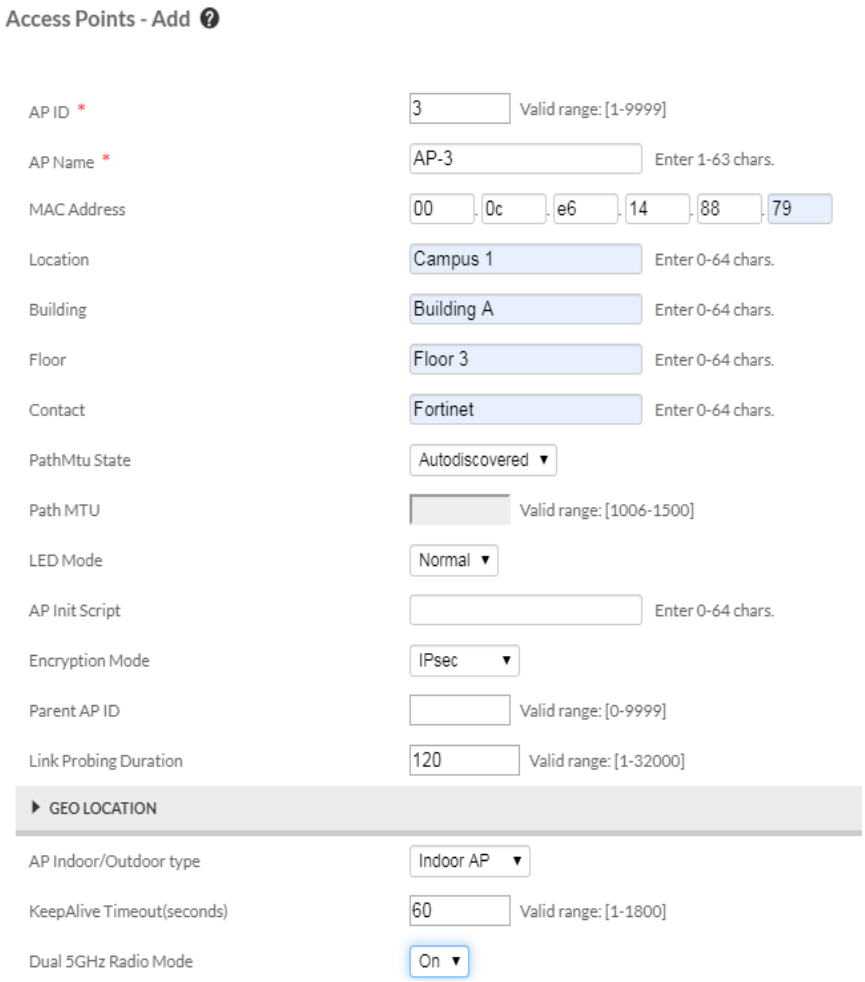
Add and Configure an AP with the Web UI

When you add an AP to a controller, you configure AP specific features described in this section. The access points in the network do not reboot after any parameter is modified on the wireless interface.

Access Points can be connected to the controller through a Layer 2 network or a Layer 3 network. To both add and configure an AP, follow these steps:

1. Click Configuration > Devices > APs > Add.
   The AP Table Add window displays.

Figure 79: *Add an AP to the Network*



2. Provide the following values and then click OK.

Field	Description
AP ID (required)	Unique AP numeric identifier up to 9999 characters long
AP Name (required)	Alphanumeric string up to 64 characters long assigned as identifier for the access point. Note that it can be helpful to name the AP something descriptive, such as a means of indicating its location in the building.

Field	Description
Serial Number (optional)	These boxes are designed to hold the MAC address which is part of the longer part number on the bottom of an AP. The MAC address is the last 12 numbers.
Location (optional)	Alphanumeric string up to 64 characters long
Building (optional)	Alphanumeric string up to 64 characters long
Floor (optional)	Alphanumeric string up to 64 characters long
Contact (optional)	Alphanumeric string up to 64 characters long
PathMTU State	The Path MTU discovery enables FortiWLC to determine the maximum transmission unit size on the network path between AP and controller; the packets sent conform to the MTU along the path, avoiding fragmentation and improving the network performance. **Note**: Path MTU discovery happens only between AP and Controller; the Path MTU is not discovered between controller and any external device like the RADIUS server or FortiWLM. Path MTU discovery works only for L3 APs and is enabled by default; you cannot disable it. The path MTU is discovered dynamically only when the AP is discovered/re-discovered. For example, if IPSec tunnel is configured between the AP and controller, Path MTU of 1438 bytes is set. Any update in the path MTU due to network changes (modification of MTU settings in L3 switch or router between AP and controller) does not take effect automatically/periodically; you are required to reboot the AP. Due to specific network requirements or the path MTU discovered by FortiWLC not being optimum, you can configure a value for path MTU. Select **Configured**, the Path MTU option is enabled. You can configure and manage Path MTU using the *path-mtu* command. For more information see the *FortiWLC CLI Reference Guide*.
Path MTU	The valid range is 1006 to 1500 bytes; the default is 1500 bytes. You are required to reboot the AP for the configured Path MTU to take effect.
LED Mode (optional)	Normal: LEDs are as described in the Access Point Installation Guide Node ID: Not supported in release 5.1 Blink: Sets all LEDs flashing; this is useful to locate one AP. The blink sequence is unique for different AP models. Dark: Turns off all LEDs except power
AP Init Script (optional)	Name of an initialization script that the access point runs when booted.

Field	Description
Encryption Mode (optional)	The following are the supported encryption modes: • **None**: This is the default option selected for the access point. No encryption is applied. • **Dataplane**: This mode enables encryption only for the data path. DTLS is used to encrypt the data traffic. • **IPsec**: This mode enables encryption of all traffic between the AP and controller (both the control and data path). The IPsec encryption mode can be applied to the access points in a feature group as well. If the access point being added to the feature group has a different encryption mode then, by default, it is modified to the encryption mode configured for the feature group. Navigate to **Configuration > System Config > Feature Group**. The IPsec encryption mode can be configured when performing a bulk update on access points. Navigate to **Configuration > Devices > APs > Bulk Update.**
AP Role (optional)	In a Mesh configuration, determines the role that the AP plays in the mesh: access: Access point is operating as a standard, wired AP. wireless: Access Point is part of the Enterprise Mesh configuration, providing wireless access services to 802.11/bg clients and backhaul services on the 802.11/a link. gateway: Access point is part of the Enterprise Mesh configuration, providing the link between the wired and wireless service.
Parent AP ID (optional)	In a Mesh configuration, a wireless AP is directed to look for a signal from a Parent AP, which provides the wireless AP with its backhaul connectivity. Several APs can be assigned the same Parent AP ID.
Link Probing Duration (optional)	Length of time (from 1 to 32000 minutes) that bridged APs wait before rebooting when the controller link is broken. This setting is used in Remote AP configurations to prevent AP reboots when the connectivity to the remote controller is lost. The default is 120.
Geo Location	The APs geographic location. The following location based attributes can be configured. • Latitude/Longitude - Coordinates separated by commas. • Zip Code • Area Code • City Name • State Name • Timezone

Field	Description
KeepAlive Timeout (seconds)	In the KeepAlive Timeout (seconds), specify the duration of time (from 1 to 1800 seconds), for the remote APs to remain in the online state with respect to the controller, even when the link to the AP is down. The discovery message from the controller to the AP is modified depending on the time lapse provided in the Link Probing Duration box and the KeepAlive Timeout (seconds) box. The default is 25.
JumboMtu State	Enable/disable the **JumboMtu State** to configure Jumbo frames for APs.
Jumbo MTU	Configures the MTU size for APs. • [All 11ac APs (*except* AP832)] The valid MTU range is **1500 - 2500** bytes and the default is 2500 bytes. • [AP832] The valid MTU range is **1500 - 9000** bytes and the default is 2500 bytes. Jumbo MTU is supported only for 11ac APs. It is not supported for port profiles configured on AP122 and on *Open VPN* APs.
AP Indoor/ Outdoor AP (optional)	An Indoor and outdoor AP have different regulatory settings for channels and power levels. This setting adjusts those values.
Dual 5GHz Radio Mode	FortiAP-U431/433F supports configuring two radio interfaces in the 5GHz band. This option is supported for FAP-U431/433F ONLY and is disabled by default. See **Dual 5GHz Radio Mode Configuration** below for configuration details. **Note:** The AP reboots whenever the Dual 5GHz Radio Mode is changed - enabled/disabled**.**

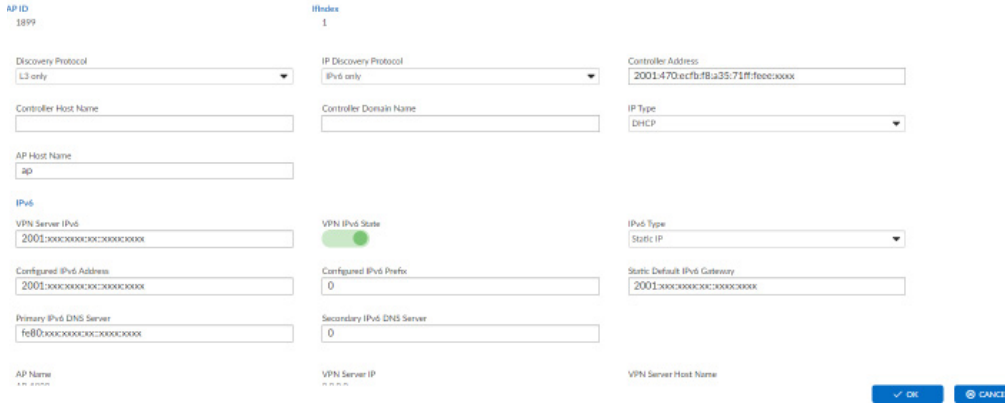
Dual 5GHz Radio Mode Configuration

When enabled/disabled, the radios operate with the default configurations described in this table.

Dual 5GHz Radio Mode	Interface 1	Interface 2	Interface 3
Disabled (Default)	[Service Mode] • 2.4 GHz • 4x4 MIMO • 802.11ax_2g RF band	[Service Mode] • 5 GHz • 4x4 MIMO • 802.11ax_5g RF band	[Scan Spectrum Mode] • 2.4/5GHz • 2x2 MIMO • 802.11ac RF band
Enabled	[Service Mode] • 2.4 GHz • 2x2 MIMO • 802.11bgn RF band **OR** [Scan Spectrum Mode] • 2.4/5GHz • 2x2 MIMO • 802.11bgn RF band	[Service Mode] • 5 GHz • 4x4 MIMO • 802.11ax_5g RF band • Low band operating in channels 36 – 64.	[Service Mode] • 5 GHz • 4x4 MIMO • 802.11ax_5g RF band • High band operating in channels 100 – 165

Configure AP Network Connectivity

You can configure access point network connectivity (requires Level 10 permission). Edit an AP and configure the following.



1. In the IP Configuration list, select one of the following:
   - No IP: Access point has no IP address. Select this option if you are using the access point in a Layer 2 network.
   - Static IP: Access point uses a static IP address.
   - DHCP: Access point is using a DHCP-assigned an IP address. This option is the default.
2. Do one of the following:
   - If you selected Static IP in step 1, go to step 3.
   - If you selected DHCP in step 1, go to step 8.
3. In the Static IP Address boxes, type the static IP address.
4. In the Static IP Netmask boxes, type the subnet mask for the IP address.
5. In the Static Default Gateway, type the IP address of the default gateway.
6. In the Primary DNS Server boxes, type the IP address of the primary DNS server.
7. In the Secondary DNS Server boxes, type the IP address of the secondary DNS server.
8. In the AP Host Name box, type the hostname of the access point. This name can be up to 63 alphanumeric characters.
9. In the Discovery Protocol list, select the method of access point discovery:
   - L2 preferred: Access point attempts to find the controller by trying Layer 2 discovery first. If the access point gets no response, the access point tries Layer 3 discovery. This option is the default.
   - L2 only: Access point is in the same subnet as the controller.
   - L3 preferred: Access point attempts to find the controller by using Layer 3 discovery first. If the access point gets no response, the access point tries Layer 2 discovery.
   - For Layer 2 and Layer 3 discovery, the access point cycles between Layer 2 and Layer 3 until it finds the controller. The access point waits 16 seconds before cycling between Layer 2 and Layer 3.

10. IPv6 type - Select the type of IPv6 address to be configured.
    - Static IP: Configure the AP IP address manually.
    - DHCP: The IP address is procured from the DHCP server.
    - Autoconfig address: The IPv6 address acquisition is based on the flags set in the router advertisement.
11. IPv6 Discovery Protocol - Select any of the following for AP discovery:
    - IPv4 preferred: IPv4 connectivity is used in the first attempt of AP discovery.
    - IPv6 preferred: IPv6 connectivity is used in the first attempt of AP discovery.
    - IPv4 only: Only IPv4 connectivity is used for AP discovery.
    - IPv6 only: Only IPv6 connectivity is used for AP discovery.
12. IPv6 DNS Server - Configure the primary and secondary IPv6 DNS servers.
13. IPv6 Address - Configure the static IPv6 address and enter a new Configured IPv6 Prefix and Static Default IPv6 Gateway.
14. VPN Server IPv6 - Configure an IPv6 address for the VPN server.
15. Primary IPv6 DNS Server/Secondary IPv6 DNS Server - Configure the primary and secondary IPv6 DNS servers.
16. Static Default IPv6 Gateway - Configure the IPv6 gateway to be used.
17. Configured IPv6 Prefix - Provide an IPv6 prefix.
18. Do one of the following:
    - If you selected L2 preferred or L3 preferred in step 9, do one of the following:
        - Go to step 11 to specify a controller IP address.
        - Go to step 12 to specify the hostname of the controller.
    - If you selected L2 only in step 9, go to step 14.
19. In the Controller Address boxes, type the IP address of the controller from which the access point is discovered. Go to step 14.
20. In the Controller Host Name box, type the hostname of the controller from which the access point is discovered. The optional name can be up to 63 alphanumeric characters, and the default controller name is wlan-controller.
21. In the Controller Domain Name box, optionally enter the domain name (up to 256 characters) of the controller from which the access point is discovered.
22. To apply access point connectivity changes, click OK.

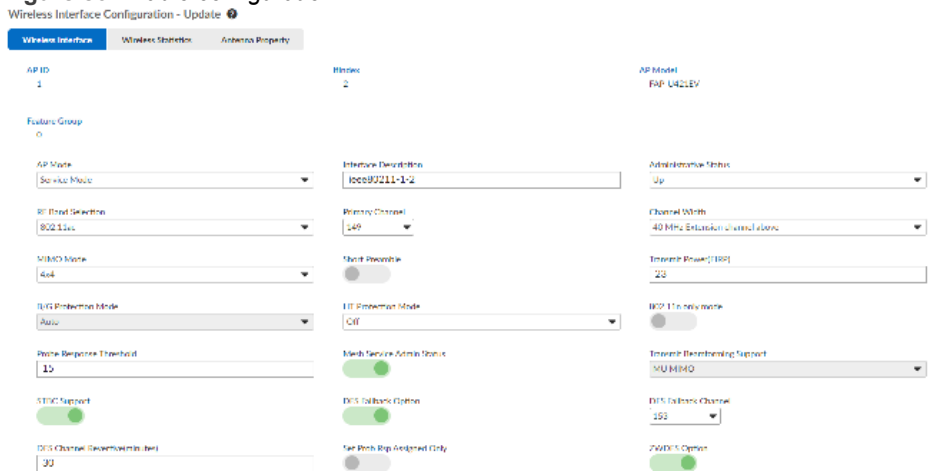
Configure an AP’s Radios with the Web UI

After you *“Add and Configure an AP with the Web UI”* ***on page 355***, the AP’s radios will be listed in FortiWLC (SD). Follow these steps to configure the radios:

1. Click Configuration > Wireless > Radio.

2. Select one of the radios by clicking the pencil icon in the first column; remember that most APs have two radios. In that case, you will want to configure both of them.
3. There are three tabs of settings for a radio, Wireless Interface, Wireless Statistics, and Antenna Property. Wireless Interface is the default tab. Here you see the existing interface settings for the radio. Any setting that is greyed out cannot be changed. Make any of the changes listed in the following chart, and then click OK.

Figure 80: *Radio configuration*



Field	Description
Interface Description	Description can be up to 256 alphanumeric characters long and contain spaces (for example, Lobby AP interface 1). By default, the description is ieee80211-ap_id-index-_ID.
Administrative Status	Indicate whether the interface is to be used: Up: Enable the interface Down: Disable the interface
Primary Channel	In the drop-down list, select the channel number for the wireless interface to use. The channel numbers displayed depend on the RF Band Selection and the regulatory domain for each country; for example, in the United States 802.11b shows channels 1 through 11 and 802.11a shows channels 36, 40, 44, etc. Two access points can belong to the same virtual AP only if they are on the same channel. Thus, two neighboring access points on different channels cannot perform seamless handoff (0 ms).
Short Preamble	Short preambles are more efficient on the air, but not all clients support them. On Off

Field	Description
RF Band Selection	Select the RF Band this interface uses. Available selections are based on both the AP model and radio cards installed (for example, 802.11an). RF bands *802.11ax_2g* and *802.11ax_5g* are supported for FAP-U431/433F only
Transmit Power (EIRP)	Fortinet AP radios operate at their maximum power level by default. High power level increases the signal strength of the frames received by the client stations, allowing a client station to decode frames at a higher rate and increasing the coverage area. This causes minimal interference because Fortinet uses Virtual Cell technology, moving clients to a better AP without re-association. For a very few cases, we recommend that you reduce the power level on APs due to co-channel-interference. Check with Support first to make sure your issue really is due to co-channel-interference. To change transmit power, change the value in the Transmit Power field. The maximum level depends on the country code and the RF band in use.
AP Mode	Select whether the radio for the interface is in Service Mode (servicing clients first and scanning in the background), ScanRogues Mode (dedicated monitoring for Rogue APs), and ScanSpectrum Mode (scans the environment continuously for interference and sends reports to Spectrum Manager).
Override Group setting	Select the Override Group setting to override the radio setting of an AP in a Feature Group by updating the radio parameters on this page. This option is available only when the AP is a part of a feature group.
B/G Protection Mode	Configures 802.11b/g interoperability mode. This setting defaults to auto and should not be changed without consulting Fortinet Support.
HT Protection Mode	HT protection is set to default Off. The options are: On Off Auto
Channel Width	Channel Width can be: 20 MHz 40MHz Extension Channel Above 40MHz Extension Channel Below 80 MHz 160 MHz (FAP-U431/433F only) Note that all APs in a Virtual Cell must have the same channel width.
MIMO Mode	Select: • 1x1 • 2x2 if you are using an 802.3af PoE • 3x3 if you are using a high-powered PoE or DC power • 4x4 if you are using FAP-U42xEV/FAP-U431/433F access points

Field	Description
802.11n Only Mode	802.11n only mode is for APs with 11n capability. Select: On: to support only 802.11n Off: (default) to support 802.11an or 802.1bgn
RF Virtualization Mode	The RF Virtualization Mode drop-down allows the user to specify the type of virtualization used. The option for selections are as follows: • Virtual Cell • Virtual Port: This option is not supported on Wave 1 and Wave 2 AP models. • Native Cell: This option disables virtualization on the ESS and is the default setting for all APs.
Probe Response Threshold	This parameter configures the probe response, gratuitous authentication, and de-authentication thresholds. The probe response threshold restricts the far away AP by not sending any probe response and quickly responds to the probe request sent from a nearby station. Gratuitous authentication threshold restricts the far away AP by not sending the authentication response and quickly responds to the authentication request sent from a nearby station. De-authentication threshold disconnects the far away client and is useful in staying clear of sticky clients, that is, (far away) clients who stick to a bad connection. The valid range is 0-100. When set to 0, the probe response, gratuitous authentication and de-authentication thresholds are disabled; they are enabled when set to 1-100. By default, the probe response threshold is set to 15, the gratuitous authentication threshold is set to 15 and de-authentication threshold is set to 12. This feature is also configured via bulk update on per AP interface level. It is per interface configuration, the probe response threshold can be configured separately on both the interfaces. The value for the gratuitous authentication threshold is the same as that of the Probe Response Threshold. If you change the Probe Response Threshold value, the changes will take effect for gratuitous authentication threshold as well.
Mesh Service Admin Status	Enable or Disable the Mesh Service Admin Status.
Transmit Beamforming Support	Select the Transmit Beamforming Support: • Disabled • SU-MIMO • MU-MIMO (to support 802.11ac Wave 2 capable clients)
STBC Support	Select the STBC Support: On Off

Field	Description
DFS Fallback Option	Select enable to allow the AP to fallback to a different channel when a radar is detected. If the DFS fallback option is **enabled**: • The configured *DFS Fallback Channel* is selected. • *DFS Channel Revertive* is set to a default value of 30 minutes. This value is configurable. • When radar is detected, it checks the fallback channel for 60 seconds and if no radar is found it switches to the fallback channel. • After the configured *DFS Channel Revertive* duration, it reverts back to original operating channel if the channel is available (Channel availability test runs successfully). If the DFS fallback option is **disabled**: • If radar is detected the system performs its own fallback channel selection. • If the AP is on a non DFS fallback channel, it continues on it unless the channel is changed manually. • If the AP is on a DFS fallback channel (DFS is enabled), after the configured *DFS Channel Revertive* duration, it reverts back to original operating channel if the channel is available (Channel availability test runs successfully).
DFS Fallback Channel	Select the fallback channel.
DFS Channel Revertive (minutes)	Select the time AP will take to revert back to its original channel.
ZWDFS Option	Enable Zero Wait DFS to enable seamless transition to a target DFS channel with almost no additional delay.

With release 8.6.0, the FAP-U24JEV supports operating its only 2x2 physical radio as a single 2x2 interface or two concurrent 1x1 interfaces.

You can configure the radio 1 MIMO mode from GUI/CLI in following modes.

1x1 - Concurrent radio mode (Default)

Two 1x1 interfaces on the AP and controller.

- Interface-1 supports only 2.4 GHz with the default channel 6.
- Interface-2 supports only 5 GHz mode with default channel 36.

2x2 - Single radio mode

Supports dual band operation and the default configuration is 2.4 GHz with channel 6, one 2x2 interface on the

AP and controller.

- Interface-1 (2x2) is up and running, all configurations on interface-1 are reflected on the AP.
- Interface-2 (1x1) status is **Administrative Status: SingleInterface and Operational Status: Disabled**.
- The AP operates in the single radio mode and brings down interface 2.
- This is applicable only on AC/AN/BGN RF bands.
- If interface-1 is in 5 GHz band/2x2 MIMO mode and is changed to 1x1 MIMO mode then you are required to change the RF band and channel width to 20 MHz.
- Interface-2 settings are disabled from the GUI and no configuration is permitted.

Mixed Configurations

Multiple modes are allowed, that is, a combination of 2x2 and 1x1 APs.

- Apply global configuration on all or specific APs using bulk update - Configurations > Wireless > Radio > Interface 1 > Bulk Update.
- Apply to multiple feature groups, for example, one feature group with 2x2 enabled on interface-1 and another feature group with 1x1 enabled on both interfaces - Configuration > Quick Start > Feature Group.

Notes:

- AP reboots when changing from 1x1 MIMO mode to 2x2 MIMO mode or vice versa. The **sh ap-rebootevent** CLI Command output displays **config-wireless-if-chan** as the reason for reboot.
- Mixed configurations are not supported with ARRP enabled.

Add and Configure an AP with the CLI

To configure an AP with the CLI, first enter AP configuration mode (first command shown below) and then use the rest of the AP configuration commands:

Command	Purpose
configure terminal	Enter global configuration mode.
ap ap-id	Enter AP configuration for the specified AP. Use the command show ap to get a list of APs.
... commands ...	Enter the AP configuration commands listed in the next chart here.

Command	Purpose
boot-script string	Name of an initialization script that the access point runs when booted. If nothing is configured here, the AP uses the default bootscript.
building string	Command to describe building identification.
contact string	Enters AP contact information
connectivity l2-only | l2-preferred | l3-preferred	This setting configures Layer 2 or Layer 3 connectivity to the controller. Using either L3 or L2 preferred also invokes AP connectivity mode where additional connectivity configuration can be done.
dataplane-encryption {on | off}	In a Mesh configuration, selects how the AP and Controller pass data packets: On: the AP-Controller link is encrypted Off: the AP-Controller link is unencrypted (default)
description string	Enters AP description. Note that this corresponds to the AP Name in the GUI.
dual5ghzradio-mode	Configures two radio interfaces in the 5GHz band (FAP-U431/433F only).
encryption-mode	Configures the encryption mode to determine the type of traffic between the controller and access point.
floor string	Enters AP floor location
jumbo	Enables/disables Jumbo frames on the AP and configures the MTU.
led {normal | blink | NodeId | Normal}	Normal: LEDs appear as described in the Fortinet Access Point Installation Guide Blink: Sets all LEDs flashing; this is useful to locate an AP Dark: Turns off all LEDs
link-probing duration minutes	For Remote AP, set the number of minutes between keep-alive signals. Minutes can be between 1 and 3200.
location string	Enters AP location information
mac-address ff:ff:ff:ff:ff:ff	Sets the MAC address if you are pre-configuring an AP
model string	Command to enter the model type of the AP if you are pre-configuring the AP

Command	Purpose
no boot-script	Disables the boot script
path-mtu	Configures the Path MTU state and size.
end	Return to privileged EXEC mode.

Configure a Layer 3 AP with the CLI

The following commands can be used to set up a Layer 3 configuration for an AP not in the same subnet as the controller. It specifies the AP will obtain its IP address from DHCP, which allows it to use a DNS server for obtaining its IP address. If the network administrator has added to the DNS server the IP address for the controller hostname “wlan-controller,” DNS can return the IP address of the controller with the hostname “wlan-controller:”

```
default# configure terminal
   default(config)# ap 1
   default(config-ap)# connectivity l3-preferred
   default(config-ap-connectivity)# ip address dhcp
   default(config-ap-connectivity)# controller hostname wlan-controller
   default(config-ap-connectivity)# end
   default#
```

The following table presents the commands available within the ap-connectivity mode.

TABLE 17: *Summary of Connectivity Mode Commands*

Command	Purpose
controller {domainname name|host-name name|ip <*ip-address*>}	Configure the controller IP information. The domainname name must be from 1 to 63 characters. The hostname name must be from 1 to 63 characters. The IP address must be in the format nnn.nnn.nnn.nnn or dhcp to obtain the AP IP address dynamically.
hostname name	Sets the AP hostname. name must be from 1 to 63 characters.
ip address {ip-address|dhcp}	Configures the IP addressing for the AP. Use ip-address to assign a static IP address to the AP. Use dhcp to obtain the AP IP address dynamically.

TABLE 17: *Summary of Connectivity Mode Commands*

Command	Purpose
ip default-gateway gateway	Adds an IP address of the default gateway in the format nnn.nnn.nnn.nnn
ip dns-server {primary <DNS ip-address> |secondary <DNS ip-address>}	Adds a DNS server entry for static IP. primary ip-address sets a primary DNS server for static IP. secondary ip-address sets the secondary DNS server for the static IP.

Configure AP Power Supply, Channel Width, and MIMO Mode with CLI

Set the power supply type, channel width, and MIMO mode by following these steps:

1. Open a terminal session on the controller.
2. Enter configuration mode by with the command terminal configuration at the CLI prompt.
3. Select the AP with the command ap #, for example, AP1:

```
default(config)# ap 1
```

4. Set the power supply value to 5V-DC for AP Power, 802.3af Power Over Ethernet, 802.3-at Power Over Ethernet with the CLI command power-supply.

```
default(config-ap)# power-supply 5V-DC
```

5. Exit ap configuration mode.

```
default(config-ap) # exit
```

6. Enter radio configuration submode with the command interface Dot11Radio ***node-id interface_ID***. For example, for AP1, interface 1:

```
default(config)# interface Dot11Radio 1 1
```

7. Change channel width from 20 MHz (default) to 40 MHz (either 40-mhz-extension-channel-above or 0-mhz-extension-channel-below 40) with the command channel-width. This command also sets channel bonding.

```
default(config-if-802)# channel-width above 40 MHz Extension channel
```

8. Change MIMO Mode from 2x2 (default) to 3x3 with the mimo-mode 3x3 command and exit.

```
default(config-if-802)# mimo-mode 3x3
   default(config-if-802)# end
```

The AP is now configured.

Configure an AP's Radios with the CLI

Before you can configure any radio settings, you need to enter radio interface configuration mode. To do this, follow these steps:

TABLE 18: *Entering Radio Interface Configuration Mode*

Command	Purpose
configure terminal	Enter global configuration mode.
interface Dot11Radio <ap-id> <Interface ID>	Enter interface configuration for the specified AP and radio interface. Use show interfaces Dot11Radio to obtain a list of radio interfaces. For AP800, the second interface provides 802.11ac support.
... commands ...	Enter the 802.11 configuration commands here.
end	Return to privileged EXEC mode.
copy running-config startup-config	This is an optional step to save your entries in the configuration file.

Summary of Radio Interface Configuration Commands

The following is a summary of the commands available in radio interface configuration mode:

TABLE 19: *Commands available in Radio Interface Configuration Mode*

Command	Purpose
admin-mode	Enables or disables a radio interface.
antenna-property	Manages external wireless interface antennas.
channel	Configures the channel ID.
localpower	Configures the AP transmit power level for all APs
mode	AP mode configuration.
n-only-mode	Supports only 802.11n clients on the radio to improve performance.
preamble-short	Enables or disables short preambles.
protection-mode	Configures 802.11b/g interoperability mode. This setting defaults to auto and should not be changed without consulting Fortinet Support.
rf-mode	Configures the Radio Frequency mode (802.11a, b, g, or bg, bgn, an, ac or ax). Note that All APs on the same channel in a Virtual Cell must have the same setting for rf-mode.

TABLE 19: *Commands available in Radio Interface Configuration Mode*

Command	Purpose
scanning channels	Configures the channels for scanning
tuning	Tunes the wireless interface

Set Radio Transmit Power with the CLI

The radio transmit power changes the AP's coverage area; this setting helps manage contention between neighboring access points. Transmit power for Fortinet APs is defined as the EIRP1 (Effective Isotropic Radiated Power) at the antenna and includes the antenna gain. (This is important to remember; transmit power is not the power at the connector.) Power level settings are dependent on the country code and the radio band (and for 802.11a, the channel) in use.

For example, if the transmit power, configured with the command localpower, is set to 20 dBm2, and the antenna gain is set 3 to 2 dBm, then the actual transmitted power at the connector is 18 dBm.

If an external antenna with an 8dBi (isotropic) gain is used, then adjust the gain value to the same value, 8. If the desired EIRP after the antenna is the same, then keep the transmit power set to the same value, 20. For higher or lower EIRP values, adjust the transmit power to the desired value.

The maximum power setting is an integer between 4-30dBm for 802.11/bg radios.

The Maximum Transmit Power for the 802.11a band is based on the channel in use, as detailed in the following table, which shows the levels for the United States:

802.11a Channel	Maximum Transmit Power (dBm) for United States
36	17
40	23
44	23
48	23
52	30
56	30
60	30
64	30
100	30
104	30
108	30
112	30
116	30

802.11a Channel	Maximum Transmit Power (dBm) for United States
120	30
124	30
128	30
132	30
136	30
140	30
149	36
153	36
157	36
161	36
165	36

Use the localpower command in the Dot11Radio interface configuration mode to configure the maximum power level.

localpower **`max-level`**

For example, to set the 802.11a radio maximum power to 15, type

localpower 15

Enable and Disable Short Preambles with the CLI

The radio preamble, also called the header, is a section of data at the head of a packet that contains information that the access point and client devices need when sending and receiving packets. By default, a short preamble is configured, but you can set the radio preamble to long or short:

- A short preamble improves throughput performance.
- A long preamble ensures compatibility between the access point and some older wireless LAN cards. If you do not have any older wireless LAN cards, you should use short preambles.

To disable short preambles and use long preambles, type:

no preamble-short

To enable short preambles, type:

preamble-short

Set a Radio to Scan for Rogue APs with the CLI

To configure radios to constantly scan for rogue APs, use this command from the Dot11Radio interface configuration mode:

```
mode scanning
```

To set the radio back to servicing clients, use the command:

```
mode normal
```

Enable or Disable a Radio Interface with the CLI

To temporarily disable a radio interface, use this command from Dot11Radio interface configuration mode:

```
admin-mode Down
```

To later enable the off-line interface, use the command:

```
admin-mode Up
```

Set a Radio to Support 802.11n Only with the CLI

To set an AP radio interface to support only 802.11n clients, and thus improve throughput, from the Dot11Radio interface configuration mode use the command:

```
n-only-mode
```

To disable the 802.11n-only support, use the command:

```
no n-only-mode
```

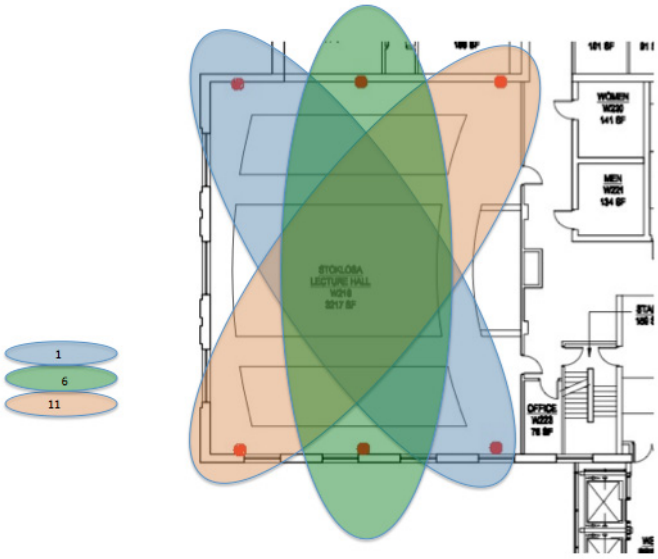
Note that All APs on the same channel in a Virtual Cell must have the same setting for n-only mode.

Configuring an AP's Radio Channels

AP channel configuration is configurable for 802.11bg which consists of 11 overlapping channels in United States deployments. Channel configuration for 802.11a is not an issue because there are no overlapping channels within the 802.11a spectrum.

In the 802.11b/g standard, there are 14 channels. As a result of FCC rules, there are 11 channels: channels 1 through 11 are used in the USA. Other countries may also use channels 12, 13, and 14. These channels represent the center frequency of the wireless transmission wave. In practice, 802.11bg has only three operational frequencies in a given area, and most deployments use channels 1, 6, and 11, for which there is no overlap.

Figure 81: *Channel 1, 6, and 11*



To assign a channel, use the Dot11Radio interface command channel. With the Web UI, configure a channel by clicking Configuration > Wireless > Radio, select a radio and then select a Channel from the drop-down list.

Sitesurvey

Fortinet sitesurvey is a simple tool that aids in network planning to find the right placement (mounting location) of APs such that clients connected to these APs receive high throughput, excellent coverage. To find the right placement of your AP, connect your Wi-Fi client to the AP that is in the sitesurvey mode and move around the deployment perimeter to identify areas that provide good connectivity (based on the results from the sitesurvey tool) to the Wi-Fi client. You can adjust the placement of the AP depending on the sitesurvey results.

Pre-requisites

- Sitesurvey is supported only on AP832, AP822, FAP-U421, and FAP-U423.
- The AP must be running FortiWLC (SD) 6.1-2 or higher and can connect only in Open Clear mode.

Configuring Sitesurvey Options

Sitesurvey configuration and monitor options are available via CLI (AP boot console) and GUI. To access sitesurvey options, Connect to AP CLI from a controller or use a serial port.

Using the CLI

After the normal AP boot process, enter the sitesurvey enable command at the AP boot prompt to restart AP into the sitesurvey mode. In the sitesurvey mode the AP displays the site-survey prompt (**ss >**).

Sitesurvey commands always begin with the sitesurvey keyword or alternatively you can use the ss (alias) instead of the sitesurvey keyword. Sitesurvey provides the following additional commands to configure and monitor sitesurvey features.

Enabling Sitesurvey

sitesurvey enable

This command enables the sitesurvey mode. The AP will reboot into sitesurvey mode and display the sitesurvey prompt.

ss > _

Disabling Sitesurvey

sitesurvey disable

This command disables the sitesurvey mode. AP will reboot into normal mode of operation.

Setting Country Code and Channel

sitesurvey countrycode set <country code>

By default the country code is set to US. When you set a country code, the first valid channel and the max supported Tx power for radio 0 and radio 1 for that country code is automatically set. To override the default channel for a country code, enter the following command

sitesurvey channel set <radio_index> <channel>

Where,

- radio_index refers to the AP radios.
- Enter 1 for radio 1 (2.4 Ghz).
- Enter 2 for radio 2 (5Ghz).

To get the list of supported country codes, use the **ss countrycode help** command.

Setting Inactivity Time

sitesurvey inactivitytime <itime>

This command sets the time (in seconds) the AP will remain in the sitesurvey mode before a client associates with it. The time is specified in seconds and by default the AP will remain in the sitesurvey mode for 3600s. After the period of inactivity, the AP will reboot into normal AP mode.

When using the GUI, the browser window will reset after 3600 seconds of inactivity, irrespective of the time set for inactivity. The browser refresh time cannot be changed.

Setting IP Address

sitesurvey ipconfig <ip_address> <netmask>

This command configures the sitesurvey AP with an IP address. You can use this IP address to access the sitesurvey GUI page via a browser. By default, the IP address and netmask are set to 192.168.0.1 and 255.255.255.0.

Configuring SSID

sitesurvey ssid <radio_index> [<ssid>]

Where,

- radio_index can be 0, 1, or 3
- Enter 0 for radio 1 (2.4 Ghz)
- Enter 1 for radio 2 (5 Ghz)
- Enter 3 to specify SSID for both the radios

This command configures SSID for the specified radio. By default, SSID for radio 1 (2.4Ghz) is set to Fortinet_Site_Survey_2.4 and SSID for radio 2 (5 Ghz) is set to Fortinet_Site_Survey_5.

Examples

ss > sitesurvey ssid 3

FORTINET_SITE_SURVEY SSID is assigned for both radio1 and radio2 as FORTINET_SITE_SURVEY

ss > sitesurvey ssid 1 <-- if SSID is not specified SSID is assigned to radio1 as FORTINET_SITE_SURVEY_2.4 by default

ss > sitesurvey ssid 2 <-- if SSID is not specified SSID is assigned to radio2 as FORTINET_SITE_SURVEY_5 by default

ss > sitesurvey ssid 3 <-- if SSID is not specified FORTINET_SITE_SURVEY_2.4 is assigned as SSID for radio1

FORTINET_SITE_SURVEY_5 is assigned as SSID for radio2.

After configuring SSID on AP radios, you can use the following command to selectively (per radio) enable or disable broadcasting SSID.

```
sitesurvey publishssid <radio_index> [on|off]
```

By default, SSID for both radios are broadcast.

Enable or Disable Radio

```
sitesurvey {radio | r} <radio_index> [on|off]
```

Where,

- radio_index can be 0, 1, or 3
- Enter 0 for radio 1 (2.4 Ghz)
- Enter 1 for radio 2 (5 Ghz)
- Enter 3 for both the radios

This command enables or disables AP radio. Wi-fi clients connecting to the sitesurvey AP must use the same radio that is enabled in the AP. By default, both the radios are enabled.

Configure Sitesurvey Refresh Rate

```
sitesurvey statsrefrate [<rate>]
```

This command configures the time interval (specified in milliseconds) at which the AP will collect and send (display) sitesurvey results. By default, the refresh rate is set to 1000ms. The sitesurvey results can be viewed from the sitesurvey GUI page or the CLI.

Setting the Tx Power

```
sitesurvey txpwr set <radio_index> [<tx_power>]
```

Where,

- radio_index can be 0, 1, or 3
- Enter 0 for radio 1 (2.4 Ghz)
- Enter 1 for radio 2 (5 Ghz)
- Enter 3 for both the radios

Use this command to selectively set the transmit power for AP radios. By default, Tx power is set to maximum possible Tx power based on the country code, channel and the hardware capabilities. The **`sitesurvey txpwr set 3`** command (without the power value) will set the max Tx power supported for the selected country to both the radios.

Save Sitesurvey Configuration

```
sitesurvey save
```

After you have configured all sitesurvey options, enter this command to save your sitesurvey configuration. This command creates an ESSID with all configured parameters. Your Wi-Fi can now associate to this AP using the ESSID.

Using GUI

You can access 192.168.1.2 (default IP address of the AP) in a browser, till the controller is discovered. Once site survey is enabled, connect a client with the site survey ESSIDs and access 192.168.0.1.
By default, the GUI page shows the site survey results page. Click the *Configure* button to access the sitesurvey configuration options.

TABLE 20: *Sitesurvey Configuration Parameters using GUI*

Parameters	Description
SSID Radio 0 SSID Radio 1	Enter a value that you will be broadcast for connecting your Wi-Fi client. The default values are Fortinet_Site_Survey_2.4 for Radio 0 and Fortinet_Site_Survey_5 for Radio 1.
Country	Select a country from this list. This selection automatically sets the first valid channel for each radio. However, you can choose to override them by selecting a different channel number.
Radio 2.4 Ghz Radio 5 Ghz	Select ON or OFF to enable or disable a radio.
Tx Power Radio 0 Tx Power Radio 1	Enter transmit power for each of the radios. Maximum value for Radio 0 (2.4 Ghz) and maximum value for Radio 1 (5 Ghz) is dependent on the selected country and the channel.
2.4 Ghz Channels 5 Ghz Channels	Select a valid channel. By default this is automatically set to the first valid channel for the selected country.
Publish SSID Radio 0 Publish SSID Radio 1	Select ON or OFF to broadcast SSID.
Stats Refresh Rate	Enter the time interval (in milliseconds) to collect and send (display) sitesurvey results.
Inactivity timeout period	Enter the time interval (in seconds) for the AP to wait for client to connect. After the inactivity time period, the AP will reboot to normal AP mode.

After configuring the above parameters click the Apply button to save the configuration.

Viewing Sitesurvey Results

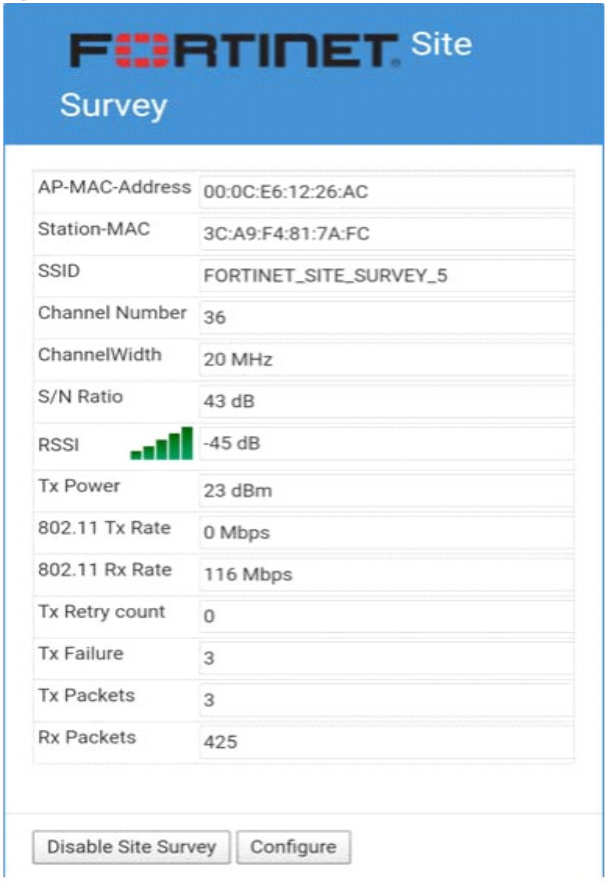
Sitesurvey results can be viewed from CLI and using the GUI.

Using GUI

By default, the Sitesurvey page (Figure 2) is displayed when you connect to the AP via browser. The Sitesurvey page among other pre-configured values displays key information about the connectivity experience of your Wi-Fi client.

The GUI page shows Sitesurvey results of only ONE client (the last connected client) connected to the AP. To view Sitesurvey results from all connected clients, use options from CLI.

Figure 82: *Viewing Sitesurvey Results*



Connectivity Experience Parameters

The Sitesurvey parameters that include RSSI, S/N Ratio, Tx Power, 802.11 Tx Rate, and 802.11 Rx Rate illustrate the connection experience of the Wi-Fi client at the given location.

Troubleshooting Parameters

The parameters, Tx Retry count and Tx Failure illustrate issues or errors in connection between the Wi-Fi client and the AP at the given location.

Network Parameters

Tx Packets and Rx Packets indicate the network data traffic between the AP and the Wi-Fi client.

NOTE : As you move with your Wi-Fi client, the survey results are updated as per configured refresh rate.

Disable Site Survey

To disable Sitesurvey on the AP, click the Disable Sitesurvey button. This button will reboot the AP into normal AP mode.

Using CLI

Viewing Sitesurvey Configuration

```
sitesurvey showconfig
```

This command displays the current sitesurvey configuration.

Sample Output

```
ss > sitesurvey showconfig
Site Survey                         : 1
Country Code                        : US
AP IP address                       : 192.168.0.1
AP Netmask                          : 255.255.255.0
SSID for radio0                     : FORTINET_SITE_SURVEY_2.4
SSID for radio1                     :  FORTINET_SITE_SURVEY_5
Broadcast SSID for radio0           : 1
```

```
Broadcast SSID for radio1            : 1

radio0 <2.4G>                        : 1

radio1 <5G>                          : 1

Channel for radio0                   : 6

Channel for radio1                   : 36

Tx Power for radio0             : 25

Tx Power for radio1             : 23

Basic Tx Rate for radio0       : 1 2 5.5 11

Basic Tx Rate for radio1       : 1 2 5.5 11

Stats Refresh Rate            : 1000

Inactivity Timeout             : 3600

ss >
```

Viewing Sitesurvey Results (Statistics)

```
sitesurvey showstatistics
```

This command displays sitesurvey results of all the Wi-Fi clients connected to the AP.

Sample Output

```
ss > sitesurvey showstatistics

ss >

      AP MAC         STATION MAC                ESSID             Ch  ChWd SNR
   RSSI TxPwr TxRate RxRate TxRetry TxFail  TxPkts  RxPkts

----------------- ----------------- ------------------------------  --- ---- --
   - ---- ----- ------ ------ ------- ------- ------- -------

00:0c:e6:12:28:1f 6c:88:14:f3:a8:04                    survey51   36   20  42
   -45    23    144    130       0       1      65     68 ss stats

ss >

      AP MAC         STATION MAC                ESSID             Ch  ChWd SNR
   RSSI TxPwr TxRate RxRate TxRetry TxFail  TxPkts  RxPkts
```

```
---------------- ---------------- ----------------------------  --- ---- --
   - ---- ----- ------ ------ ------- ------- ------- -------

00:0c:e6:12:28:1f 6c:88:14:f3:a8:04                     survey51   36   20  42
   -45    23    144    130       0       1      66     68 ss stats

ss >

      AP MAC         STATION MAC                ESSID             Ch  ChWd SNR
   RSSI TxPwr TxRate RxRate TxRetry TxFail  TxPkts  RxPkts

---------------- ---------------- ----------------------------  --- ---- --
   - ---- ----- ------ ------ ------- ------- ------- -------

00:0c:e6:12:28:1f 6c:88:14:f3:a8:04                     survey51   36   20  42
   -45    23    144    123       0       1      68     68 ss stats

ss >

      AP MAC         STATION MAC                ESSID             Ch  ChWd SNR
   RSSI TxPwr TxRate RxRate TxRetry TxFail  TxPkts  RxPkts

---------------- ---------------- ----------------------------  --- ---- --
   - ---- ----- ------ ------ ------- ------- ------- -------

00:0c:e6:12:28:1f 6c:88:14:f3:a8:04                     survey51   36   20  42
   -45    23    144    104       0       1      69     691

ss >
```

Automatic Radio Resource Provisioning (ARRP)

By using the ARRP feature, each AP scans all channels and provides the scan details to the controller. The controller uses this information to select and allocate the best available channel per radio. By default, this feature is disabled.

- Supported only on 11ac/11ax APs.
- Once enabled, the virtual cell is not available for 11ac APs.
- Non-11ac/11ax APs will continue to work as configured and will not be affected by auto channel feature.

Configuring Using WebUI

To enable this feature, go to **Configuration > Wireless > ARRP** and in the configuration tab, enable the Auto Channel option.

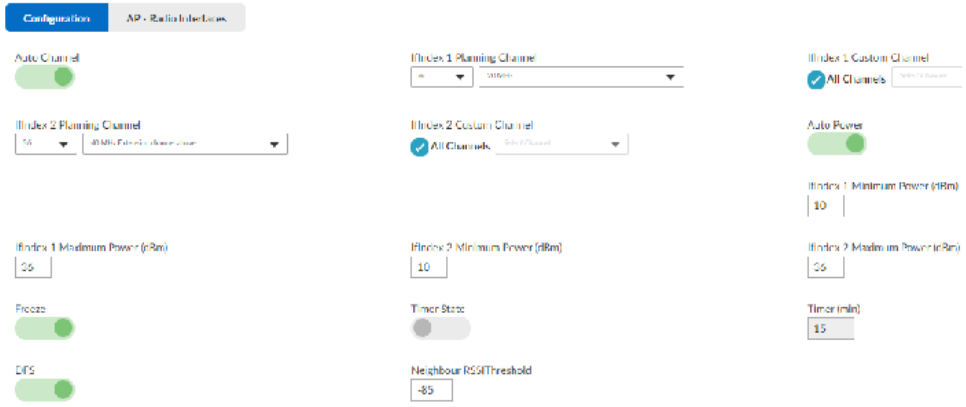
The ARRP planning status on the Feature Group page displays the date and time when the planning was done and a list of overlapping APs (APs sharing channels with their neighbours). See *"Feature Group"* ***on page 84***.

You can configure the maximum and minimum power levels at ARRP mode. The AP operates within these limits.

- FortiWLC automatically changes parameters such as the transmit power of the connected APs and RF channel as per changing conditions, interference/noise status and other foreign APs in the same environment.
- If an AP failure is detected by a neighboring AP then it automatically tries to reduce the RF coverage gap by increasing their transmit power.
- Different channels are assigned to APs in case of interferences like microwave, bluetooth and so on.

Note: When global ARRP is enabled, all FAP-U431/433F APs should have the same dual-mode settings (enabled or disabled on APs).

Figure 83: *Configuring ARRP*



You can configure ARRP settings for interface 1 (**IfIndex1**) and interface 2 (**IfIndex2**).

- Planning Channel: Once enabled, the respective radios of all APs are set to the channels selected for radio 1 and radio 2. Based on the report received by all APs, the controller allocates the optimum channel.
- Custom Channel: Based on the planning channel width, the custom channels can be configured for the radios.
  Note: DFS channels are not available to be set as planning channel.
- Auto Power: The auto power functionality is applied only after channel allocation irrespective of when the auto power option was enabled. When enabled, the controller will determine the optimum power level between neighbouring (by channel) 11ac APs. The auto

power option can be enabled and applied only when Auto RF feature is enabled. You can specify the Minimum Power and Maximum Power in the range of 10-36 dBm.

- Freeze: The option is applied after the initial planning phase. When this option is disabled, the 11ac APs perform periodic scan (at the end of every minute) on their allocated channels. This is used to determine the quality of the channel. If the quality of the channel crosses the threshold limit (based on three consecutive scans), it sends a request for change of channel. If enabled, the periodic scan is disabled and the 11ac APs remain in allocated channels irrespective of the channel quality.
- Planning Channel Width: Select the planning channel width.

Note: If this option is disabled, the radio interface settings cannot be modified.

- Timer State and Timer: This option is available only when the Freeze option is disabled. To avoid frequent channel change, you can set the channel scan interval to happen at the end of 15 minutes. By default the timer interval is set to 15 minutes and maximum is 3600 minutes. When enabled, the APs start their channel quality scan at the end of 15th minute and continue to scan at the end of every minute for 10 minutes. Based on the data gathered during this period channel change may happen. At the end of the 10 minute of the scan, the channel scanning is disabled for the next 15 minutes.
- DFS: By default scanning and allocation of DFS channel is disabled during the planning phase. If enabled, the APs can scan DFS channels and they can be allocated DFS channels.
  Note: DFS option must be selected when the ARRP is enabled. Enabling DFS after enabling ARRP will require re-planning of channel allocation for all APs.
- Neighbour RSSI Threshold: Set the minimum RSSI value for the neighbouring APs. The default is -85dbm and the valid range is -95dbm to -30dbm. The AP-Radio Interfaces tab lists all APs with operating frequency and power rating.
- Replan: This option is to be used if a new AP is added to the network after the initial planning is complete. The AP-Radio Interfaces tab lists all APs with operating frequency and power rating.

The AP-Radio Interfaces tab lists all APs with operating frequency and power rating.

Configuring Using CLI

- Use the **`show arrp-config`** command to view the current settings

```
Default-AC-MCA(15)# show arrp-config

MCA Global Settings

Enable/Disable Auto Channel : enable

Radio 1 Channel             : 11

Radio 1 Channel Width       : 20-mhz
```

```
Radio 2 Channel             : 48

Radio 2 Channel Width       : 20-mhz

Auto Power on/off           : off

Freeze yes/no               : No

Timer State on/off          : on

Timer                       : 15

Dfs on/off                  : on
```

- Use the **show arrp-ap-radio-interface** command to view the list of APs and their operating frequency and power values.

```
Default-ARRP(15)# show arrp-ap-radio-interface

AP ID AP Name Radio1 oper ch Radio2 oper ch Radio1 Transmit Power (dBm) Radio2
   Transmit Power (dBm)

3     AP-3     6              36             24                          23

4     AP-4     1              36             24                          23

6     AP-6     6              40             24                          23

13    AP-13    1              36             24                          23

17    AP-17    1              36             24                          23

19    AP-19    6              36             10                          13

20    AP-20    6              36             24                          23

ARRP radio interfaces(7 entries)
```

- Use the **arrp global** command followed by one of the following options to configure and use the ARRP feature

```
-auto-power - To enable or disable auto allocation of transmit power

-dfs - To enable or disable the use of DFS channels in planning

-disable - To disable ARRP

-Enable - To enable ARRP

-Freeze- To enable or disable dynamic channel scanning

-radio1-channel-planning- To specify channel for initial planning

-radio2-channel-planning- To specify channel for initial planning
```

-replan- To perform re-planning if a new AP has joined network

-timer-state- Enable or disable to avoid frequent channel change

-timer-value- To specify the time interval for the dynamic channel scan

Limitations

- If disabled, existing vCell profiles will be pushed to all 11ac APs irrespective of whether the AP was part of the vCell profile before auto channel feature was enabled. Native cell profiles will remain unchanged.
- As part of auto power functionality, the Tx power levels on the AP is not increased back to default values if the neighboring AP which this AP earlier reported as having high power goes down.

Hotspot 2.0

Hotspot 2.0 is a specification by the Wi-Fi Alliance that specifies a framework for seamless roaming between WiFi networks and Cellular networks. The specification is based on the IEEE802.11u standard; a Generic Advertisement Service (GAS) that provides over-the-air transportation for frames of higher layer advertisements between stations APs and external information servers. This feature will allow users to configure hotspot profiles that can (optionally) be connected to existing ESS Profiles as desired. An ESS-profile connected to a hotspot profile will advertise 802.11u capabilities in its beacons.

FAP-U42x and FAP-U32x are Passpoint R2 certified.

Adding a Hotspot 2.0 Profile

The Hotspot Profiles can be created from the **Configuration > Wireles > Hotspot 2.0** page. By default, the page shows the following details about a Hotspot profile.

- **Hotspot Profile Name** - Displays the name of the Hotspot Profile.
- **Description** - Displays the Description provided for the Hotspot profile.
- **Internet connectivity** - Enable to advertise whether internet connectivity is available or not at the AP from beacons and probe responses.
- **Venue Type** - Displays the Venue Type.
- **Access Network Type** - Select the Access Network Type from the list. The default selection is displayed as Private Network. The types are as follows:
  - Private Network
  - Private Network with Guest Access
  - Chargeable Public Network
  - Free Public Network

    - Personal Device Network
    - Emergency Services Only Network
    - Test or Experimental Network
    - Wildcard Network
- **IPv6 Availability** - Select the IPv6 Availability from the list. The default selection is displayed as Address type not available. The types are as follows:
    - Address type available
    - Address type not available
    - Availability of the Address type not known
- **IPv4 Availability** - Select the IPv4 Availability from the list. The default selection is displayed as Address type not available. The types are as follows:
    - Address type available
    - Address type not available
    - Availability of the Address type not known
    - Port-restricted IPv4 address available
    - Single NATed private IPv4 address available
    - Double NATed private IPv4 address available
    - Port-restricted IPv4 address and single NATed IPv4 address available
    - Port-restricted IPv4 address and double NATed IPv4 address available
- **Roaming Consortium** - Enter the roaming ORG ID for the Hotspot profile. The valid range is 0-10 characters.
- **Operators** - Enter multiple network operators. Select a language and enter a name. The valid range is 0 - 256 characters.
- **Venue** - Enter multiple Hotspot venues wit descriptions. Select a language and enter a name. The valid range is 0 - 512 characters.
- **3GPP Cell Network** - Provide the following details:
    - Country name of the operator.
    - Country code of the operator.
    - Provide the 3GPP Cell Network MCC. The default value is displayed is 0. The Valid range is [1-999].
    - Provide the 3GPP Cell Network MNC. The default value is displayed is 0. The Valid range is [1-999].
- **Domain Name** - Provide the Domain Name. The valid range is [0-128] chars.
- **NAI Realm from 1-10** - Provide the NAI Realm [1-10] from the list. The valid range is [0-50] chars.

- **NAI Realm Auth Method from 1-10** - Select the NAI Realm Auth Method [1-10] from the list. The valid range is [0-50] chars. The types are as follows:
  - EAP TLS Certificate
  - EAP TTLS MSCHAPv2 Username/Password
  - EAP SIM
  - EAP AKA
  - EAP AKA`
- **Advanced Settings** - Provide the following configuration details for advanced settings:
  - HESSID - A globally unique identifier, used to give a single identifier for a group of APs connected to the same SP or other destination network(s).
  - GTK Per Station - Enables the Group Temporal Key (GTK) to be assigned per station.
- Gas Come Back Flag - Enables the Generic Advertisement Service (GAS) comeback request/response option.
  - Gas Come back Delay (millisecs) - At the end of the GAS comeback delay interval, the client can attempt to retrieve the query response using the comeback request action frame.
  - ASRA Flag - Enable the Additional Step Required for Access (ASRA) to indicate that the network requires one more step for access.
  - Authentication type - Configure the network authentication type required as per ASRA. Supported values are, Acceptance of terms and conditions, On line enrolment supported, http/https redirection, and DNS redirection.
  - Redirect URL - Specify the Redirect URL in case of http/https redirection and DNS Redirection.
- **WAN Metrics** - Provide the following configuration details for WAN metrics:
  - Link Status State - Select the status of the WAN link.
  - Symmetric Link - Enable symmetric bandwidth.
  - At Capacity - Select whether the WAN link is at capacity and no additional mobile devices will be allowed to associate with the AP.
  - Down Link speed/Up Link speed - The WAN Backhaul link for current downlink/uplink speed in KBPS.
  - Down Link load/Up Link load - The current percentage load of the downlink/uplink connection, measured over an interval the duration of which is reported by the Load Measurement Duration.
  - Load Measurement Duration - The duration over which the downlink/uplink load is measured in KBPS.
  - Connection CapabilityThe Connection Capability enables filtering of protocols, allowing or restricting traffic on some protocols and ports. A set of system defined protocols as listed. Additionally, you can also create rules for custom protocols.

- **QoS Map** - Create a Quality of Service (QoS) policy by configuring the following DSCP ranges and DSCP exceptions.
  - DSCP Ranges - For a given DSCP range, specify the User Priority (valid range: 0 -7), DSCP High Priority (valid range: 0 - 255), and DSCP Low Priority (valid range: 0-255).
  - DSCP Exceptions - For a given DSCP exception, specify the User Priority (valid range: 0 -7) and the DSCP Value (valid range: 0 - 255).
- **3rd Party attributes** - The following third party attributes can be configured in **Advanced Settings**.
  - SVR Device Type
  - SVR Device Model Number
  - Aggregation AAA
  - BW Class
  - Venue Id
- **Validate User Id -** When enabled, the data packets that do not match the configured **3GPP Cell Network** values of **MCC** and **MNC** are dropped. This parameter is disabled by default.
- **Include Vendor Attributes -** When enabled, the data packets configured with the **3rd Party Attributes**, **NAS IP** (RADIUS), and **Geo Location** are processed. This parameter is disabled by default.
- **OSU Settings** - The Online Sign Up (OSU) Service settings configures one or more Hotspot providers offering OSU service.
  - Online Sign Up Support - Select to enable OSU.
  - OSEN Enable - Enable OSU Server-only authenticated layer-2 Encryption Network (OSEN) to indicate that the hotspot uses a OSEN network type. This network provisions clients using the OSU functionality.
  - OSU/OSEN ESSID - Specify the OSU ESSID.

OSU Server URL - Specify the URL of the OSU server.

- OSU NAI - Specify the OSU NAI for authentication.

Click Settings to configure the OSU provider settings.

- OSU Provider Friendly Names
- OSU Provoder Icons
- OSU Provider Method - Select one of the OSU provider provisioning methods, OMA-DM or SOAP-XML.
- OSU Provider Description - The description of the OSU Provider.

Select **OK**. The Hotspot Profile is added and displayed on the Hotspot Profile screen.

The following operations can be performed on the Hotspot 2.0 profile.

- **Delete** - Select a Hotspot Profile and click **Delete**. The selected Hotspot Profile gets deleted from the Hotspot Profile screen.
- **Edit** - Select a Hotspot Profile and click **Edit**.
- **View** - Allows to view the details of the Hotspot Profile. Select a Hotspot Profile and click **View**.

Configuring 802.11k/r

Devices can now benefit from the 802.11r implementation to fast roam between best available access points within a controller domain. Additionally, with implementation of 802.11k specifications you can now calculate 802.11k neighbor and radio measurement reports.

The fast roaming capability and 802.11k is configurable in ESS profile.

Limitations

- Supported only for clients that are compliant with 802.11k/v/r specifications
- Fast roaming is not available in inter-controller roaming.

Enabling 802.11k

Using WebUI

- Go to Configuration > Wireless > ESS and in the ESS Profile tab, change the following:
  - For 802.11r, select **On**.
  - For 802.11r Mobility Domain, enter an integer value.
  - For 802.11k, select **On** to perform radio measurements.

Using CLI

```
default(15)# configure terminal

default(15)(config)# essid fastroam-1

default(15)(config-essid)# 802.11r on

default(15)(config-essid)# 802.11k on

default(15)(config-essid)# 802.11r-mobility-domain-id 100
```

Roaming Across Controllers (RAC)

Clients can roam between access points connected to two different controllers in same subnet or different subnets. FortiWLC (SD) allows you to specify static or dynamic roaming.

The RAC feature is supported for 802.11r clients from FortiWLC 8.6 onwards. As the clients roam between the controllers configured in the RAC domain, M1 to M4 authentication processes are eliminated; this enables fast roaming and reduces re-authentication latency.

Things to consider before enabling RAC

- IP PREFIX validation has to be OFF in the RAC enabled ESS profile.
- RAC can be enabled on more than one ESSID
- If any parameter of an ESSID profile is changed, then RAC must be stopped and the changes made in the ESSID must be updated to all controllers in the roaming domain.
- Ensure that the controller IP is reachable before adding its IP address to the roaming domain.
- In the output of show roaming-domain all command, the -1 value in the VLAN column depicts tunnelling to another controller in the roaming domain.

In **static DHCP home configuration**, you specify one of the controllers (in the roaming domain) as the home controller. A client associating with any controller in the roaming domain will receive an IP address from this home controller. Once a controller is set has the home controller, it applies to all the native VLAN, configured VLAN and dynamic VLAN configurations of that controller as per the "tunnel interface type" set in the ESS profile.

In **dynamic DHCP home configuration**, a client associating with a controller for the first time will continue to receive IP address from that controller and will be the clients the home controller. To allow dynamic roaming, set the home controller IP address as 0.0.0.0.

Roaming Time-out

In a dynamic roaming scenario, if a client leaves the coverage area and returns after the configured timeout value, a fresh association happens and the client may get associated with a different controller as its home controller. The roaming time-out value (in minutes) for clients can be configured via CLI:

```
default(15)(config)# roaming-domain roam-time-out 70
```

Default and minimum timeout value is 60 minutes and maximum is 240 minutes. The roaming timeout countdown starts as soon as the client leaves the coverage area.

NOTE: When RCA is stopped all the existing clients are forcefully de-authenticated and forced to reconnect. Irrespective of the client has roamed or not, this process is applied to all clients in the roaming domain.

Setting up RAC requires the following steps

Static Roaming

1. Specify an ESSID for the roaming domain.
2. Add your controller's IP address as the member controller.
3. Add your controller's IP address as the Home controller.
4. Repeat the above steps for adding peer controllers. Ensure that you keep the same ESSID name and the home controller IP address.

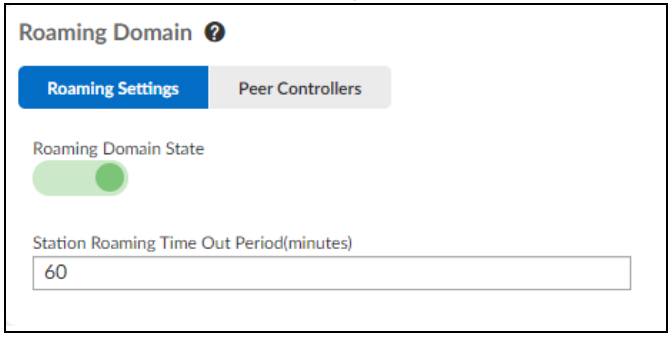
Dynamic Roaming

1. Specify an ESSID for the roaming domain.
2. Add your controller's IP address as the member controller.\
3. Add 0.0.0.0 as the IP address of the home controller.
4. Repeat the above steps for adding peer controllers. Ensure that you keep the same ESSID name and the home controller IP address as 0.0.0.0.

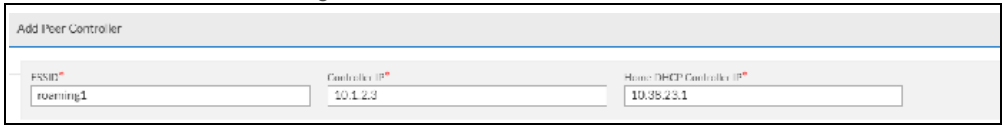
Configuring Using WebUI

1. Go to Configuration > Wired > RAC.
2. In the Peer Controllers tab add the following:

- ESSID: This should be replicated as-is across in all controllers in the roaming domain.
- Peer Controller IP address
- Home DHCP controller IP address: IP address of the home controller in the roaming domain. All the DHCP packets from the visiting client will be forwarded to this home controller and will be delivered locally in the home controller.



3. Select Enable for Roaming Domain State



Configuring Using CLI

A new CLI command roaming-domain with the following options is available to set up RAC

- essid - Specify the name of the common ESSID that is available in all 6 controllers in the roaming domain
- start - To start RAC.
- stop - To stop RAC
- peer-controller - To specify the IP address of the peer controller in the roaming domain
- homedhcp-controller - To specify the home controller in the roaming domain.

Example

```
default(15)(config)# roaming-domain start
```

```
default(15)(config)# roaming-domain essid Roaming1 peer-controller 10.10.1.20
   homedhcp-controller 10.10.12.100
```

Dynamic DHCP home

```
default(15)(config)# roaming-domain essid Roaming1 peer-controller 10.10.1.20
   homedhcp-controller 0.0.0.0.
```

Where, essid is the name of the "ESS profile" string displayed in the show essid command.

Replacing Access Points

You can replace APs in one of the following conditions:

- If you have a faulty AP, you can replace that with a new AP of the same model as the faulty AP.
- Migrate from an older AP model to a newer AP model.

Before Replacing Access Points

The following are important points to remember before you replace your access points:

- Replacing one AP model with another usually preserves the settings of the original configuration. A newer AP may have settings that the older one does not; those settings will be set to the default.
- Despite the fact that some AP settings and configurations can be carried over when replacing an AP, users cannot simply replace an AP with a different model The two models have very different capabilities and configuration specifications and should not be considered synonymous.

How to Replace Access Points

If you are replacing existing APs with a newer model of APs, use the **ap-swap** command to ease the task of updating your site's AP settings. To use the **ap-swap** command, you need the MAC addresses of the new and old APs. You can check MAC addresses of the APs to be replaced with the **show ap** command.

The **ap-swap** command equates the MAC address of an AP that you want to replace with the MAC address of the new AP. By linking the numbers to an AP ID in the replacement table, the system can assign the configured settings from the old AP to the new AP. The settings that are tracked are the channel number, preamble, and power settings. After inputting the swap information, use the **show ap-swap** command to double check the AP MAC settings before physically swapping the APs.

Once you have double-checked the MAC addresses, take the old APs off-line by disconnecting them from the system. Replace the APs. When the APs are discovered, the replacement table is checked, and the changes are applied to the new APs. Once the new AP has been updated, the entry is removed from the replacement table.

To summarize the steps to replace the APs:

```
forti-wifi (config)# show ap (gets the serial numbers of the APs you are replacing)
   forti-wifi (config)# swap ap 00:oc:e6:00:00:66 00:CE:60:00:17:BD
   forti-wifi (config)# exit
   forti-wifi# show ap-swap
    AP Serial Number        New AP Serial Number
   00:0c:e6:00:00:66       00:ce:60:00:17:bd
   AP Replacement Table(1 entry)
   forti-wifi# show ap
```

After you completed the commands for replacing APs, disconnect the old APs and make sure they show Disconnect/off-line status) and then replace the old APs with the new APs

Configuration Updates After AP Replacements

TABLE 21: *Configuration Updates After AP Replacement*

AP Types	Configuration Changes	Other
Both APs (new and the one that is replaced) are same	The following configurations are preserved: • ATS-Entry: AP name, location, Contact, Descr, KeepAlive • 802.11 Entry: RFType, Channel, Tx Power, Channel-Width, VCell Mode. • ESS-AP Entry: BSSID, Channel	This is usually used while replacing faulty APs.
AP Models are different	Only the following AP configurations will be preserved • ATS-Entry: AP name, location, Contact, Descr, KeepAlive The following Radio/BSSID configuration will be changed to default setting for the newer AP model. • 802.11 Entry: RFType, Channel, Tx Power, Channel-Width, VCell Mode. • ESS-AP Entry: BSSID, Channel	This is usually done while migrating from older AP models to newer AP models.

AP Packet Capture

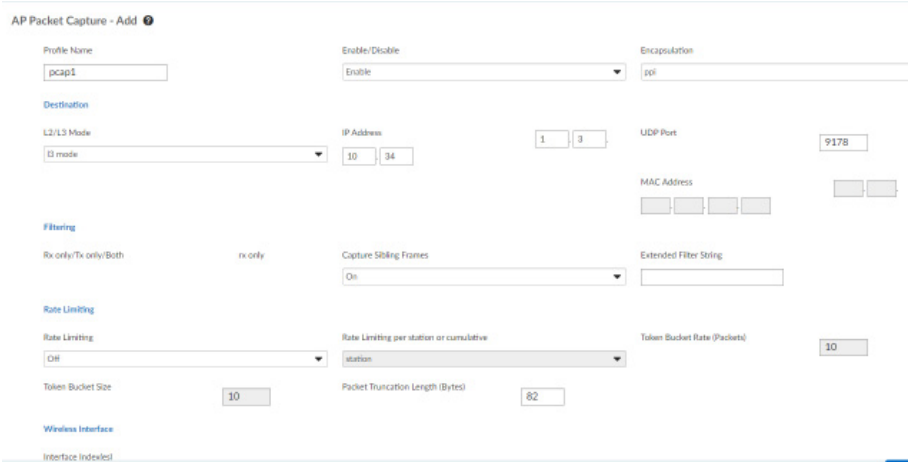
The AP Packet Capture feature is essential on the Fortinet based Access Point products which helps the Customer Support and the Engineering to gather 802.11 wireless packet captures to isolate root cause failure analysis. The packet capture module will leverage the existing packet capture functionality in the Fortinet APs. To modify the AP Packet Capture Profiles, the below fields must be modified:

The following AP Packet Capture Profiles information is displayed.

- Profile Name: Displays the Name of the AP Packet Capture Profile.
- Enable/Disable: Displays if the Profile is Enabled or Disabled.
- L2/L3 Mode: Displays the transmit mode if L2 or L3
- Interface Index: Displays the Interface Index.
- Packet Truncation Length: Displays the Packet Truncation Length (Bytes).
- Rate Limiting: Displays the Rate Limiting if On or Off.

Adding an AP Packet Capture Profile

To Add an AP Packet Capture Profiles, the below mentioned steps must be followed.



1. Click the **Add** button on the AP Packet Capture Profiles screen. The **AP Packet Capture Profiles - Add** screen is displayed.
2. On the **AP Packet Capture Profiles - Add** screen, update all the fields.

- Profile Name: In the Profile Name box, type the name of the AP Packet Capture Profile. The AP Packet Capture Profile Name is an alphanumeric string that is 0 to 63 characters long. You must enter an AP Packet Capture Profile Name.
- Enable/Disable: Select the AP Packet Capture Profile to be Enabled or Disabled.
  - Enable: If the AP packet capture profile is set to Enable, the packets will be forwarded to destination.
  - Disable: If the AP packet capture profile is set to Disable, no packets will be forwarded to destination
- Destination: It is the location Server that can receive the captured packet stream either in L2 payload or in L3 payload. It can also be a host in the same L2 network as the AP identified by the destination MAC address, or can be a identified by an IP address (L3).
  - L2/L3 Mode: Select the transmit mode if L2 or L3.
    - L2: Select the transmit mode as L2 and specify the MAC Address. In L2 mode, the AP forwards the captured packet stream to the Location Server's MAC address. The Location Server's MAC address must be configured.
    - L3: Select the transmit mode as L3 and specify the IP Address and UDP Port. In L3 mode, the AP forwards the captured packet stream to the Location Server's IP address. The Location Server's IP address and UDP port must be configured .

    - IP Address: This feature is enabled only when the mode selected is L3. Type the IP Address.
    - UDP Port: This feature is enabled only when the mode selected is L3. Type the UDP Port number. The UDP Port is an alphanumeric string that is 0-65535 characters long.
    - MAC Address: This feature is enabled only when the mode selected is L2. Type the MAC Address.
- Rx only/Tx only/Both: Displays the traffic snort if Rx only/Tx only/Both. Here Rx is the default and only this can be can be configured. All the packets received by the AP will be forwarded to the destination
- Capture Sibling Frames: Select the Capture Sibling Frames if On or Off. It filters the packets based on the Fortinet OUI.
    - On: All the Fortinet frames will be captured.
    - Off: All the Fortinet frames will not be captured.
- Extended Filter String: Type the Extended Filter String. The Extended Filter is an alphanumeric string that is 0-32 characters long. The existing capture profile allows to specify a list of MAC-addresses. If any of these MAC addresses are found in the frame header (AD1, AD2 or AD3), the packet will pass the filter.
- Rate Limiting: Select the Rate Limiting if On or Off.
    - On: By selecting the rate limiting as On, the number of packets passed to the server must match the Token rates. Also, only the rate limiting per station is configured no support for cumulative
    - Off: By selecting the rate limiting as Off, all the packets are forwarded by AP to the location server.
- Rate Limiting per station or cumulative: Displays the rate limit per station or cumulative.
- Token Bucket Rate (Packets): Displays the number of packets per second. Valid range. The Token Bucket Rate is an alphanumeric string ranges between 0-65535.
- Token Bucket Size: Displays the bucket’s capacity in terms of number of packets. The Token Bucket Rate is an alphanumeric string ranges between 0-65535.
- Packet Truncation Length (Bytes): Type the Packet Truncation Length (Bytes). The Packet Truncation Length is an alphanumeric string ranges between 0-1400.
- Interface Index(es): Select the Interface Index(es)if 1st, 2nd, or all
    - When Interface is configured as 1, only packets from interface 1 are forwarded by the AP.
    - When interface is configured as 2, only packets from interface 2 are forwarded by the AP.
    - When interface is configured as 'all', packets from both the interface will be forwarded by the AP.
- AP Selection: Any enabled packet capture profile is downloaded to an AP, only if the AP is listed in the profile.

- AP List: Displays a list of APs in string which are separated by comma
- Add: Select the Add button to add APs. The AP Table screen is displayed. The AP's can be added to the AP list by the 'Add' option on which a packet capture profile is downloaded.
- Delete: Select the AP and click Delete. The selected AP is removed from the AP List. Here the AP's can be deleted from the AP List through.
- AP ID: Displays the Id of an AP.
- AP Name: Displays the Name of an AP.
- Operational State: Displays the Operational State of an AP, if Enabled or Disabled.
- Availability Status: Displays the Availability Status of an AP, if Online or Offline.
- AP Model: Displays the Model type of an AP.

3. Complete the details on the AP Packet Capture Profiles - Add and Click OK.
4. The New AP Packet Capture Profile gets added and is displayed on the AP Packet Capture Profiles screen.

You can delete and modify an existing packet capture profile.

On the AP Packet Capture Profiles screen select one AP Packet Capture Profile and click the **View Details** button. The AP Packet Capture Profiles – Details screen is displayed.

The AP Packet Capture Profiles – Details screen displays a summary of all the details of the selected AP Packet Capture Profile.

On the AP Packet Capture Profiles screen select the Arrow button located beside every AP Packet Capture Profile. The **AP Packet Capture Profiles – Update** screen is displayed.

The **AP Packet Capture Profiles – Update** screen displays a summary of all the details of the selected AP Packet Capture Profile. Some of the fields can be modified in this screen. The details provided on the **AP Packet Capture Profiles – Update** screen is similar to the details provided on the AP Packet Capture Profiles – Add screen.

Modify the AP Packet Capture profile and click **Ok**.

The modified AP Packet Capture Profile is updated and is displayed on the AP Packet Capture Profiles screen.

Supported Modes of Operation for APs

AP Model	Radio 1	Radio 2	Radio 3
AP122	BGN	AC	-
AP822	BGN	AC	
AP832	BGN	AC	-
FAP-U42xEV	BGN	AC	-
FAP-U32xEV	BGN	AC	-

Security Modes

802.11i security standard supports WEP, WPA, WPA2 and mixed mode, 802.11n supports only clear and WPA2 security. Even though you can configure any security mode for 802.11n, you only gain 11n benefits using WPA2 or clear. Because of this, any 11n client connected to an SSID configured for WEP or WPA will behave like a legacy ABG client. An 802.11n ESSID configured for either WEP or WPA has no 802.11n rates for that ESSID. If you configure an ESSID for Mixed Mode, 802.11n rates are enabled only for the WPA2 clients; WPA clients behave like a legacy ABG client. See the chart below for details.

ESSID Security	11n Benefits
Clear and WPA2	All 11n benefits are realized.
WEP and WPA	No 11n benefits are realized. Clients behave like legacy ABG clients.
Mixed Mode	11n performance in ESS configured for mixed mode depends on kind of application used in the network. Only WPA2 clients connected to mixed mode have 11n benefits. WPA clients behave like legacy ABG clients.

When APs are in a Virtualization

All APs on the same channel in a Virtualization must have the same setting for these values:

- RF-Mode

- Channel Width
- N-only Mode
- Channel and MIMO mode

Configure Gain for External Antennas

The total power that an AP produces must not exceed 30dbi; this number includes any antenna gain. Therefore, if an antenna produces 2dbi, the radio can produce 28dbi. FortiWLC (SD) automatically sets antenna gain; it assumes an antenna with 5dbi and therefore sets the AP to 25dbi. This may or may not be correct for your antenna.

To check and change antenna gain, follow these steps from FortiWLC (SD):

1. Click Configuration > APs (under Devices).
2. Select an AP ID.
3. Click the Antenna Property tab.
4. Select an Interface (1/2).
5. Change the gain if needed.
6. Click OK.

The antenna gain value can never exceed the local power of the radios as set in the Dot 11 physical configuration.

Automatic AP Upgrade

The automatic AP upgrade features is enabled by default. It allows an AP's firmware to be automatically upgraded by the controller when the AP joins the WLAN. An AP cannot provide service (and consequently be part of the WLAN) if its firmware is at a different level than that of the controller.

When an AP initiates its discovery phase, the controller checks the firmware version and initiates an upgrade if the version is not at the same level as that of the controller. This feature simplifies the process of adding and maintaining a group of APs on an existing WLAN.

When the automatic AP upgrade feature is enabled, you can check the upgrade status of affected APs through syslog messages and SNMP traps that warn of an AP/controller software version mismatch. An alarm is dispatched to an SNMP manager if a mismatch exists. After the firmware is downloaded to the AP, the AP boots, attempts discovery, is checked, and after upgrading, runs the new software version. Once the match is confirmed, another set of syslog messages and SNMP traps are sent notifying that the AP/controller software versions match. Alarms are then cleared.

To disable this feature:

```
default# auto-ap-upgrade disable
  FortiWLC# show controller

Global Controller Parameters

Controller ID : 1

Description : controller

Host Name : default

Uptime : 18d:00h:13m:08s

Location :

Contact :

Operational State : Enabled

Availability Status : Online

Alarm State : No Alarm

Automatic AP Upgrade : off

Virtual IP Address : 10.33.96.201

Virtual Netmask : 255.255.255.0

Default Gateway : 10.33.96.1

IPv6 Global Address : 2001:470:ecfb:45f:feaa:14ff:fee7:2d4a

IPv6 Link Local Address : fe80::feaa:14ff:fee7:2d4a

Default IPv6 Gateway : fe80::d27e:28ff:fe48:96

DHCP Server : 127.0.0.1

Statistics poll period (sec)/0 => disabled : 60

Audit poll period (sec)/0 => disabled : 60

Software Version : 8.5-0dev-27

Network Device Id : fc:aa:14:e7:2d:4a

System Id : 2701C69EB576

Default AP Init Script :

DHCP Relay Passthrough : on
```

```
Controller Model : FortiWLC-200D

Region Setting : US

Country Setting : United States Of America

Manufacturing Serial # : N/A

Management by wireless stations : on

Controller Index : 0

FastPath Mode : on

Bonding Mode : single

Station Aging Out Period(minutes) : 2

Roaming Domain State : enable

Station Roaming Time Out Period(minutes) : 60

Layer3 Routing Mode : off

Force Dhcp Retries : 4

VM NIC Queues :0#
```

From the Web UI, view AP radio status by clicking Monitor > Dashboard > Radio or Monitor > Diagnostics > Radio. Click Help for descriptions of the charts. The icons at the bottom of all screens include a green AP (enabled) and a red AP (disabled); you can also see the same information at Monitor > Dashboard > System.

There are several CLI commands you can use to view AP status:

TABLE 22: *Commands to View System Status*

Command	Purpose
show ap [index]	Displays the status of the AP, such as serial number, uptime, operational status, availability, alarm state, security mode, privacy bit, boot script, AP model, and FPGA version. If the AP index is not specified, a summary of the AP status is displayed.
show antenna-property	Displays the antenna properties.
show ap-connectivity	Displays the access point connections.
show ap-discovered	Displays the list of discovered access points and stations.

TABLE 22: *Commands to View System Status*

Command	Purpose
show ap-limit	Displays how many APs are licensed for this controller.
show ap-siblings	Displays the AP Siblings table. APs operating in the same channel that can hear each other are AP-siblings. APs can hear beacons with RSSI as low as -80 to -85dbm, but RSSI values lower than this are not heard.
show ap-swap	Displays the access point replacement table.
show ess-ap	Displays the ESS-AP table for the access point.
show interfaces Dot11radio	Displays the configuration of the wireless interface.
show interfaces Dot11Radio statistics	Displays the statistics related to the wireless interface.
show regulatory-domain	Displays the regulatory information for the country.
show statistics top10-ap-problem	Displays a list of the top 10 problem access points.
show statistics top10-ap-talker	Displays a list of the top 10 most active access points.
show topoap	Displays the topology of all access points as seen by the coordinator.
show topoapap	Displays the Received Signal Strength Indicator (RSSI) between all pairs of APs.

15 Configuring Quality of Service

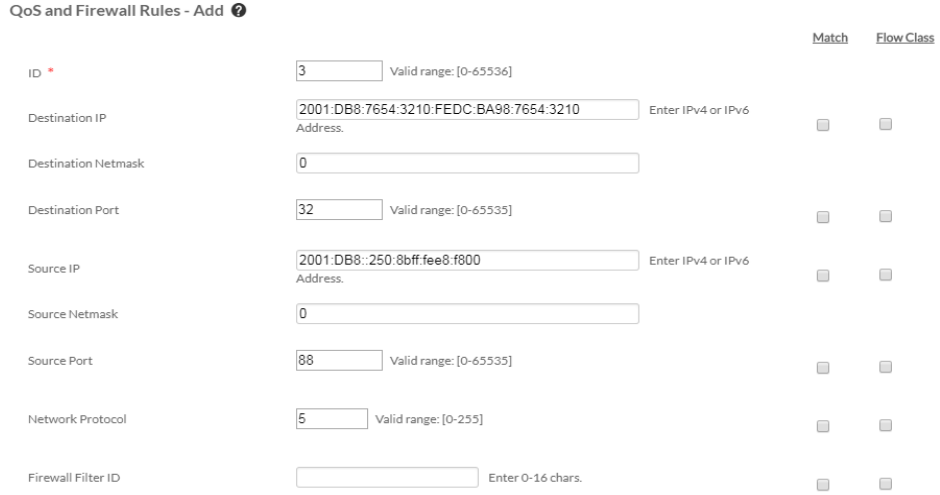
Quality of Service rules evaluate and prioritize network traffic types. For example, you can prioritize phone calls (VoIP) or prioritize traffic from a certain department (group, VLANs) in a company. This chapter describes QoS settings for Wireless LAN System.

Configuring QoS Rules With the Web UI

To configure QoS rules from the GUI, follow these steps:

1. Click Configuration > QoS Settings > QoS and Firewall Rules (tab).
2. Click Add. The screen below appears.

Figure 84: *Add a QoS Rule --- change..*



3. In the ID field, type a unique numeric identifier for the QoS rule. The valid range is from 0 to 6000.
4. In the Destination IP fields, type the destination IP address (IPv4/IPv6) to be used as criteria for matching the QoS rule. The destination IP address is used with the destination subnet mask to determine matching.
5. In the Destination Netmask fields, type the subnet mask for the destination IP address.
6. In the Destination Port field, type the TCP or UDP port to be used as criteria for matching the QoS rule. To specify any port, type 0 (zero).
7. In the Source IP fields, type the source IP address (IPv4/IPv6) to be used as the criteria for matching the QoS rule. The source IP address is used with the source subnet mask to determine matching.
8. In the Source Netmask fields, type the subnet mask for the source IP address.

Note:
The source and destination netmasks can be in the dotted quad format for IPv4 or in the prefix length notation for IPv6.

9. In the Source Port field, type the TCP or UDP port to be used as criteria for matching the QoS rule. To specify any port, type 0 (zero).
10. In the Network Protocol field, type the protocol number of the flow protocol for the QoS rule. The protocol number can be a number 0 through 255. The protocol number of TCP is 6, and the protocol number for UDP is 17. For a list of protocol numbers, see http://www.iana.org/assignments/protocol-numbers.
    If you are also using a QoS protocol detector, you must match the network protocol with the type of QoS protocol. Use the following network protocol and QoS protocol matches:

- UDP: SIP
- TCP: H.323 or SIP

11. In the Firewall Filter ID field, enter the filter-ID to be used (per-user or per-ESS), if Policy Enforcement Module configuration is enabled (optional feature). This ID must be between 1 and 16 alphanumeric characters.
12. In the Packet minimum length field, specify the size of the minimum packet length needed to match the rule. (Valid range: 0-1500.)
13. In the Packet maximum length field, specify the size of the maximum packet length needed to match the rule. (Valid range: 0-1500.)
14. In the QoS Protocol dropdown list, select one of the following:
    - SIP
    - H.323
    - Other
    - None

    For capture rules, the QoS protocol determines which QoS protocol detector automatically derives the resources needed for the flow (implicitly). Select Other if you want to specify the resource requirements for matched flows explicitly. The QoS protocol value is ignored for non-capture rules.
15. In the Average Packet rate box, type the average flow packet rate. The rate can be from 0 through 200 packets/second.
16. In the Action list, select the action the rule specifies:
    - Forward: A flow is given an explicit resource request, bypassing the QoS protocol detector and regardless of whether a QoS protocol was specified.
    - Capture: The system, using a QoS protocol detector, analyzes the flow for its resource requirements.
    - Drop: The flow is dropped.
17. In the Token Bucket Rate box, type the rate (in Kbps or Mbps, depending on the option checked) at which tokens are placed into an imaginary token bucket. Each flow has its own bucket, to which tokens are added at a fixed rate. To send a packet, the system must remove the number of tokens equal to the size of the packet from the bucket. If there are not enough tokens, the system waits until enough tokens are in the bucket.
18. In the Priority box, type the priority at which the flow is placed in a best-effort queue. Packets in a higher priority best-effort queue are transmitted by access points before packets in lower-priority queues, but after packets for reserved flows.
    Priority can be a value from 0 through 8, with 0 specifying no priority and 8 specifying the highest priority. The default value is 0. If you enable priority (specify a non-zero value), you cannot specify an average packet rate or token bucket rate.
19. In the Traffic Control list, select one of the following:
    - On

- Off

  For all types of flows (explicit, detected, and best-effort), selecting On for traffic control restricts the flow to the rate you specified. Packets above that rate are dropped.

20. In the DiffServ Codepoint list, select the appropriate DiffServ setting, if applicable.
21. In the QoS Rule Logging list, select whether to enable or disable logging activity for this QoS rule:
    - On
    - Off
22. In the QoS Rule Logging Frequency field, change the default collection interval in which packets related to this rule are logged, if QoS Logging is enabled. The interval must be a number between 30 and 60 (seconds).
23. Match Checkbox: For any field with the corresponding Match checkbox selected, the action mentioned in the ACTION field is performed on the matched packets. If the match checkbox is not checked, packets with any value are matched regardless of the data in the field and the action mentioned in the ACTION field is not performed on the packets. Also see *"More About the Match Checkbox and Flow Class Checkbox"* ***on page 411***.
24. Flow Class Checkbox: Flow Class options are relevant only for Flow Control rules (rules with Traffic Control enabled and Token Bucket Rate specified) and Firewall rules. This is typically rate limiting. When Flow Class is checked for a field, if a packet has matched a rule (either Flow Control or Firewall types), these fields are stored in the Flow Class entry. A Flow Class entry is used by the system for aggregating a set of flows so that they can be subjected to similar behavior, be it dropping the packets, or rate limiting them.

    For example, if a rule has a Src IP address of 0.0.0.0 and the Flow Class box checked, and Token Bucket Rate set to 10 kbytes/sec, all packets passing through the system must match this rule, and each flow will be allowed a maximum throughput of 10000 bytes/sec. If the rule were to have Src IP address of 10.0.0.10 and the Flow Class box checked, with a Token Bucket Rate of 10 kbytes/sec, all packets coming from a machine with IP address 10.0.0.10, must match this rule, and the cumulative throughput allowed for this machine shall be no more than 10000bytes/sec. Also see *"More About the Match Checkbox and Flow Class Checkbox"* ***on page 411***.
25. To add the QoS rule, click OK.

QoS Rules for Bridge Mode Traffic

QoS rules support bridge mode traffic (IPv4). For bridge mode traffic the following conditions are matched to either Forward or Drop packets.

- Destination IP
- Destination Port
- Source IP

- Source Port
- Network Protocol: A QoS rule for bridge mode traffic must mandatorily include the network protocol if the destination or source port is specified.

The following are some points to consider while creating QoS rules for bridge mode traffic:

- You can specify ports only for the protocols that support specifying ports. Protocols that do not have port specifications (example, ICMP etc.,) will be ignored by the AP.
- QoS rules with firewall filter-ID are ignored.
- Any rule with match value set to '0' will be considered as a wildcard and will match ANY traffic.
- The QoS rules for bridge mode traffic do not support any other conditions including the Capture action.
- If application visibility is enabled, and if either QoS rule OR the app-visibility policy dictates a DROP action for a packet, the packet is going to be dropped. Packet is forwarded only if BOTH QoS and app-visibility allow it.

NOTES:

- Any rules that block traffic between controller and AP will cause AP - controller dis-connectivity and such rules should not be created.
- If the number of QoS rules exceed 50, it may affect overall system performance.

More About the Match Checkbox and Flow Class Checkbox

The two checkboxes Match and Flow Class operate independently from each other; they perform two different functions. Match will almost always be used because checking this box indicates that the setting on the left must match - this sets the matching criteria for the QoS rule. You can check more than one matching criteria. Matching is the first phase of QoS rule execution - see the green box in **Figure 85**.

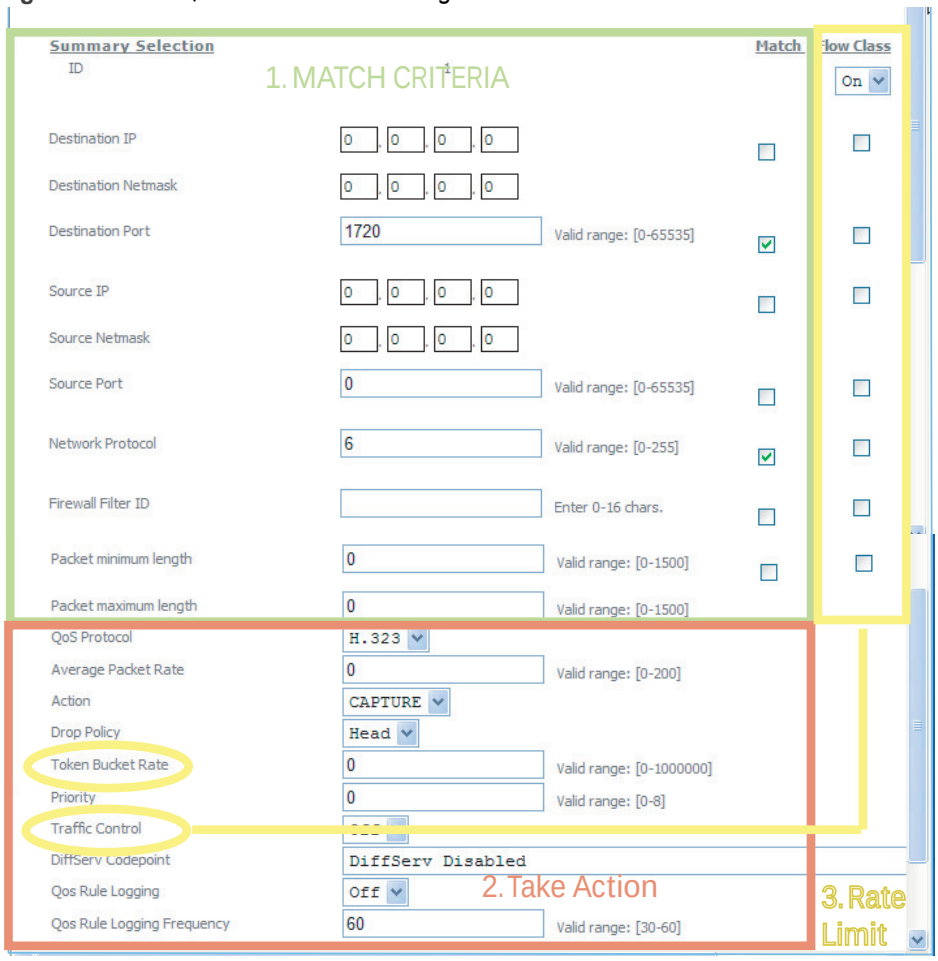
After criteria are matched, the action phase of the QoS rule is executed. This phase is enclosed in the orange box in **Figure 85**. Here are the directions that describe what to do with the matched packet from phase 1, Matching. For example, the rule can capture the packet from a named source and drop it. Action is phase 2 of QoS rule execution.

The Flow Class column is all about rate limiting. If a rule involves rate limiting, the actions Traffic Control and Token Bucket Rate must have been turned on. When the QoS rule executes traffic control, it looks at the check marks in the flow class column. If there are no check marks at all, the rate limiting is applied to everything. If Destination, Source, or Network Protocol have Flow Class checked, the following happens:

- Destination Flow Class - Each destination flow is limited to the rate.

- Source Flow Class - All source flows combined must be less than or equal to the rate.
- Network Protocol Flow Class - Any data transported using this protocol is limited to the rate.

Figure 85: *How QoS Rules Work -- change*



During creation of a QoS rule, at least one Match Flow flag must be selected or else the system will not allow the user to proceed.

Configuring QoS Rules With the CLI

To configure QoS rules with the CLI, you need to be in QoS Rule configuration mode. Enter configure terminal, then specify a QoS rule with the command qosrule <rule-id>. See the chart below for the options for these two commands.

Command	Purpose
configure terminal	Enter global configuration mode.
qosrule rule-id netprotocol {6|17|***protocolnumber***} qosprotocol {H323|sip|none|other|sccp}	Enter QoS Rule configuration for the specified rule ID. Use show qosrules to obtain a list of rule IDs. The required parameters are: netprotocol: The network protocol is a standard network protocol number such as 6 for TCP or 17 for UDP. It can be any valid protocol number such as 119 for the SVP protocol, used with Spectralink phones. [Full listing at: http://www.iana.org/assignments/ protocol-numbers] qosprotocol: The QoS protocol. This can be one of the following: H.323 sip (SIP - Session Initiation Protocol) none (Used to denote all other protocols)
... commands ...	Enter the QoS rule configuration commands here (see the following table).
end	Return to privileged EXEC mode.
copy running-config startup-config	This is an optional step to save your entries in the configuration file.

Commands for QoS Rule CLI Configuration

Once you are in QoS rule configuration mode (see directions above), you can issue any of these QoS rule configuration commands:

Command	Purpose
dstip ip	Destination IP in the format 255.255.255.255.
dstmask ipmask	Destination netmask in the format 255.255.255.255
dstport port	Destination port number from 0 to 65535.
srcip ip	Source IP in the format 255.255.255.255.
srcmask ipmask	Source netmask in the format 255.255.255.255.
srcport port	Source port number from 0 to 65535.
action {forward | capture | drop}	Action to take for packets matching the rule. This can be one of the following: forward—A flow is given an explicit resource request, bypassing the QoS protocol detector and regardless of whether a QoS protocol was specified. capture—The flow is passed through the QoS protocol detector, using the specified QoS protocol. This is the recommended action for static QoS rules that are H.323/SIP based. drop—The flow is dropped.
dscp class	The DiffServ codepoint class. This lets you choose a per-hop forwarding behavior for the packets in the flow. It is recommended that you be familiar with RFCs 2475 and 2597 before changing these values.
priority rate	The number (0-8) that specifies best effort priority queue, where 0 is default (best-effort) and 8 is highest priority. Priority may be turned on (non-zero) or the average packet rate and TSpec token bucket rate may be specified, but not both. Defaults to 0.
avgpacketrate rate	Average packet rate: from 0 to 200 packets per second. If this is a non-zero value, then the TSpec token bucket rate must also be a non-zero value, and priority cannot be set to a non-zero value. Defaults to 0.
tokenbucketrate rate	TSpec token bucket rate, from 0 to 1000 Kbps or 1-64 Mbps, depending on the box checked. If this is a non-zero value, then the average packet rate must also be non-zero, and the priority cannot be set to a non-zero value. Defaults to 0.
trafficcontrol-enable	Turns traffic control policing on. When traffic control is on, traffic assigned a priority will travel at the assigned rate and no faster.
no trafficcontrol	Turns traffic control policing off. This is the default setting.

QoS Rule CLI Configuration Example

The following commands configure QoS rule 10 for the set of IP phones whose server is at the IP address 10.8.1.1:

```
controller (config)# qosrule 10 netprotocol 17 qosprotocol none
   controller (config-qosrule)# srcip 10.8.1.1
   controller (config-qosrule)# srcmask 255.255.255.0
   controller (config-qosrule)# srcport 0
   controller (config-qosrule)# dstip 10.8.1.1
   controller (config-qosrule)# dstmask 255.255.255.0
   controller (config-qosrule)# dstport 0
   controller (config-qosrule)# action forward
   controller (config-qosrule)# tokenbucketrate 9400
   controller (config-qosrule)# avgpacketrate 35
   controller (config-qosrule)# end
```

When SCCP phones are used, we recommend that you create a separate VLAN for the SCCP phones and create the following qosrules for G.711 (20ms) codec to handle qosflow traffic:

```
controller (config)# qosrule 123 netprotocol 17 qosprotocol none
   controller (config-qosrule)# srcmask subnet_mask (for example, 255.255.192.0)
   controller (config-qosrule)# srcip subnet_IP_addr (for example,172.27.128.0)
   controller (config-qosrule)# action forward
   controller (config-qosrule)# avgpacketrate 50
   controller (config-qosrule)# tokenbucketrate 10000
   controller (config-qosrule)# exit
   controller (config)# qosrule 124 netprotocol 17 qosprotocol none
   controller (config-qosrule)# dstip subnet_IP_addr  (for example,172.27.128.0)
   controller (config-qosrule)# dstmask subnet_mask (for example, 255.255.192.0)
   controller (config-qosrule)# action forward
   controller (config-qosrule)# avgpacketrate 50
   controller (config-qosrule)# tokenbucketrate 10000
   controller (config-qosrule)# exit
```

The following example configures a QoS rule for a 1 Mbps CBR-encoded video streamed from Windows Media Server 9 over UDP transport.

The following lists the example's configuration parameters:

- Rule ID: 11
- Network protocol: 17 (UDP)
- QoS protocol: None
- Source IP address: 0.0.0.0
- Source subnet mask: 0.0.0.0
- Source port: 0

- Destination IP address:10.10.43.100 (This is the IP address of the wireless station receiving the video stream.)
- Destination subnet mask: 255.255.255.255
- Destination port: 5004
- Action to take if packets match rule: Forward
- Drop policy: Head
- Token bucket rate: 128 kbytes/second
- Average packet rate: 10 packets/second

The following commands configure the QoS rule for the video streamed from Windows Media Server 9 over UDP transport:

```
controller (config)# qosrule 11 netprotocol 17 qosprotocol none
   controller (config-qosrule)# srcip 0.0.0.0
   controller (config-qosrule)# srcmask 0.0.0.0
   controller (config-qosrule)# srcport 0
   controller (config-qosrule)# dstip 10.10.43.100
   controller (config-qosrule)# dstmask 255.255.255.255
   controller (config-qosrule)# dstport 0
   controller (config-qosrule)# action forward
   controller (config-qosrule)# tokenbucketrate 128000
   controller (config-qosrule)# avgpacketrate 10
   controller (config-qosrule)# end
```

Optimizing Voice Over IP

Transmitting voice over IP (VoIP) connections is, in most senses, like any other network application. Packets are transmitted and received from one IP address to another. The voice data is encoded into binary data at one end and decoded at the other end. In some sense, voice is just another form of data. However, there are a few special problems.

The requirements for quality voice traffic are not exactly the same as the requirements for most data traffic:

- If a data packet arrives a second late, it is usually of no consequence. The data can be buffered until the late packet is received. If a voice packet arrives a second late, it is useless and might as well be thrown away.
- If a data packet takes a third of second to arrive at the destination, that is usually fast enough. If voice packets routinely take a third of a second to arrive, the users will begin to take long pauses between sentences to make sure that they don’t interfere with the other person’s speech.

Quality VoIP calls need data to be delivered consistently and quickly. Meeting the requirements of VoIP data requires either a connection with plenty of bandwidth all along the data route or a means of ensuring a certain quality of service (QoS) for the duration of the call.

Even if the bandwidth is available, setting up the phone call can be a non-trivial task. When a phone call is initiated, the destination of the call might be a standard telephone on the public switched network (PSTN) or an IP-to- device at a particular IP number, or one of several computers (for example, a computer at home or office). If the destination device is a phone on the public network, the initiation protocol must locate a gateway between the Internet and the telephone network. If the destination device is in the local network, the initiation protocol must determine which computer or device to call.

After the destination device has been found, the initiating and the destination devices must negotiate the means of coding and decoding the data. This process of finding a destination device and establishing the means of communication is called ***session initiation***.

The two main standards for initiating sessions are:

- Session Initiation Protocol, or SIP, used for most VoIP telephone calls.
- H.323, used for multimedia communication, for example by Microsoft NetMeeting.

In both cases, the initiating device queries a server, which then finds the destination device and establishes the communications method.

After the two devices have been matched and the communication standards chosen, the call is established. The VoIP server may remain in the communication loop or it may step out of the loop depending on the server configuration.

Using QoS Rules for VoIP

The Wireless LAN System is designed to automatically provision voice traffic with a level of QoS appropriate for voice calls. Incoming traffic are matched against the pre-defined QoS rules and depending on the match, the traffic is assigned with appropriate prioritization.

The port numbers monitored for incoming traffic are:

- 5060 for SIP service (UDP or TCP)
- 1720 for H.323 service (TCP)
- 5200 for Vocera (UDP)

If your VoIP devices and servers are configured to use different ports, modify the QoS rules on the controller to match the ports your system uses. Change QoS rules with either the Web UI or the CLI.

Modifying QoS Rules for Nonstandard Ports

The controller is pre-configured to detect the bandwidth requirements for a SIP or H.323 call and make a bandwidth reservation. Change QoS rules with either the Web UI or the CLI. The following default QoS rules are configured at the factory:

```
default(15)# show qosrule

ID    Dst IP          Dst Mask        DPort Src IP          Src Mask        SPort
   Prot Firewall Filter Qos   Action

1     0.0.0.0         0.0.0.0         1720  0.0.0.0         0.0.0.0         0
   6                    h323  capture
   2     0.0.0.0         0.0.0.0         0     0.0.0.0         0.0.0.0         1720
   6                    h323  capture
   3     0.0.0.0         0.0.0.0         5060  0.0.0.0         0.0.0.0         0
   17                   sip   capture
   5     0.0.0.0         0.0.0.0         5060  0.0.0.0         0.0.0.0         0
   6                    sip   capture
   7     0.0.0.0         0.0.0.0         5200  0.0.0.0         0.0.0.0         0
   17                   other forward
   8     0.0.0.0         0.0.0.0         0     0.0.0.0         0.0.0.0         5200
   17                   other forward
   9     0.0.0.0         0.0.0.0         80    0.0.0.0         0.0.0.0         0
   17                   other capture
   10    0.0.0.0         0.0.0.0         0     0.0.0.0         0.0.0.0         5060
   6                    other capture

         QoS and Firewall Rules(8 entries)
```

The first two pre-configured QoS rules give priority to H.323 traffic sent to and from TCP port 1720 respectively. The next two QoS rules give priority to SIP traffic sent to and from UDP/TCP port 5060 respectively. Rules 7 and 8 are for Vocera badges and use port 5200 with UDP.

You normally do not need to configure QoS rules in the controller, unless you have special requirements in your configuration. For example:

- You want to drop packets coming from certain ports or IP addresses.
- You want to configure the controller to give priority to traffic other than H.323 and SIP traffic.

You can configure rules to provide priority-based or reserved QoS. QoS is applied with reserved traffic being allocated the first portion of total bandwidth, followed by fixed priority levels, and finally by the best-effort (default) traffic class. You can configure reserved QoS for new applications using the average packet rate and token bucket rate parameters together as the traffic specification (also called TSpec in IETF IntServ RFCs).

Global QoS Settings

Global QoS parameters configure settings that determine call quality on a global level. These settings allow you to fine tune Call Admission Control (CAC), client load balancing, bandwidth scaling, and time-to-live settings.

You can configure the following global quality-of-service parameters:

TABLE 23: *Global Quality-of-Service Parameters*

Command	Purpose
qosvars admission { admitall | pending | reject }	Admission control. Valid values are admitall, pending, and reject.
qosvars ttl ttl-value	Default time-to-live in seconds for all other protocols besides TCP and UDP.
qosvars tcpttl ttl-value	Time-to-live for TCP protocol, in seconds.
qosvars udpttl ttl-value	Time-to-live for UDP protocol, in seconds.
qosvars bwscaling value	Scale factor for Tspec bandwidth, in percent. May range from 1% to as high as 100% ; 100% is typical
qosvars cac-deauth {on | off}	Configures the optional 802.11 de-authentication behavior.
qosvars calls-per-ap max	Configures the maximum number of calls per AP.
qosvars calls-per-bssid max	Configures the maximum number of calls per BSSID.
qosvars drop-policy {head|tail}	Configures the drop policy. Valid values are head or tail respectively.
qosvars load-balance overflow {on | off}	Enables and disables load balancing across BSSIDs.
qosvars max-stations-per-radio max	Configures the maximum stations (0-128) allowed to associate with a single radio. 128 is the default. Recommendation: • 14 voice clients per radio for all AP models • 40 data clients per radio for all AP models except AP122, and 20 data clients for AP122
qosvars max-stations-per-bssid max	Configures the maximum stations (0-1023) allowed to associate with an BSSID.

TABLE 23: *Global Quality-of-Service Parameters*

Command	Purpose
qosvars no enable	Turns off QoS.
SIP Idle Timeout	Sets the time period after which an idle SIP connection will time out.
Station Assignment Aging Time (s)	Sets the time period after which stations will begin aging out.
Maximum Calls Per Interference Region	Specifies the number of calls that are permitted in a given interference area.

Rate Limiting QoS Rules

Rate limiting controls the overall traffic throughput sent or received on a network interface. A specific bandwidth limit can be set for a network or device; then, if the actual traffic violates that policy at any time, the traffic is shaped in some way. In this implementation, packets are dropped until the traffic flow conforms to the policy with some queuing (delaying packets in transit) applied.

Rate Limiting with the CLI

You can rate limit traffic by turning on Traffic Control and using the Token Bucket Rate as the token bucket limiter. Follow these steps to rate limit the client 10.11.31.115 to approximately 3Mbps and then run a quick test to verify functionality.

1. Determine the token bucket rate to achieve the desired rate limit. In the example below, we'll limit it to 3Mbps (3Mbps = 3000000bps. 3000000/8/8=46875).
2. Create a qosrule that does rate limiting for a client.

```
Controller1# sh qosrule 23
   QoS and Firewall Rules

ID : 23
   Id Class flow class : on
   Destination IP : 10.11.31.115 (this is the client to be rate limited)
   Destination IP match : on
   Destination IP flow class : on
   Destination Netmask : 255.255.255.255
   Destination Port : 0
   Destination Port match : none
   Destination Port flow class : none
   Source IP : 0.0.0.0
   Source IP match : none
   Source IP flow class : none
   Source Netmask : 0.0.0.0
```

```
Source Port : 0
Source Port match : none
Source Port flow class : none
Network Protocol : 6
Network Protocol match : on
Network Protocol flow class : on
Firewall Filter ID :
Filter Id match : none
Filter Id Flow Class : none
Packet minimum length : 0
Packet Length match : none
Packet Length flow class : none
Packet maximum length : 0
QoS Protocol : other
Average Packet Rate : 0
Action : forward
Drop Policy : head
Token Bucket Rate : 46875
Priority : 0
Traffic Control : on
DiffServ Codepoint : disabled
Qos Rule Logging : on
Qos Rule Logging Frequency : 31
```

Rate Limiting QoS Rules with the GUI

You can rate limit traffic for a single user by turning on Traffic Control and using the Token Bucket Rate as the token bucket limiter. Follow these steps to rate limit the traffic:

1. Click Configure > QoS Settings > QoS and Firewall rules tab > Add.
   The QoS and Firewall rules Add window displays.
2. Scroll down to the lower half of the QoS and Firewall rules Add window.
3. Set Traffic Control On.
4. Set the token bucket rate to achieve the desired rate limit. This can be entered in either Kbps (from 0-1000) or Mbps (from 0-64), depending on the needs of your deployment.
5. Click OK.

The rate limit is now set.

Rate Limiting Examples

Rate-Limit Clients in the Same Subnet for TCP

To rate-limit clients from the subnet 10.11.31.0, follow these steps:

1. Determine the token bucket rate to achieve the desired rate limit. In the example below, we'll limit it to 3Mbps (3Mbps = 3000000bps. 3000000/8/8=46875).

2. Create the following qosrule to rate-limit clients from a particular subnet:

```
Controller1# sh qosrule 23
   QoS and Firewall Rules
   ID: 23
   ID Class flow class : on
   Destination : 10.11.31.0 (this is the subnet to be rate limited)
   Destination IP match : on
   Destination IP flow class : on
   Destination Netmask : 255.255.255.0
   Destination  Port  : 0
   Destination  Port  match : none
   Destination  Port  flow class : none
   Source IP : 0.0.0.0
   Source Netmask : 0.0.0.0
   Source  Port  : 0
   Source  Port  match : none
   Source  Port  flow class : none
   Network Protocol : 6
   Network Protocol match : on
   Network Protocol flow class : on
   Firewall Filter ID :
   Filter Id match : none
   Filter Id Flow Class : none
   Packet minimum length : 0
   Packet Length match : none
   Packet Length flow class : none
   Packet maximum length : 0
   QoS Protocol : other
   Average Packet Rate : 0
   Action : forward
   Drop Policy : head
   Token Bucket Rate : 46875
   Priority : 0
   Traffic Control : on
   DiffServ Codepoint : disabled
   Qos Rule Logging : on
   Qos Rule Logging Frequency : 60
```

3. Configure Chariot to send a TCP downstream to the client 10.11.31.115 using the throughput script. You should see throughput averaging around3Mbps on Chariot.

   As a result of this QoS rule, each client in the 10.11.31.xxx network will get approximately get 3 mbps from each individual source in the same subnet.

Rate-Limit Clients From Different Subnets for TCP

To rate-limit clients from any subnet other than the one that those clients are currently using, follow these steps:

1. Determine the token bucket rate to achieve the desired rate limit. In the example below, we'll limit it to 3Mbps (3Mbps = 3000000bps. 3000000/8/8=46875).
2. Create the following qosrule to rate-limit clients from a particular subnet:

```
Controller1# sh qosrule 23
   QoS and Firewall Rules
   ID : 23
   Id Class flow class : on
   Destination IP : 10.11.31.0 (this is the subnet to be rate limited)
   Destination IP match : on
   Destination IP flow class : none
   Destination Netmask : 255.255.255.0
   Destination  Port  : 0
   Destination  Port  match : none
   Destination  Port  flow class : none
   Source IP : 0.0.0.0
   Source Netmask : 0.0.0.0
   Source  Port  : 0
   Source  Port  match : none
   Source  Port  flow class : none
   Network Protocol : 6
   Network Protocol match : on
   Network Protocol flow class : on
   Firewall Filter ID :
   Filter Id match : none
   Filter Id Flow Class : none
   Packet minimum length : 0
   Packet Length match : none
   Packet Length flow class : none
   Packet maximum length : 0
   QoS Protocol : other
   Average Packet Rate : 0
   Action : forward
   Drop Policy : head
   Token Bucket Rate : 46875
   Priority : 0
   Traffic Control : on
   DiffServ Codepoint : disabled
   Qos Rule Logging : on
   Qos Rule Logging Frequency : 60
```

3. Configure Chariot to send a TCP downstream to the different clients in 10.11.31.xxx using the throughput script.

   All the clients in 10.11.31.xxx network should now share the 3 Mbps from each individual source.

Configuring Codec Rules

Codec rules are configurable and can be specified with the commands in this section.

If your SIP phones support "ptime" then you will not need to configure any codec rules. Otherwise, you should configure QoS rules and ensure the rule you set is based on the packetization/sample rate that the phone uses.

The SIP ptime attribute is an optional part of the SIP Specification. It allows a SIP media device to advertise, in milliseconds, the packetization rate of the RTP media stream. For example, if ptime is set to the value “20” the SIP device sends 1 RTP packet to the other party every 20 milliseconds. With this specification, the Wireless LAN System can accurately reserve QoS bandwidth based on the Codec and Packetization rate.

The following is a sample of the "ptime" attribute included as part of an SDP media attribute:

```
m=audio 62986 RTP/AVP 0
a=rtpmap:0 PCMU/8000
a=ptime:20
```

If the ptime attribute is not present when the media is negotiated in SDP between the SIP devices, the Wireless LAN System uses the default value of the codec type specified with the qoscodec command.

The proper packetization rate must be configured to match the actual media traffic or the QoS reservation will be inaccurate. A spreadsheet, qoscodec_parameters.xls, is available from the Customer Support FTP site that can help you to determine the correct values for the relevant parameters. Please contact Customer Support for details and access.

To configure QoS Codec rules, you need to enter Codec configuration mode. To do this, follow these steps:

Command	Purpose
configure terminal	Enter global configuration mode.
qoscodec rule-id codec <codec-type> qosprotocol {H323v1|sip} tokenbucketrate tbr maxdatagramsize maxdg minpolicedunit minpol samplerate sr	Enter QoS Codec configuration for the specified rule ID. Use show qoscodec to obtain a list of rule IDs. The following are the required parameters: codec. Enter the Codec type after at the Codec keyword. The acceptable Codec types are given below. qosprotocol. The QoS protocol. This can be one of the following: H323 (H.323); sip (SIP - Session Initiation Protocol) tokenbucketrate. Token bucket rate, from 0 to 1000 Kbps or 1-64 Mbps, depending on the box checked. maxdatagramsize. Maximum datagram size. From 0 to 1,500 bytes. minpolicedunit. Minimum policed unit. From 0 to 1,500 bytes. samplerate. Sample rate. From 0 to 200 packets per second.
... commands ...	Enter the QoS CODEC configuration commands here.
end	Return to privileged EXEC mode.
copy running-config startup-config	This is an optional step to save your entries in the configuration file.

The Codec type can be one of the following

TABLE 24: *QoS Codec Type*

Type	Description
1016	1016 Audio: Payload Type 1, Bit Rate 16 Kbps
default	Contains the default TSpec/ RSpec for unknown codecs or codecs for which there is no entry in the codec translation table
dv14	DV14 Audio: Payload Type 5, Bit Rate 32 Kbps
dv14.2	DV14.2 Audio: Payload Type 6, Bit Rate 64Kbps
g711a	G711 Audio: Payload Type 8, G.711, A-law, Bit Rate 64 Kbps

TABLE 24: *QoS Codec Type*

Type	Description
g711u	G711 Audio: Payload Type 0, G.711, U-law, Bit Rate 64 Kbps
g721	G721 Audio: Payload Type 2, Bit Rate 32 Kbps
g722	Audio: Payload Type 9, Bit Rate 64 Kbps, 7KHz
g7221	G7221 Audio: Payload Type *, Bit-Rate 24 Kbps, 16KHz
g7221-32	G7221 Audio: Payload Type *, Bit-Rate 32 Kbps, 16KHz
g723.1	G7231 Audio: Payload Type 4, G.723.1, Bit Rate 6.3Kbps
g728	G728 Audio: Payload Type 15, Bit Rate 16Kbps
g729	G729 Audio: Payload Type 16, Bit Rate 8Kbps
g7red	Proprietary MSN Codec Audio: Payload Type *
gsm	GSM Audio: Payload Type 3, Bit Rate 13Kbps
h261	H.261 Video
h263	H.263 Video
lpc	IPC Audio: Payload Type 7, Bit Rate 2.4 Kbps
mpa	MPA Audio: Payload Type 14, Bit Rate 32 Kbps
siren	Proprietary MSN Audio: Payload Type *, Bit Rate 16Kbps, 16KHz

The following commands are used in the QoS Codec configuration mode:

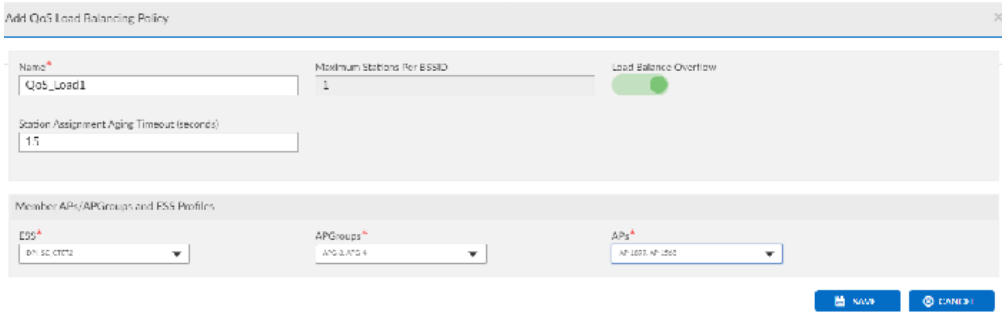
TABLE 25: *QoS CODEC Configuration Mode Commands*

Command	Purpose
tokenbucketsize size	Token bucket size in bytes. From 0 to 16,000 bytes. Defaults to 8.
peakrate rate	Traffic spec peak rate. From 0 to 1,000,000 bytes/second. Defaults to 0.
rspecrate rate	Reservation spec rate. From 0 to 1,000,000 bytes/second. Defaults to 0.
rspecslack slack	Reservation spec slack. From 0 to 1,000,000 microseconds. Defaults to 0.

QoS Load Balancing

The QoS load balancing configurations optimize the performance of wireless clients by balancing the load in case of multiple access points in the network. Thereby, preventing any access point from getting overloaded. The load balancing profile can be applied to specific APs, AP groups, and ESS profiles. The load balancing screen lists the existing profiles with the configured parameters.

Figure 86: *Adding QoS Load Balancing*



1. In the **QoS Load Balancing Profil**e screen, select **Add**. The **Add QoS Load Balancing Profile** screen is displayed.
2. Provide the details for the following parameters. You can create multiple profiles.
   - **Name** - Unique name for this QoS load balancing profile. The supported range is 1-64 alphanumeric characters.
   - **Max Stations Per BSSID** - This field specifies the maximum number of stations to be supported by a single BSSID on a per-station basis. The supported range is 0-2007.
   - **Overflow** - Setting this option to **On** allows new stations to join the network beyond the maximum allowed per radio in a round-robin fashion. This allows the user to permit for periodic spikes in association traffic and balances the new stations evenly across the deployment. By default, this is set to **Off**.
   - **Station Assign Age Time** - Specifies the amount of time an assigned station can be idle before being dropped. Measured in seconds and the supported range is 5-2000 and the default is 15 seconds.
   - **Member APs/APGroups and ESS Profiles** - Select the ESS profiles and the APs/AP groups to apply the load balancing profile.
3. Click **Save**. The QoS Load Balancing Profile is created.

You can edit and delete the QoS load balancing profiles by selecting the relevant options.

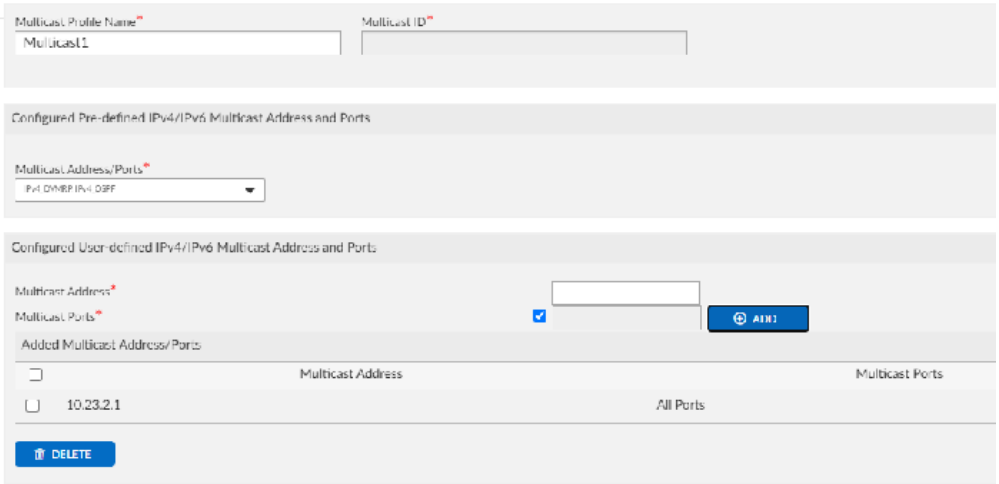
QoS Throttle Policies

The QoS throttle policies allow bandwidth ratelimiting for multicast and broadcast traffic. You can configure and control multicast and broadcast suppression profiles and apply to one or multiple ESS profiles/APs/AP groups.

Multicast Profile

You can define multicast suppression profiles to allow a collection of specific ports/multicast addresses to be configured within one or multiple ESS profiles/APs/AP groups to allow multicast traffic, thereby providing granular control. A multicast profile can be attached to one or more ESS profiles.

Figure 87: *Adding a multicast profile*

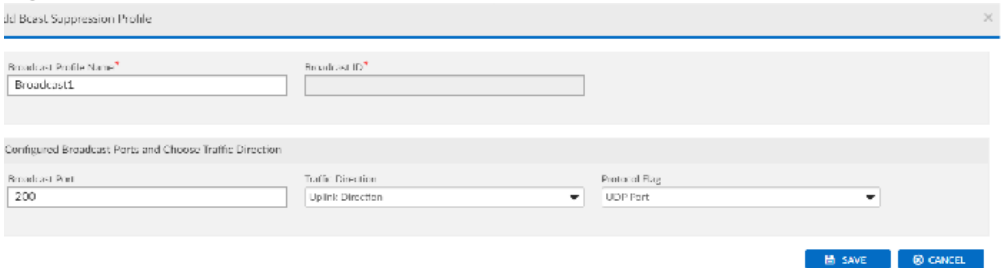


1. Click **Add** and enter a unique multicast profile **Name** and **Multicast ID**. The multicast profile ID must include 1-128 integers.
2. You can select **Pre-defined IPv4/IPv6 Multicast Address and Ports** from the drop down options. These are supported for both IPv4 and IPv6 addresses.
3. You can configure **User-defined IPv4/IPv6 Multicast Address and Ports**. Enter the Multicast IPv4/v6 address and ports. Select the checkbox against the **Multicast Ports** option to select all ports. The configured multicast address and ports are listed.

Broadcast Profile

You can define broadcast suppression profiles to open broadcast ports for specific applications limited to small portions of the network. The broadcast profile provides granular control by allowing you to configure IPv4 broadcast ports along with the traffic direction. A broadcast profile can be attached to one or multiple ESS profiles/APs/AP groups.

Figure 88: *Adding a Broadcast profile*



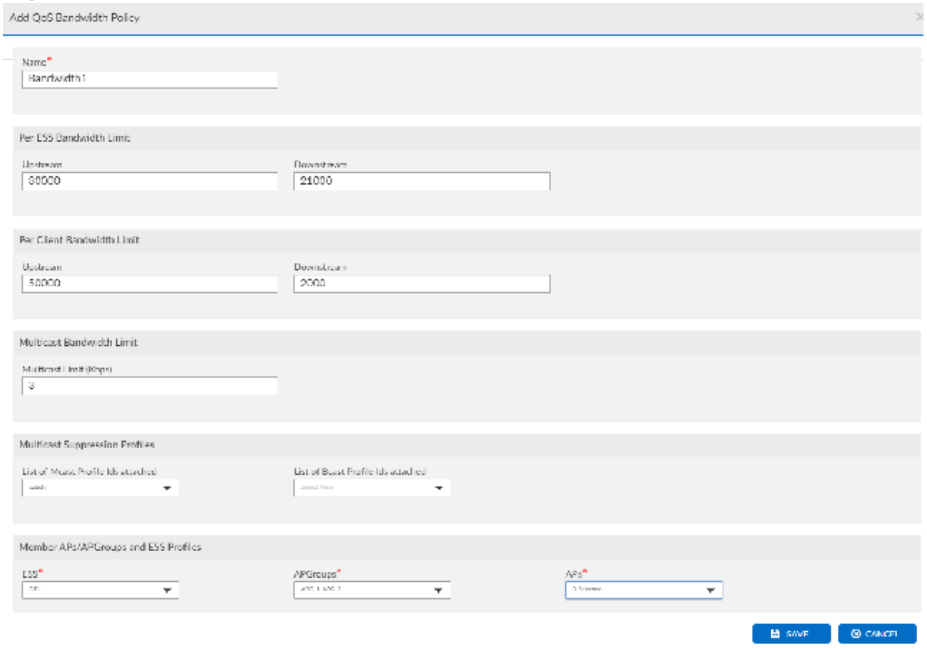
Note: Enable the global broadcast setting for this local configuration to take effect. If the port is 0, all broadcast traffic is dropped.

1. Click **Add** and enter a unique broadcast profile **Name** and **Broadcast ID**. The broadcast profile ID must include 1-128 integers.
2. Enter the broadcast ports. You can add multiple comma-separated broadcast ports.
3. Select the **Traffic Direction** for the specified broadcast ports, uplink, downlink, or both.
4. Select the type of protocol for the broadcast port, **UDP Port** or **EtherType**. Ethertype is configured to handle L2 broadcast traffic, enter the hex value of the ethertype, for example, 0x806.

QoS Bandwidth Policies

You can configure bandwidth for unicast and multicast traffic. A QoS bandwidth policy allows you to set bandwidth limits per ESS and per client for unicast traffic and the total bandwidth for multicast traffic.

Figure 89: *Adding a bandwidth policy*



1. Click **Add** and enter a unique bandwidth policy **Name**.
2. Enter the broadcast ports. You can add multiple comma-separated broadcast ports.
3. For unicast traffic, enter the **Per ESS Bandwidth Limit** and /or **Per Client Bandwidth Limit** for upstream and downstream traffic. The valid range is 0-64000 Kbps.
4. For multicast traffic, enter the total **Multicast Bandwidth Limit**. The valid range is 0-64000 Kbps. Enter the **Multicast Profile** and **Broadcast Profile** IDs for bandwidth limiting, you can enter multiple comma-separated IDs./

QoS Statistics Display Commands

Displaying Phone/Call Status

To display the active SIP phones that have registered with a SIP server, use the show phones command.

```
Controller(15)# show phones
   MAC                 IP              AP ID AP Name         Type User-
   name            Server           Transport

00:01:3e:12:24:b5   172.18.122.21    3     QoS-Lab         sip  100
   172.18.122.122   udp
          Phone Table(1 entry)
```

```
Controller(15)#
   To display the active SIP phone calls, use the show phone-calls command.
   controller# sh phone-calls
   From MAC           From IP         From AP From AP Name    From Username
   From Flow Pending   To MAC             To IP           To AP   To AP Name
   To Username         To Flow   Pending   Type State

00:0f:86:12:1d:7c   10.0.220.119     1       AP-1           5381
   100       off       00:00:00:00:00:00   10.0.220.241    0
   69                   101       off       sip  connected

        Phone Call Table(1 entry)
   controller#
```

Displaying Call Admission Details

To view the current calls supported by APs, use the show statistics call-admission-control ap command.

```
controller# show statistics call-admission-control ap
   AP ID Current Calls Cumulative Rejected Calls
   6     0             0
   Call Admission Control AP Statistics(1 entry)
```

To show calls in relation to specific BSSIDs, use the show statistics call-admission control bss command.

```
controller# show statistics call-admission-control bss
   BSSID             Current Calls Cumulative Rejected Calls

00:0c:e6:13:00:da 0             0

00:0c:e6:52:b3:4b 0             0

00:0c:e6:f7:42:60 0             0

        Call Admission Control BSS Statistics(3 entries)
```

More QoS Rule Examples

The following are in addition to the previous examples in this chapter, *"QoS Rule CLI Configuration Example"* ***on page 415*** and *"Rate Limiting Examples"* ***on page 421***:

- *"Rate-Limit a Certain Client"* ***on page 431***
- *"Wireless Peer-to-Peer Qos Rules"* ***on page 433***

Rate-Limit a Certain Client

To rate-limit the client 10.11.31.115 from any source, follow these steps:

1. Determine the token bucket rate to achieve the desired rate limit. In the example below, we'll limit it to 3Mbps (3Mbps = 3000000bps. 3000000/8/8=46875).
2. Create the following qosrule to rate-limit a particular client from any source:

```
Controller1# sh qosrule 23
   QoS and Firewall Rules
   ID : 23
   ID Class flow class : on
   Destination IP : 10.11.31.115 (this is the client to be rate limited)
   Destination IP match : on
   Destination IP flow class : on
   Destination Netmask : 255.255.255.255
   Destination Port : 0
   Destination Port match : none
   Destination Port flow class : none
   Source IP : 0.0.0.0
   Source Netmask : 0.0.0.0
   Source Port : 0
   Source Port match : none
   Source Port flow class : none
   Network Protocol : 6
   Network Protocol match : on
   Network Protocol flow class : on
   Firewall Filter ID :
   Filter Id match : none
   Filter Id Flow Class : none
   Packet minimum length : 0
   Packet Length match : none
   Packet Length flow class : none
   Packet maximum length : 0
   QoS Protocol : other
   Average Packet Rate : 0
   Action : forward
   Drop Policy : head
   Token Bucket Rate : 46875
   Priority : 0
   Traffic Control : on
   DiffServ Codepoint : disabled
   Qos Rule Logging : on
   Qos Rule Logging Frequency : 60
```

3. Configure Chariot to send a TCP downstream to the client (10.11.31.115) using the throughput script.
   You should see throughput averaging around 3Mbps on Chariot. As a result of this QoS rule, when the client 10.11.31.115 receives traffic, it will be rate-limited to approximately 3mbps.

Wireless Peer-to-Peer Qos Rules

In general, to create a priority QoS rule for a particular protocol between two IP addresses, specify the network protocol and then select the match flow for the protocol. This creates QoS priority for a particular protocol between the IP's.

Prioritize Peer-to-Peer

This particular IP-Based QoS rule prioritizes peer-to-peer traffic generated from 172.18.85.11 and destined to 172.18.85.12.

```
Testing# show qosrule 11
   QoS and Firewall Rules
   ID : 11
   Id Class flow class : on
   Destination IP : 172.18.85.12
   Destination IP match : on
   Destination IP flow class : none
   Destination Netmask : 255.255.255.255
   Destination Port : 0
   Destination Port match : none
   Destination Port flow class : none
   Source IP : 172.18.85.11
   Source Netmask : 255.255.255.255
   Source IP match    : on
   Source IP flow class : none
   Source Port : 0
   Source Port match : none
   Source Port flow class : none
   Network Protocol : 0
   Network Protocol match : none
   Network Protocol flow class : none
   Firewall Filter ID :
   Filter Id match : none
   Filter Id Flow Class : none
   Packet minimum length : 0
   Packet Length match : none
   Packet Length flow class : none
   Packet maximum length : 0
   QoS Protocol : none
   Average Packet Rate : 100
   Action : forward
   Drop Policy : head
   Token Bucket Rate : 1000000
   Priority : 0
   Traffic Control : off
   DiffServ Codepoint : disabled
```

```
Qos Rule Logging : on
Qos Rule Logging Frequency : 31
```

Peer-to-Peer Blocking

In this peer-to-peer blocking example, rules 60 and 61 apply to an isolated WLAN for guest internet access where the DNS server is actually on that network. Rules 60 and 61 are only needed if the DNS server for the wireless clients is on the same subnet as the clients themselves.

```
ID    Dst IP          Dst Mask        DPort Src IP          Src Mask        SPort
   Prot Firewall Filter Qos   Action   Drop
   60    0.0.0.0        0.0.0.0        53    0.0.0.0        0.0.0.0        0
   0                     none  forward  tail
   61    0.0.0.0        0.0.0.0        0     0.0.0.0        0.0.0.0        53
   0                     none  forward  tail
   100   192.168.2.0    255.255.255.0  0     192.168.2.0    255.255.255.0  0
   0                     none  drop     tail

qosrule  60 netprotocol  0 qosprotocol  none
   firewall-filter-id  ""
   id-flow  on
   dstip  0.0.0.0
   dstmask  0.0.0.0
   dstport  53
   dstport-match on
   dstport-flow on
   srcip  0.0.0.0
   srcmask  0.0.0.0
   srcport  0
   action  forward
   droppolicy  tail
   priority  0
   avgpacketrate  0
   tokenbucketrate  0
   dscp  disabled
   qosrulelogging  off
   qosrule-logging-frequency  60
   packet-min-length  0
   packet-max-length  0
   no  trafficcontrol
   exit
   qosrule  61 netprotocol  0 qosprotocol  none
   firewall-filter-id  ""
   id-flow  on
   dstip  0.0.0.0
   dstmask  0.0.0.0
   dstport  0
   srcip  0.0.0.0
```

```
srcmask  0.0.0.0
srcport  53
srcport-match on
srcport-flow on
action  forward
droppolicy  tail
priority  0
avgpacketrate  0
tokenbucketrate  0
dscp  disabled
qosrulelogging  off
qosrule-logging-frequency  60
packet-min-length  0
packet-max-length  0
no  trafficcontrol
exit
qosrule  100 netprotocol  0 qosprotocol  none
firewall-filter-id  ""
id-flow  on
dstip  192.168.2.0
dstip-match on
dstip-flow on
dstmask  255.255.255.0
dstport  0
srcip  192.168.2.0
srcip-match on
srcip-flow on
srcmask  255.255.255.0
srcport  0
action  drop
droppolicy  tail
priority  0
avgpacketrate  0
tokenbucketrate  0
dscp  disabled
qosrulelogging  off
qosrule-logging-frequency  60
packet-min-length  0
packet-max-length  0
no  trafficcontrol
```

802.11n Video Service Module (ViSM)

Video streaming has the low latency and loss requirements of with the high-throughput requirements of data. The Fortinet Video Service Module™ (ViSM) is an optional licensed software module that delivers predictable 802.11 video performance with minimal delay, latency and jitter. Sustainable high data rates, even in mixed traffic, are supported along with synchronization of video and audio transmissions.

ViSM also introduces additional mechanisms for optimizing unicast and multicast video such as application aware scheduling, /video synchronization, and client-specific multicast group management. Features include the following:

- High throughput with low burstiness offers predictable performance and consistent user experience
- Application-aware prioritization synchronizes the and video components of a video stream, adapting the delivery of each frame based on its importance to the application.
- Multicast group management optimizes delivery to only those Virtual Ports whose clients are members of the multicast group.
- Seamless video-optimized handoff proactively reroutes the multicast delivery tree to prevent lost video frames during a transition between access points and ensures zero loss for mobile video.
- User and role based policy enforcement provides granular control over application behavior.
- Visualization reveals which clients are running which applications.

Implementing ViSM

Virtual Port already changes multicast to unicast transmissions (for non-U-APSD clients). ViSM adds per-client IGMP Snooping to the transmission. Therefore, to implement ViSM, turn on IGMP Snooping. CLI commands control IGMP snooping (see ***FortiWLC (SD) Command Reference***). At this time, ViSM licensing is not enforced.

Configuring Call Admission Control and Load Balancing with the CLI

To help shape a global Quality of Service for calls and traffic, Call Admission Control (CAC) and client load balancing can be set per AP or BSSID.

CAC commands can set threshold levels for the number of new SIP connections (calls) that can exist per AP or BSSID to ensure a global amount of bandwidth is available. The result is that existing calls maintain a consistent level of service, even if new calls have to be temporarily denied. When CAC is enabled, as the set call level threshold is neared for the AP or BSSID, the admin can configure actions to occur such as having the system send a 486_BusyHere response, a modified INVITE message to the ipPathfinder, or alternatively, sending a 802.11 De-authentication message the originator of the call. If an existing call moves to another AP without sufficient bandwidth, the call is classified as Pending/Best-effort until the needed resources are available.

A unique CAC value can be configured for an ESSID, that affects only only that ESSID. Setting CAC at the ESSID level takes precedence over the global settings described in this section. To configure CAC for an ESSID, see *"Configuring CAC for an ESSID AP with the CLI"* ***on page 150***.

Enabling client load balancing implements round-robin load balancing of client associations for an AP or BSSID. When the maximum number of stations are associated, new stations are allowed to join in a round-robin fashion.

The following commands enable CAC and limits the number of calls per AP to 12:

```
controller (config)# qosvars cac-deauth on
   controller (config)# qosvars calls-per-ap 12
```

The following commands enable client load balancing overflow protection and sets the maximum number of stations per AP to 15:

```
controller (config)# qosvars load-balance-overflow on
   controller (config)# qosvars max-stations-per-radio 15
```

The following commands limits the number of calls per BSSID to 14 and sets the maximum number of stations per BSSID to 30:

```
controller (config)# qosvars calls-per-bssid 14
   controller (config)# qosvars max-stations-per-bssid 30
```

Application Visibility (DPI)

You can monitor and/or block specific application traffic in your network. FortiWLC (SD) can monitor and restrict access applications/services, as listed in the **Configuration** > **Access Control > Application**

- Supported only on 11ac access points.
- Properties defined in a custom application will take precedence over system defined applications set up for blocking and monitoring.

Limitations and Recommendations

- To export DPI status to an FortiWLM server, the export destination port must be set to 4739.
- If the total number of ESS profiles and the total number APs in the controller are the maximum allowed, then a policy cannot be created. When configuring each policy:
  - The total number of ESS that can be applied to is 64. ***Tip***: To support this maximum, ensure that an ESS name is 15 characters or less.
  - The total number APs that can be applied are 186. To support this maximum, the AP IDs need to between the 1 to 500 AP ID range. ***Tip***: to maximize the coverage of APs, you can create AP groups and use this instead of listing individual APs.
- Bittorent downloads can be monitored but cannot be blocked.

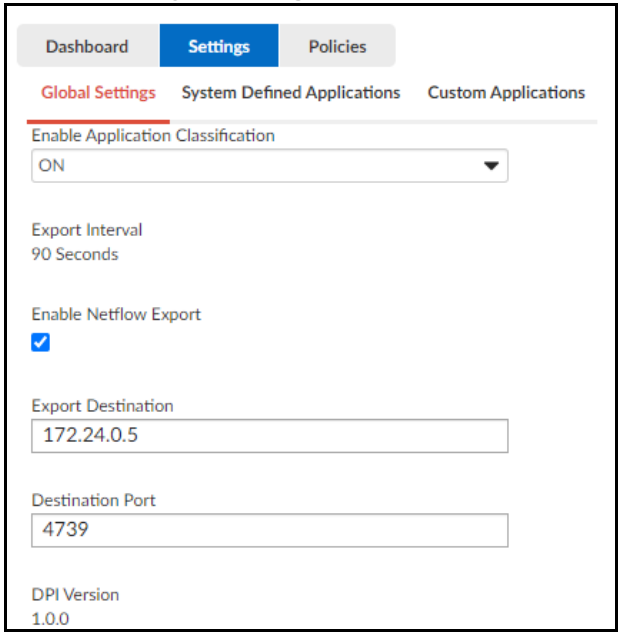
- In a custom app, Bittorent traffic cannot be monitored or blocked.
- Advanced detection of sub-protocol traffic is a resource intensive task, so we recommend that you use it in moderation.
- It is recommended that you do not delete custom application (under the Settings > Custom Application tab in Application). Deleting a custom application can result in incorrect status display of top 10 applications in the dashboard.
- A custom application is by default monitored even if it is not mapped to a policy. But for it to be blocked, it must be added to a policy
- Setting up application monitoring or blocking requires you to enable DPI and creating appropriate policies.

To set up and use the application monitoring:

1. Enable Application Visibility
2. Create Policies
3. Associate system defined and/or custom applications to policies

Enable Application Visibility

To enable DPI, go to **Configuration** > **Applications** > **Settings** tab



1. Select **ON** for Enable Application Classification. This is a global settings and enables DPI on all APs.
2. Export Interval is a non-configurable field that set at 90 seconds.

3. Export Destination: Specify or edit (*if automatically pushed by Network Manager*) the IP address of the correct Network Manager server. This is used to export stats to Network Manager server
4. To export values to Fortinet Network Manager, select ***Enable Netflow Export*** and specify the Fortinet Network Manger server IP (Export Destination).

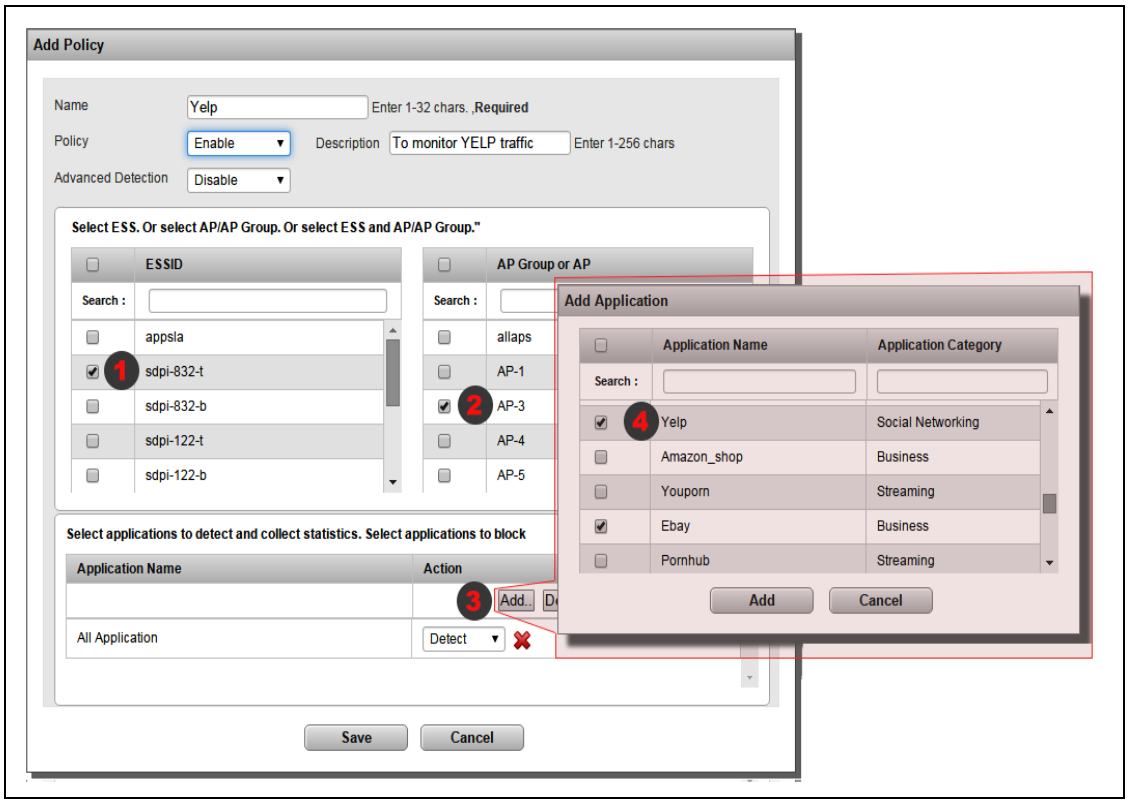
Creating a Policy

You can create policies to monitor and block one or more application traffic. This can be done for one of the following condition:

- All ESS profiles
- Per ESS profile
- All APs
- Per AP
- Per AP Group
- ESS and AP Combination

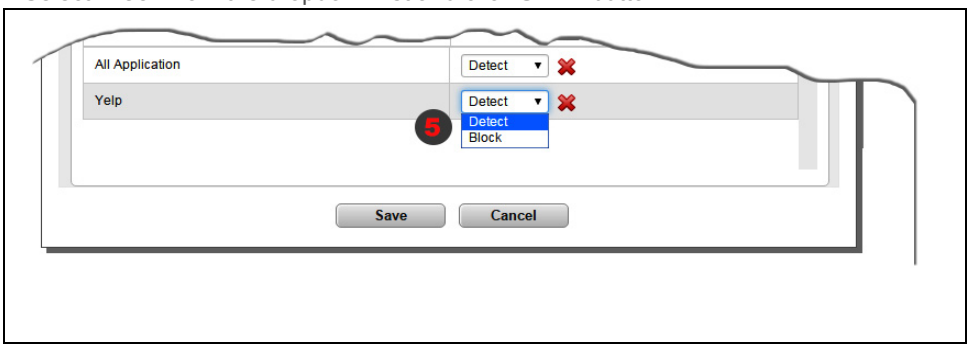
Example

The following screen-shots illustrate the procedure to create a policy to block ***Yelp*** traffic by clients that are connected to **sdpi-832-t** ESS profile via **AP-3**.



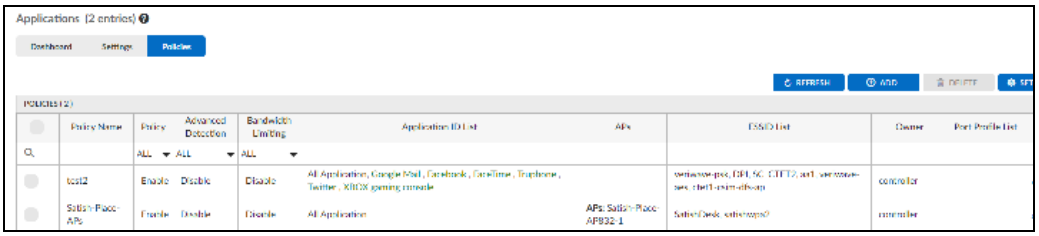
1. Select the ESS profile from the ESSID table.
2. Select the AP from the AP Group or AP table.
3. Click the ADD button to view application lists
4. Select the application from the list and click ADD button

5. Select ***Block*** from the dropdown list and click **SAVE** button



List of policies

By default, the Policies tab displays the following:



- **Policy Name**: The name to identify the policy.
- **Policy**: The status of the policy
- **Advanced Detection**: Select enable to view sub-protocols for a system defined application and protocols.
- **Application ID List**: List of system defined application and /or custom applications that are blocked or monitored by the policy. Blocked applications are shown in red colour and applications that are only monitored are shown in green colour.
- **ESSID List**: The name of the ESS profile configured for this policy. Clients that connect using this ESSID profile and accessing the monitored application.
- **AP Groups or APs**: The list of APs that are configured for this policy. Clients that connected via these APs or AP groups and accessing the monitored application.
- **Owner**: The owner is either controller or NMS. If the policy is created in the controller the owner is listed as controller.
- **Search**: To locate a specific policy by Name, AP, ESS, or owner, enter the keyword in the search box and hit the Enter key. This will highlight the corresponding row that matches the keyword. To filter the display based on Status, select the status (from the dropdown) to highlight the corresponding rows.

- **Policy Reordering**: Policies are executed in the order they are displayed. To reorder policy priority, click the Reorder button and use the arrows in the action column to move them up or down the listing order. You must save this for the reorder changes to take effect.

If an ESS and AP combination appear in more than one policy, then the policy that is on top in the order will be triggered.

In the following illustration, the ESSID MTS and APID AP-8 appear in both corporate-1 and corporate-2 policies. The corporate-1 policy allows Facebook traffic and corporate-2 blocks Facebook traffic. Since corporate-1 is higher in the order than corporate-2, Facebook will be allowed and not blocked. However, for AP-10 Facebook will be blocked as per corporate-2 policy.

Custom Applications

Custom applications are user-defined applications that are not part of the system defined applications. You can add a maximum of 32 applications in the controller and a maximum of 32 applications on Network Manager.

Protocol/sub-protocol detection/support for custom applications is not available

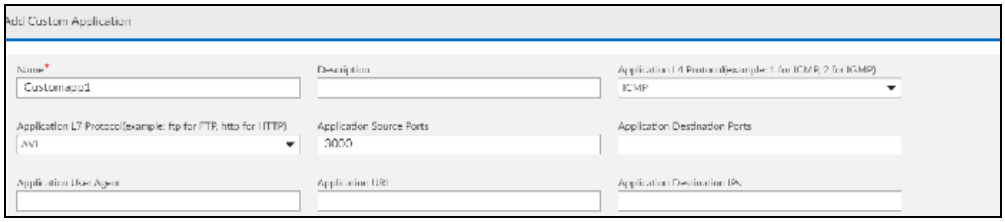
A custom application is a combination of one or more of the following:

- Predefined L4 and L7 protocols
- Source and/or Destination Ports
- User Agents
- Any HTTP/HTTPS URL
- Destination IP

For a custom application to be monitored or blocked by a policy, all of its properties must match the traffic.

Creating a Custom Application and assigning it to a Policy

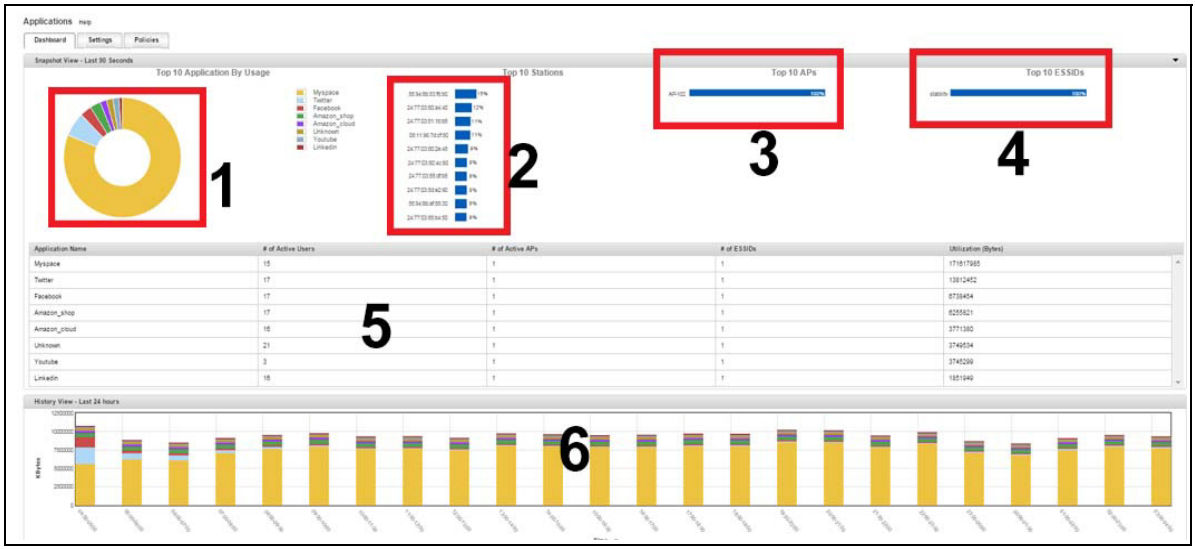
1. To create a custom application, go to **Application** > **Settings** > **Custom Applications** and click the **Add** button.



2. Enter properties for the custom application and click **Save**.
3. View the custom application listing.
4. Add custom application to a policy. Use the same steps mentioned in See *"Example" on page 440.* But in the sub-step 4 of the figure, scroll down to very end to location the custom application. Select the custom application and then select policy setting.
5. Custom application is listed in the policy.

DPI Dashboard

The DPI dashboard shows applications that are configured for monitoring (detect) only. Applications that are blocked are not displayed in the dashboard as they are dropped by the AP.



1. The graph displays a pie chart with the top 10 applications (by usage) that are monitored.
2. The list of top 10 stations that are connected to one or more of the top 10 applications. This does not represent the usage of a specific application by the station.
3. List of APs that are passing traffic for one or more of the top 10 applications
4. List of ESS profiles that are passing traffic for one or more of the top 10 applications
5. This table lists the top 10 application and displays numerical (integer) statistics about number of stations, ESS profiles, APs and traffic size in bytes.
6. This table shows historical data for application traffic in the last 24 hours.

Using CLI

Creating a Policy

1. In the config mode, use the **`app-visibility-policy <policy-name> command`**.
2. Enable the status using the **`state enable`** command
3. Specify the application id and the policy type using **`appids <application-ID>:<type>`**
   - Use **A**, to allow and monitor the traffic usage
   - Use **B**, to block traffic.
4. In a single policy you can add rules to monitor and block application traffic.

```
Default(15)(config)# app-visibility-policy  CorpNet

Default(15)(config-app-visibility-policy)# description  ""

Default(15)(config-app-visibility-policy)# state  enable

Default(15)(config-app-visibility-policy)# appids  6:B

Default(15)(config-app-visibility-policy)# essids  stability

Default(15)(config-app-visibility-policy)# apids  "5:A"

Default(15)(config-app-visibility-policy)# owner  controller

Default(15)(config-app-visibility-policy)# version  0

Default(15)(config-app-visibility-policy)# exit
```

To View the list of policies and type configured for a specific AP, use the **show application-visibility policy-config-service <app-id>** command.

```
Default(15)# show application-visibility policy-config-service 5

AP      ESSID           APPID           Action

5       1               2               Allow

5       1               5               Allow

5       1               6               Block

5       1               8               Allow

5       1               24              Allow

5       1               32              Allow

5       1               41              Allow

5       1               70              Allow

        Application Visibility Policy Service(8)
```

Legends

Figure 90: *DPI Config Option Legends*

Label	Description
A	When used for an application, it means to allow, detect, and monitor the application traffic.
B	Used to detect and block the application traffic
A	When use as an AP-ID, refers to adding an individual AP.
L	Used to add an ap-group to a policy.

Monitoring Policies

```
Default(15)# sh service-summary Application-Visibility

Feature                 Type            Name                    Value   ValueStr

Application-Visibility  Application     myspace                  100
  {"util":3006.76,"tx":6943001576,"rx":257651566}

Application-Visibility  Application     amazon_cloud             0
  {"util":474.84,"tx":1093389603,"rx":43774451}

Application-Visibility  Application     facebook                 0
  {"util":184.00,"tx":421673492,"rx":18973696}

Application-Visibility  Application     twitter                  0
  {"util":164.58,"tx":358628579,"rx":35513363}

Application-Visibility  Application     unknown                  0
  {"util":97.92,"tx":221291109,"rx":13202213}

Application-Visibility  Application     amazon_shop              0
  {"util":77.81,"tx":162324404,"rx":24026568}

Application-Visibility  Application     linkedin                 0
  {"util":48.60,"tx":109814218,"rx":6565367}

Application-Visibility  Application     youtube                 0       {"util":
  1.34,"tx":2910287,"rx":292302}

Application-Visibility  Station         58:94:6b:b5:ca:c4        100
  {"util":591.86,"tx":1364192275,"rx":53208638}

Application-Visibility  Station         00:27:10:cb:90:40        0
  {"util":571.51,"tx":1317000065,"rx":51657115}

Application-Visibility  Station         10:0b:a9:44:f6:ac        0
  {"util":297.04,"tx":681777356,"rx":29579769}
```

```
Application-Visibility  Station         24:77:03:80:4c:60       0
  {"util":294.30,"tx":676177538,"rx":28620457}

Application-Visibility  Station         84:3a:4b:48:1e:c0       0
  {"util":291.67,"tx":668985331,"rx":29513381}

Application-Visibility  Station         24:77:03:80:2e:48       0
  {"util":287.46,"tx":660217415,"rx":28188180}

Application-Visibility  Station         08:11:96:7d:cf:80       0
  {"util":286.78,"tx":657504303,"rx":29271859}

Application-Visibility  Station         24:77:03:80:a4:40       0
  {"util":281.94,"tx":646183947,"rx":29009375}

Application-Visibility  Station         24:77:03:80:5f:54       0
  {"util":280.23,"tx":645624714,"rx":25475052}

Application-Visibility  Station         24:77:03:85:b4:50       0
  {"util":279.89,"tx":641592459,"rx":28689908}

Application-Visibility  EssId           stability               100
  {"util":4055.84,"tx":9313033268,"rx":399999526}

Application-Visibility  AP              AP-109                  100
  {"util":4055.84,"tx":9313033268,"rx":399999526}

        Service Data Summary(20 entries)

Default(15)# sh ap

ap                    ap-certificate         ap-discovered          ap-online-
  history       ap-reboot-event         ap-redirect             application-
  visibility

ap-assigned           ap-connectivity        ap-neighbor            ap-reboot-
  count         ap-reboot-top10         ap-swap

Default(15)# sh application-visibility application-summary


APPID         Name               Station Counts  AP Counts      ESS Counts
  Tx Bytes        Rx Bytes        TxRx Bytes


5             myspace              12            1              1
  7274981850      269918317       7544900167

24            amazon_cloud          13            1              1
  1149026229      45994062        1195020291
```

```
2              facebook              13            1             1
   443832821       19962877        463795698

8              twitter               13            1             1
   375850987       37259491        413110478

0              unknown               20            1             1
   233565871       13899667        247465538

70             amazon_shop            13            1             1
   170637983       25318821        195956804

41             linkedin              12            1             1
   115430025       6896689         122326714

32             youtube               13            1             1
   3022484         304784          3327268

        Application Visibility Statistics Summary(8)

Default(15)#


Default(15)# sh service-summary-trend Application-Visibility

Feature                Type           Name                  StartTime
   EndTime              Value     ValueStr


Application-Visibility  Application     myspace                01/17/2009
   01:00:00  01/17/2009 02:00:00  370191907
   {"util":254501.59,"tx":3561906268,"rx":140012805}

Application-Visibility  Application     amazon_cloud           01/17/2009
   01:00:00  01/17/2009 02:00:00  523131985
   {"util":35964.57,"tx":502700232,"rx":20431753}

Application-Visibility  Application     twitter                01/17/2009
   01:00:00  01/17/2009 02:00:00  221967525
   {"util":15259.95,"tx":202733592,"rx":19233933}

Application-Visibility  Application     facebook               01/17/2009
   01:00:00  01/17/2009 02:00:00  220636588
   {"util":15168.45,"tx":210304218,"rx":10332370}

Application-Visibility  Application     unknown                01/17/2009
   01:00:00  01/17/2009 02:00:00  113502079
   {"util":7803.10,"tx":106412520,"rx":7089559}
```

```
Application-Visibility  Application     amazon_shop             01/17/2009
  01:00:00  01/17/2009 02:00:00  106703142
  {"util":7335.69,"tx":93322094,"rx":13381048}

Application-Visibility  Application     linkedin                01/17/2009
  01:00:00  01/17/2009 02:00:00  58696435
  {"util":4035.30,"tx":55165018,"rx":3531417}

Application-Visibility  Application     youtube                 01/17/2009
  01:00:00  01/17/2009 02:00:00  1454576
  {"util":100.00,"tx":1315107,"rx":139469}

Application-Visibility  Application     myspace                 01/17/2009
  02:00:00  01/17/2009 03:00:00  781850640
  {"util":264335.11,"tx":7508697893,"rx":309808509}

Application-Visibility  Application     amazon_cloud            01/17/2009
  02:00:00  01/17/2009 03:00:00  112454581
  {"util":38019.66,"tx":1078606475,"rx":45939338}

Application-Visibility  Application     facebook                01/17/2009
  02:00:00  01/17/2009 03:00:00  472612999
  {"util":15978.53,"tx":448955762,"rx":23657237}

Application-Visibility  Application     twitter                 01/17/2009
  02:00:00  01/17/2009 03:00:00  442033093
  {"util":14944.65,"tx":401239344,"rx":40793749}

Application-Visibility  Application     amazon_shop             01/17/2009
  02:00:00  01/17/2009 03:00:00  229558452
  {"util":7761.12,"tx":202329371,"rx":27229081}

Application-Visibility  Application     unknown                 01/17/2009
  02:00:00  01/17/2009 03:00:00  215482783
  {"util":7285.24,"tx":200402948,"rx":15079835}

Application-Visibility  Application     linkedin                01/17/2009
  02:00:00  01/17/2009 03:00:00  125984872
  {"util":4259.41,"tx":118235346,"rx":7749526}

Application-Visibility  Application     youtube                 01/17/2009
  02:00:00  01/17/2009 03:00:00  2957801
  {"util":100.00,"tx":2659330,"rx":298471}

Application-Visibility  Application     myspace                 01/17/2009
  03:00:00  01/17/2009 04:00:00  859492100
  {"util":269614.13,"tx":8269499897,"rx":325421104}

Application-Visibility  Application     amazon_cloud            01/17/2009
  03:00:00  01/17/2009 04:00:00  116518953
  {"util":36550.84,"tx":1119128571,"rx":46060960}
```

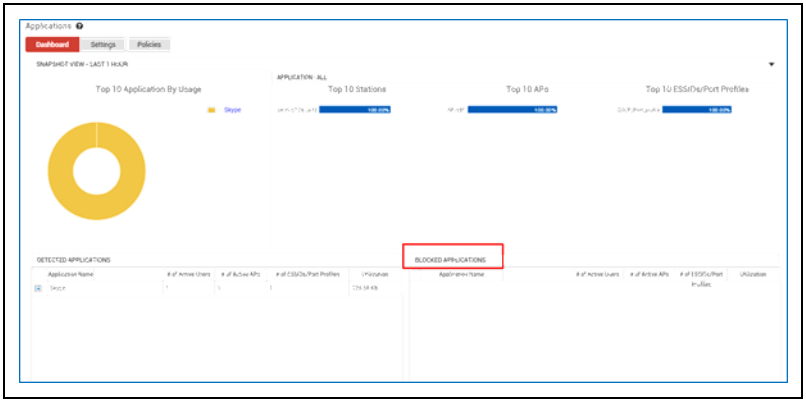
```
Application-Visibility  Application     facebook                01/17/2009
  03:00:00  01/17/2009 04:00:00  461844358
  {"util":14487.60,"tx":440897736,"rx":20946622}

Application-Visibility  Application     twitter                 01/17/2009
  03:00:00  01/17/2009 04:00:00  408573605
  {"util":12816.55,"tx":369504893,"rx":39068712}

Application-Visibility  Application     unknown                 01/17/2009
  03:00:00  01/17/2009 04:00:00  237048541
  {"util":7435.98,"tx":221824322,"rx":15224219}

Application-Visibility  Application     amazon_shop             01/17/2009
  03:00:00  01/17/2009 04:00:00  204090068
  {"util":6402.10,"tx":178965615,"rx":25124453}

Application-Visibility  Application     linkedin                01/17/2009
  03:00:00  01/17/2009 04:00:00  121917540
  {"util":3824.43,"tx":114827231,"rx":7090309}

Application-Visibility  Application     youtube                 01/17/2009
  03:00:00  01/17/2009 04:00:00  3187860
  {"util":100.00,"tx":2879796,"rx":308064}

        Service Data Summary Trend(24 entries)
```

Additional capabilities in Application Visibility include the following:

- Blocked traffic statistics
- Support for wired clients using port profile
- Bandwidth throttling
- DSCP Markings

Blocked Statistics

The dashboard now provides detailed statistics on blocked traffic.



The BLOCKED APPLICATIONS section provides the following statistics:

- Application Name: The application traffic set to be blocked.
- # of Active Users: The number of users requesting access to the application.
- # of Active APs: The APs that block the traffic.
- # of ESSIDs / Port: The ESSID and Port profile connected to the wireless and wired clients.
- Utilization: Shows how much traffic is blocked.

Support for Wired Clients

You can add port profiles to enable adding wired clients to detect, block, or bandwidth control traffic. The new policy page is updated to list port profiles created in the controller. A policy can be created with a mix of both ESSID and Port Profiles or only with ESS profiles or only with port profiles. The following is an example to create a policy and view policy details for wired ports via CLI.

```
default(15)# configure terminal

default(15)(config)#

default(15)(config)# app-visibility-policy wiredPorts

default(15)(config-app-visibility-policy)#

default(15)(config-app-visibility-policy)# port-profiles wired-profile

default(15)(config-app-visibility-policy)# state enable

default(15)(config-app-visibility-policy)# appids *

default(15)(config-app-visibility-policy)# advanced-detection enable
```

You can use comma separated values to add multiple port profiles.

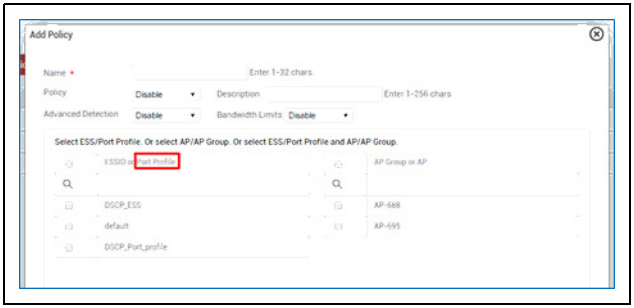
Example: **`default(15)(config-app-visibility-policy)# port-profiles wired-profile,default`**

View Policy Details

```
default(15)# sh application-visibility policy wiredPorts

Application Visibility Policy

Policy Name          : wiredPorts

Policy Order         : 2

Description          :

Policy               : enable

Advanced Detection   : enable

Bandwidth Limiting   : disable

Application ID List : *

ESSID List           :

AP Groups or APs     :

Owner                : controller

Port Profile List    : wired-profile

default(15)#
```

Bandwidth Throttling

You can enforce bandwidth usage limits on selected applications.



1. To enable bandwidth throttle, create a policy and select Enable option for Bandwidth Limits.
2. Select ESSID or Port Profile.
3. Specify maximum bandwidth limits for clients and SSID/Port.

	Minimum	Maximum
Client	150 kbps	1 Gbps
ESSID / Port Profile	150 kbps	12 Gbps

Limitations:

- Bandwidth throttle can be implemented on a maximum of 10 applications (individually or cumulatively across policies).
- When enabled the bandwidth throttling policy is applicable to all APs. AP and AP group selection is not available.
- The maximum bandwidth value configured for a client usage must be less than or equal to the value configured in ESSID or port traffic usage.
- Supported only for client traffic with tunnelled profile.

DSCP Markings

You can now add a DSCP value to application traffic (upstream: AP to controller and downstream: AP to station) to change its priority. The DSCP value for the selected application is used to mark the detected application traffic (to wireless or wired STA).

When a DSCP value is applied to application traffic, this value and the associated priority is maintained till the next node in the traffic. If the traffic carrying the DSCP value encounters a QoS-aware switch, then the DSCP value may be overridden by a QoS value specified by the switch.

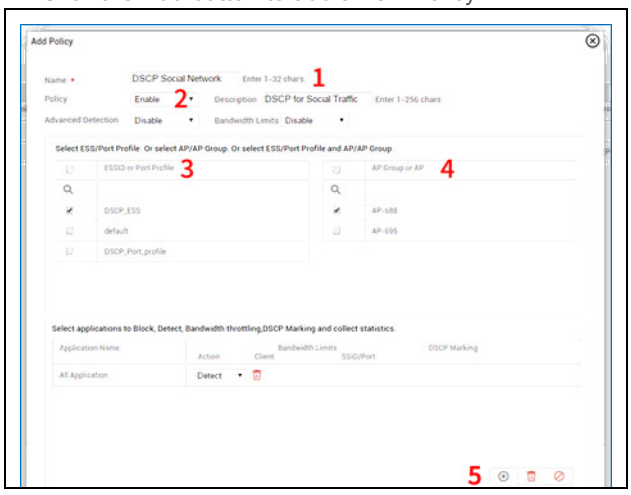
In a downstream traffic, the DSCP value is applied by the controller before forwarding to the AP. This is supported for ESSID's in tunnelled mode only.

NOTE: DSCP markings can be added to a maximum of 10 applications (includes all policies).

To assign DSCP value to application traffic, do the following:

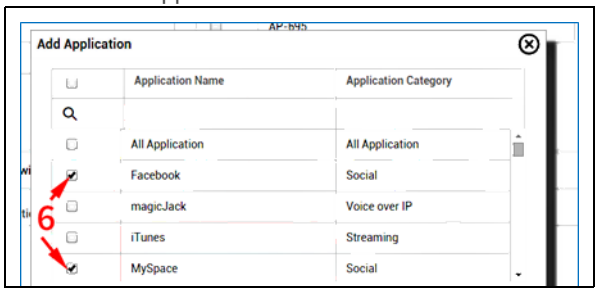
1. Go to Configuration > Access Control > Application > Policies tab.

2. Click the Add button to add a new Policy.

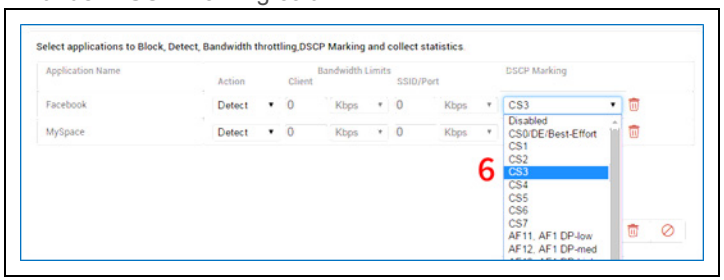


In the new Policy enter the following details

1. Name for the policy.
2. Select Enable to activate the policy
3. Select ESS profile
4. Select AP or AP group
5. Now click the add icon to view list of applications
6. Selection applications to be marked with DSCP values



7. For the listed application, you can specify individual DSCP values from the dropdown under DSCP Marking column.



Valid DSCP value strings

- af11
- af12
- af13
- af21
- af22
- af23
- af31
- af32
- af33
- af41
- af42
- af43
- cs0
- cs1
- cs2
- cs3
- cs4
- cs5
- cs6
- cs7
- no
- ef

For more details about DSCP values, see: https://tools.ietf.org/html/rfc4594

CLI Commands

To enable DSCP marking for downstream traffic, use the following command:

```
default(15)(config)# app-visibility-config controller-dscp-marking-state enable
```

The following command format configures DSCP marking and specifies bandwidth restrictions:

```
<app-id>:A or B|C:<per-client-bw-value>:<bw-unit>|E:<per-ess-bw-value>:<bw-unit>|D:<dscp-string>
```

- Application Id - <app-id:>
- Rule type (A- allow, B - block) - < A or B>
- Per client bandwidth limit - C:<bw-value>:<bw-unit> [Supported units K, M, G]
- Per ESSID bandwidth limit - E:<bw-value>:<bw-unit> [Supported units K, M, G]
- DSCP value - D:<dscp-value-string> [Supported values]

Example:

```
2:A|C:150:K|E:1:M|D:af11
```

The above command will allow traffic for application with id 2, limit bandwidth for client and ESS profile accessing this application traffic to 150 kilobits and 1 Megabits respectively, and set the DSCP for upstream traffic to af11.

Best Practices

The following is a recommended best practice while create application visibility policies.

- While it is possible to create a single policy that can detect, block, or enforce bandwidth limits, it is recommended that you create individual policies that independently detect, block, or enforce bandwidth limits.
- Policies are prioritized in the following order
  - Block
  - Bandwidth Throttling
  - Detect (General)

Load Balancing for APs in Virtual Cell

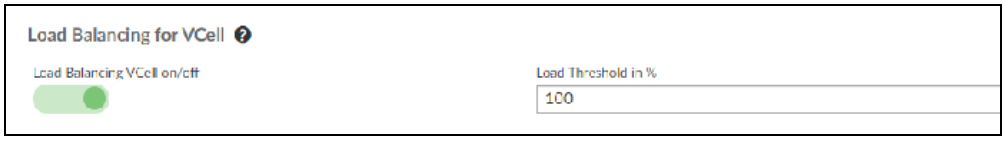
You can configure load balancing to effectively distribute wireless clients to alternate access points. The load balancing is performed by the controller based on two factors; Current Load of the AP and RSSI value of the client.

- Current load of an AP - Current load represents the number of clients assigned to an AP.

- RSSI value of the Client - The RSSI value of the client is received by the controller.

When a new client joins the network, the controller will connect the client to an AP that is running below its maximum load threshold and providing the best RSSI value.

To enable load balancing, configure the Load Threshold for the access point. Go to Configuration > Wireless > Load Balance.



1. Load Balancing vCell: Select On to activate this functionality.
2. Load Threshold: Specify the load threshold. This value denotes the number (in percentage) of clients that can connect to an AP. Example, if the optimum capacity of an AP is 80 clients, and the threshold is set to 90%, then a maximum of 72 clients are allowed to connect.
3. RSSI Threshold- Configurable via CLI (**`load-balance-vcell rssi-threshold <rssi-value>`**). Specify the RSSI value of the best and an alternate AP. Load balance is activated for a value below the configured RSSI value. The default value is -65dbm and the configurable range is -75dbm to -45dbm. The following table provides the recommended RSSI threshold for various modes and channel bandwidth:

	20 MHz	40 MHz	80 MHz	160 Mhz / 80+80 Mhz
802.11b	-76 dbm	NA	NA	NA
802.11a/g	-65 dbm	NA	NA	NA
802.11n	-64 dbm	-61 dbm	-58 dbm	NA
802.11ac	-57 dbm	-54 dbm	-51 dbm	-48 dbm

nPlus1 Support: The load balance feature allows the clients to connect to the best available access point during roaming in an nplus1 set up.

The following table illustrates various load balancing scenarios between two APs (AP1 and AP2) and the expected result when a client tries to join the network. :

- L1 represents the load on AP1; L2 represents the load on AP2. The value '1' represents AP1 has reached its load threshold.

- R1 represents RSSI value on AP1, and R2 represents RSSI value of AP2, The value '1' represents an RSSI value that is higher than the configured value.

Scenario	Expected Result
L1=1, L2=0 and R1=0 and R2=0	Since AP1 is running in full capacity the client will be assigned to AP2.
• L1=0, L2=0 and R1=0 ,R2=0 • L1=0 , L2=0 and R1=-1, R1=-1 • L1=1, L2=1 and R1=1 and R2=1	In these scenarios, the controller will use default association mechanism to assign the client to AP.
• L1=0, L2=1 and R1=1, R2=0 • L1=1, L2=0 and R1=1, R2=0 • L1=1, L2=0 and R1=1, R2=1 • L1=1, L2=1 and R1=1, R2=0	In these scenarios, the client will be assigned to AP2.
For other cases where L1 or L2 =1	The client stay associated with the current AP i.e. AP1

DSCP Marking for Management Packets

You can apply Differentiated Services Code Point (DSCP) values to management and application traffic (see Application Visibility Enhancements section). DSCP value is a selectable field that can be used to assign various levels of precedence to network traffic.

By default, traffic packets contained an EF value and with the introduction of this feature you can change the priority bit from EF to an appropriate DSCP value that meets your requirements.

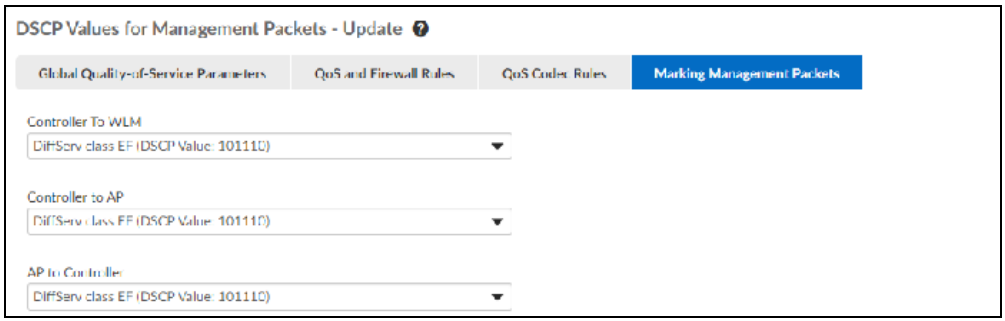
Management traffic between the following can be assigned DSCP values:

- AP to Controller
- Controller to AP
- Controller to Network Manager

Enable DSCP Value

To configure DSCP from WebUI, go to Configuration > Policies > QoS Settings > Marking Management Packets (tab).

Select the DSCP values for each traffic and click the SAVE button.



16 Mesh Network

Enterprise Mesh is an optional wireless alternative for the Ethernet links connecting APs to controllers. Deploy the Enterprise Mesh system to replace a switched wired backbone with a completely wireless 802.11 backbone, while providing similar levels of throughput, QoS, and service fidelity.

The following are Enterprise Mesh features:

- Hierarchical bandwidth architecture
- Dynamic allocation and balancing of the RF spectrum
- Full duplex capability
- Extend virtual cell, QoS, and RF coordination over backbone
- Wireless DS-to-DS (WDS) encapsulation of the Enterprise Mesh traffic
- Dataplane Encryption (affects performance because encryption/decryption is in software)

Mesh deployments are not intended for use in:

- Metropolitan or municipal Wi-Fi networks
- High throughput, density, or quality video/audio applications

Mesh Restrictions

The following restrictions apply to the design and implementation of Fortinet mesh networks.

- Enterprise Mesh APs require L3 connectivity to the controller.
- Monitoring of backhaul links via SAM is not supported.
- A radio that is not actively used for mesh cannot be used for SAM purposes.
- Bridged mode is not supported for wireless clients in Enterprise Mesh—only tunneled mode is supported.
- Gateway and mesh APs support a maximum of 4 backhaul links.
- From the gateway (i.e., an AP physically connected to the network), a maximum of 3 hops is supported with no more than 16 APs per cloud.
- A maximum of 500 stations can be active on a mesh cloud at any given time.
- Minimum channel separation guidelines are to use non-overlapping channels.

- Mesh operation on DFS channels is not recommended.
- Aggregation of multiple uplink connections is not supported.
- A single AP cannot be assigned to multiple mesh clouds.
- A maximum of 64 mesh profiles can be created on a controller. Each mesh profile can contain a maximum 16 APs.
- Since OAP832 has only radio 1 in 5GHz, mesh can be established only on that radio.

Enterprise Mesh Design

Enterprise Mesh is typically composed of hub-and-spoke configurations (as shown in **Figure 91**), chain configurations (as shown in **Figure 92**), or a variation of these.

In a dense network, hub-and-spoke (all APs point to the gateway) is the best topology, although collisions can occur.

- For optimal performance, avoid collisions between adjacent small clouds by creating each cloud on a separate channel. A cloud is defined as a set of APs communicating along a backhaul topology path to/from a gateway AP.

Figure 91: *Enterprise Mesh Network - Hub and Spoke Design*

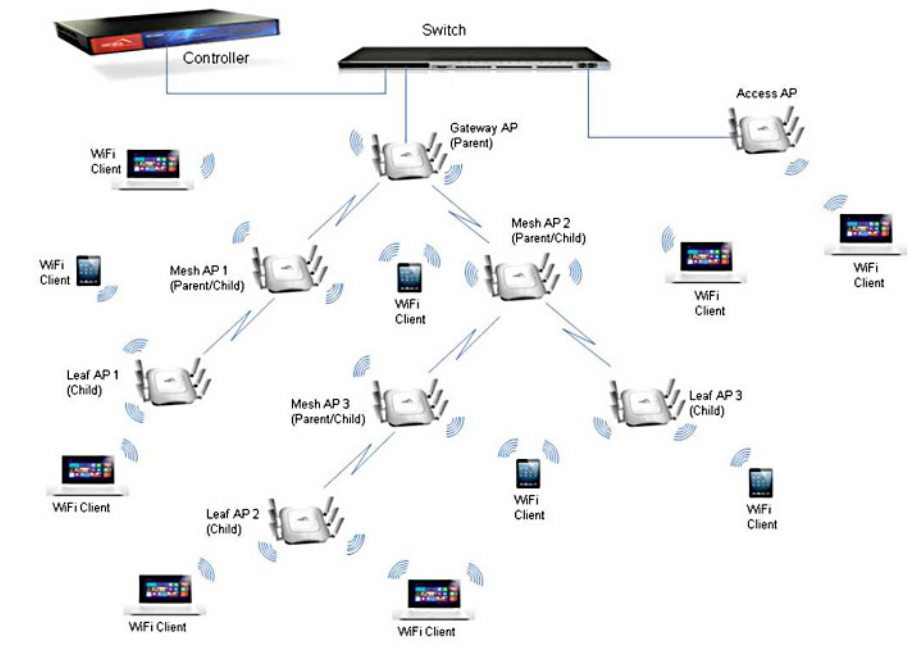
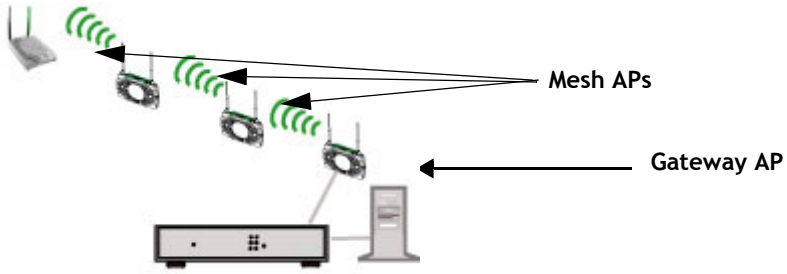


Figure 92: *Three Hop Enterprise Mesh - Chain Design*



Gateway APs

A gateway AP is located at the wired edge of the Enterprise Mesh network, and provides the link between wired and wireless service. The gateway AP is the only AP that has a wired connection to the network.

Mesh APs

Mesh APs refer to all APs that are not acting as gateway APs. They can provide intermediate service between other mesh APs or used as the endpoint in a mesh chain (as shown in **Figure 92**).Mesh APs can have wired connection to the network.

The unused Ethernet port on a Mesh AP can be configured and used in the same manner as a wired port on an Ethernet switch. As such, users can connect a hub/switch with other wired devices to it in order to access the corporate network. In order to use the port, a Port Profile must be configured for it. Refer to **Configuring Port Profiles** for details.

Leaf APs

An AP that is connected to the controller via a wireless back haul connection but cannot provide wireless back haul service to other nodes.

Wired Clients

Unused Ethernet port (interface 1) of an AP122, AP832, AP832, AP822 and FAP-U421EV, and FAP-U423EV configured as a Mesh AP can be used to connect up to 512 wired clients.

•

Mesh Discovery

The following are the various discovery scenarios in a mesh network:

Scenario 1: Regular Discovery

In a regular discovery process, a mesh AP uses the process as mentioned in the *"CAPWAP and Legacy Reference"* ***on page 353*** .

Scenario 2: L2/L3 discovery failure.

In L2/L3 discovery failure, the AP switches to mesh discovery. In this mode, the AP searches (on 5G for AP122, 822, FAP-U4xx, OAP832 and for other supported APs, on 5G and then followed by 2.4G) for a mesh beacon (a hidden ESS-Id). When it finds this hidden ESS-Id, it creates an association. After the association is complete, the AP starts the DHCP process to get an IP address from the controller. However, this AP (mesh AP) must be in the same mesh cloud in order to establish a connection.

NOTE: Backhaul links are always encrypted.

Refer to the online help for more information on creating mesh cloud

Scenario 3: AP is Unable to find a suitable backhaul service

If the AP is unable to find a suitable backhaul service or if key exchange fails, the AP scans to wireless medium for recovery service.

When a recovery service is found, the AP completes key exchange and 4-way handshake to discover the controller. After the discovery is complete, the configuration is downloaded. However, this AP does not provide any WLAN services.

To enable WLAN services, this AP must be added to a mesh cloud.

NOTE: A mesh AP can be part of only one cloud at a time.

Failover / Re-discovery

In a mesh cloud, if a mesh AP or a leaf AP loses contact with its parent, the AP switches to discovery mode. The discovery process begins with scenario 1-regular AP discovery process..

Parent Selection Mechanism

In a mesh cloud, an AP selects its best parent AP using a match to the following parameters and values.

- snr-weight: 3
- child-weight: 1

- hop-weight: 10

The above are default values and they can be customized to your RF environment using the following AP-CLI commands:

```
mesh {parent_selection | psel}
```

Set/Get weights for parent selection parameters

To set:

```
mesh parent_selection [snr|child|hop] <integer>
```

To get:

```
mesh parent_selection
```

To reset:

```
mesh parent_selection reset
```

Installing and Configuring an Enterprise Mesh System

Determine Antenna Placement

An Enterprise Mesh uses APs (as repeaters) to extend the range of wireless coverage. An AP in a Enterprise Mesh configuration is directed to look for a signal from a Parent AP. As such, antenna placement and reception is important for the optimum performance of the system.

If there are obstacles in the radio path, the quality and strength of the radio signal are degraded. Calculating the maximum clearance from objects on a path is important and should affect the decision on antenna placement and height. It is especially critical for long-distance links, where the radio signal could easily be lost.

When planning the radio path for a wireless hop, consider these factors:

- Be cautious of trees or other foliage that may be near the path between nodes, or ones that may grow to obstruct the path.
- Be sure there is enough clearance from buildings and that no building construction may eventually block the path.

- Check the topology of the land between the antennas using topographical maps, aerial photos, or even satellite image data (software packages are available that may include this information for your area).
- Avoid a path that may incur temporary blockage due to the movement of cars, trains, or aircraft.

Installing the Fortinet Enterprise Mesh

Enterprise Mesh APs are configured in five phases.

These steps assume that the deployment is not being configured via the PlugNPlay functionality. See *"Adding Mesh APs Via PlugNPlay"* ***on page 469*** for additional details.

- **Phase 1: Connect Controller and APs with an Ethernet Switch**
- **Phase 2: Create a Mesh Profile**
- **Phase 3: Add APs to the Mesh**
- **Phase 4: Configure the APs for Mesh Operation**
- **Phase 5: Remove the Cables and Deploy the APs**

Phase 1: Connect Controller and APs with an Ethernet Switch

In a standard initial mesh setup, the user can configure all mesh APs desired at once via wired connection through a local switch. (This configuration is intended to happen prior to remote deployment.) For an alternative mechanism that allows APs to be deployed remotely prior to them being configured locally, refer to **Adding Mesh APs Via PlugNPlay**.

1. Connect all APs directly to a controller through a switch or hub.
2. Power on the controller.
3. Connect the APs to a power source using either separate power supplies or Power over Ethernet (PoE) connections.
4. If the controller does not have an assigned IP address, configure with the following; otherwise, skip to step 5:
   - Connect a computer to the controller using a serial cable.
   - Using a PC terminal program with the settings 115200 baud, 8 bit, no parity, access the controller and log in with the default admin/admin username/password.
   - Use the setup command to assign the controller an IP address.
   - Reboot the controller and log in again as admin.
5. Log into the controller's CLI under the admin account (if not already logged in).

6. For the APs that will be in the Enterprise mesh, verify they are connected to the controller (enabled and online) and ensure that their runtime version is the same version of FortiWLC (SD) as the controller's:
   - Check the FortiWLC (SD) version with the command show controller
   - Verify the APs with the command show ap

Phase 2: Create a Mesh Profile

A single controller can manage multiple separate meshes as desired. Follow these steps to create a mesh profile.

1. From the WebUI (accessed by opening an Internet browser and navigating to your controller's IP address), navigate to Configuration > Wireless > Mesh. The Mesh Configuration screen appears. (The screen will be empty unless a mesh profile is already present.)
2. Click Add.
3. On the Mesh Configuration - Add screen, provide the following details:
   - Name: Enter a name for the mesh profile.
   - Description: Enter a brief description for the profile (e.g., its location).
   - Pre-shared Key: Enter an encryption key for mesh communications. This key will be shared automatically between APs that have been added to the mesh profile; the user will not be required to input it manually later on. This key must be between 8 and 63 characters.
   - Admin Mode: Setting this field to Enable activates the mesh profile. If the profile needs to be disabled for any reason, set this field to Disable.
   - PlugNPlay Status: This option allows APs to be added to the mesh by eliminating the need to have them wired connected during mesh configuration. See **Adding Mesh APs Via PlugNPlay** for details.
4. Click OK when all fields have been configured. The new mesh profile is listed in the mesh table.

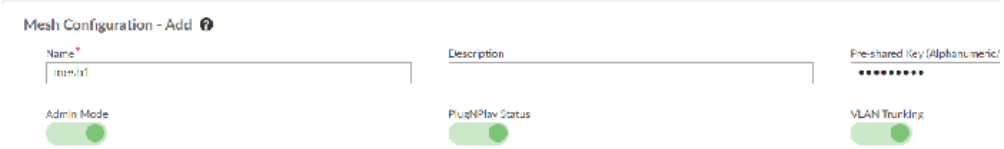
Phase 3: Add APs to the Mesh

Now that the mesh has been created, you can add your APs to it. Follow the instructions below.

The mesh APs must exist in the controller's AP table (i.e., they must be added manually or have been connected to the controller as performed in previous steps) before they can be added to the mesh.

1. From the Configuration > Wireless > Mesh screen, check the box alongside the mesh profile to be modified and click Settings. A summary of the configured mesh settings will be displayed.

Figure 93: *Modifying the Mesh*



2. Click the Mesh AP Table tab provided. Since no APs have been added yet, the table will be blank.
3. Click Add.
4. In the resulting page, use the AP ID drop-down to specify the desired AP.
5. Click OK to add the AP. It will be displayed in the Mesh AP table.

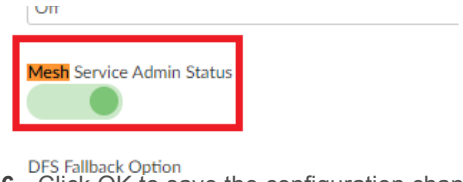
Repeat these steps for all desired APs. Once all APs have been added, they can be configured to utilize mesh operation.

Phase 4: Configure the APs for Mesh Operation

Despite the fact that the APs have been added to a mesh profile, they still must be configured to utilize mesh operation. Follow the steps below.

1. From the WebUI, navigate to Configuration > Devices > APs.
2. Check the box alongside one of the mesh APs and click the pencil icon.
3. Click the Wireless Interface tab to display the available wireless interfaces on the AP.
4. Check the box alongside one of the interfaces and click Settings. Either interface can be selected, but dual interface mesh is not currently supported.
5. From the Wireless Interface tab, click the drop-down box for Mesh Service Admin Status and select Enable.

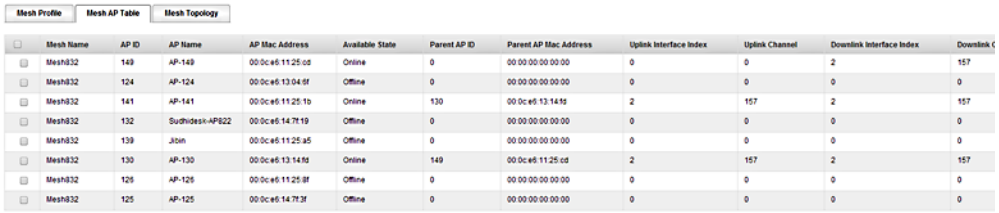
Figure 94: *Enabling Mesh Service*



6. Click OK to save the configuration change.

Repeat these steps for all APs that are part of the mesh. Verify that they are all displayed in the Mesh-AP member table, as shown in **Figure 95**.

Figure 95: *Mesh AP Member Table*



Phase 5: Remove the Cables and Deploy the APs

Phase 5 consists of removing the cables, deploying the APs in their final locations, and turning them on. They will then be picked up by the controller as wireless APs.

To deploy the APs, follow these steps:

1. Ensure that each AP has a power source; if you are using PoE, you need to provide a power adapter for mesh nodes before they can be activated.
2. Unplug the APs and physically install them in the desired locations.
3. Power up the APs in order (i.e., power up the gateway AP first, then any mesh nodes connecting directly to the gateway, etc.). Make sure each AP is online before powering up the next one.
4. From the controller's CLI, use the copy running-config startup-config command to save your configuration.
5. Create ESSIDs for clients and connect clients. Try pinging, browsing, etc. with the clients.

Once deployed, the APs will automatically determine the appropriate parent configurations to provide backhaul access. Provided the APs are in range with each other as per design, they should appear online automatically with no further settings. Your installation is complete.

Adding Mesh APs Via PlugNPlay

As mentioned in *"Phase 2: Create a Mesh Profile"* ***on page 467***, the PlugNPlay option allows mesh nodes to be connected to an existing mesh, without requiring them to be wired directly to the controller. This function is disabled by default.

With PlugNPlay enabled on an existing mesh, deploying a mesh-capable AP to its intended location allows the AP to automatically seek out a mesh within range and add itself to the controller. In effect, this means that a user can set up a mesh profile with only one AP configured for mesh service (by following the instructions earlier in this chapter) and then install additional mesh-capable APs to their intended locations. Once the new APs are powered up, they will

link with the previously-configured mesh AP and add themselves to the controller's AP database.

This does **not** mean that the new AP automatically assumes mesh operation. PlugNPlay operation allows it to add itself to the database directly, but it must still be added to the Mesh AP table on the controller and configured for mesh operation. PlugNPlay simply allows the AP to sync with the controller without requiring a physical connection.

Follow the steps below to install a new mesh AP using the PlugNPlay mechanism. Note that this scenario assumes that a mesh profile has already been created and has at least one active mesh AP added to it and configured via the steps detailed in *"Phase 2: Create a Mesh Profile"* ***on page 467*** and *"Phase 3: Add APs to the Mesh"* ***on page 467*** above.

1. Unbox the new mesh-capable AP and install it within range of the existing mesh node.
2. Connect its power source and allow it to come online. Note that since it will connect to the controller automatically, it may require some time to download new firmware and configurations.
3. Use a computer to access the controller's WebUI.
4. From the web browser, navigate to Configuration > Wireless > Mesh.
5. Check the box next to your existing mesh and click Settings.
6. Click the Mesh AP Table tab.
7. Click Add and select the newly-added AP from the drop-down list. Since it has just been connected, it is likely the most recent (or highest) AP ID number in the list.
8. Click OK to add the new AP to the table.

Now that the AP is part of the mesh, you can enable mesh service on it by performing the following steps.

1. Navigate to Configuration > Devices > APs.
2. Check the box alongside the new mesh AP and click Settings.
3. Click the Wireless Interface tab to display the available wireless interfaces on the AP.
4. Check the box alongside one of the interfaces and click Settings. Either interface can be selected, but dual interface mesh is not currently supported.
5. From the Wireless Interface Configuration - Update screen, click the drop-down box for Mesh Service Admin Status and select Enable as shown in **Figure 94**
6. Click OK to save the configuration change.

These steps can be repeated for as many new mesh nodes need to be configured. Once all the desired nodes have been added, it is recommended that PlugNPlay be disabled on the mesh until additional nodes are needed.

Configuring VLAN in MESH

Mesh APs now supports VLAN trunking.

Before you enable VLAN trunking on a mesh network, follow the recommendations listed below:

- Secondary redundancy network is not support and hence use mesh rediscovery to achieve redundancy.
- The gateway AP in a VLAN mesh should use ESS and port profile in tunnel mode if the profiles contain VLAN tags.

Enabling VLAN Trunk

Using CLI

```
controller(15)# configure terminal

controller(15)(config)# port-profile vlantrunk

controller(15)(config-port-profile)# enable

controller(15)(config-port-profile)# vlantrunk enable

controller(15)(config-port-profile)# multicast-enable

controller(15)(config-port-profile)# end

controller(15)(config)# mesh vlantest

controller(15)(config-mesh)# admin-mode enable

controller(15)(config-mesh)# psk key 12345678

controller(15)(config-mesh)# meshvlantrunk enable

controller(15)(config-mesh)# end

controller(15)#

controller(15)# sh mesh-profile

Name            Description      Admin Mode     PlugNPlay Status VLAN Trunking
  St

vlantrunk                        enable         disable          enable

testvlan                         enable         disable          enable

vlantest                         enable         disable          enable
```

```
        Mesh Configuration(3)

controller(15)# configure terminal

controller(15)(config)# mesh-profile vlantest

controller(15)(config-mesh)# mesh-ap 65

controller(15)(config-mesh-mesh-ap)# end

controller(15)#

controller(15)# sh port-profile

Profile Name                      Enable/Disable VlanTrunk      Dataplane Mode
  VLAN Name   Security Profile Allow Multicast IPv6 Bridging


default                  enable      enable      bridged
  on              off

vlantrunk                enable      enable      bridged
  off             off

        Port Table(2)
```

Enterprise Mesh Troubleshooting

Viewing Mesh Topology

The WebUI provides a Mesh Topology view to quickly assess the current mesh deployment. To access it, navigate to Configuration > Wireless > Mesh > [select mesh] > Mesh Topology.

Within the Mesh Topology tab, click the displayed mesh nodes to expand the tree and view connections between the various nodes.

Problem-Solution Chart

Problem	Possible Cause & Solution
Wireless APs are not connecting to their designated parent AP.	Ensure that per-essid bridge is not enabled on wireless or gateway APs.
APs are picking up a configuration that I did not create	Your APs may have inherited an old configuration from a previously-used AP. Try resetting all APs to factory defaults with the CLI command reload ap id default (for one AP) or reload all default. Then, follow the setup directions in *"Installing and Configuring an Enterprise Mesh System"* ***on page 465***.
APs are rebooting	A possibility could be bad channel conditions. Check the backhaul channel condition using a wireless sniffer.

17 Configuring SNMP

The SNMP Agent offers the network administrator performance management and fault management features, with the collection of statistics as well as notification of unusual events via traps.

The Wireless LAN System SNMP Agent can inter-operate with 3rd party Network Management Systems (NMS) such as HP OpenView, and present alarm and trap information to configured management stations.

Fortinet FortiWLC (SD) supports several versions of SNMP protocols. On Fortinet software, all versions (SNMPv1, SNMPv2c, and SNMPv3) of the Internet-Standard Management Framework share the same basic structure and components. Furthermore, all versions of the specifications of the Internet-Standard Management Framework follow the same architecture.

No	Feature	RFCs
1	SNMPv1	RFC-1155, RFC-1157
2	SNMPv2c	RFC-1901, RFC-1905, RFC-1906
3	SNMPv3	RFC-1905, RFC-1906, RFC-2571, RFC-2574, RFC-2575
4	MIB-II	RFC-1213
5	Fortinet Private MIB	Fortinet Wireless LAN Proprietary MIB

Note that Fortinet FortiWLC (SD) doesn't support write operation through SNMP. You need to provision any required configuration through the CLI or Web UI.

Features

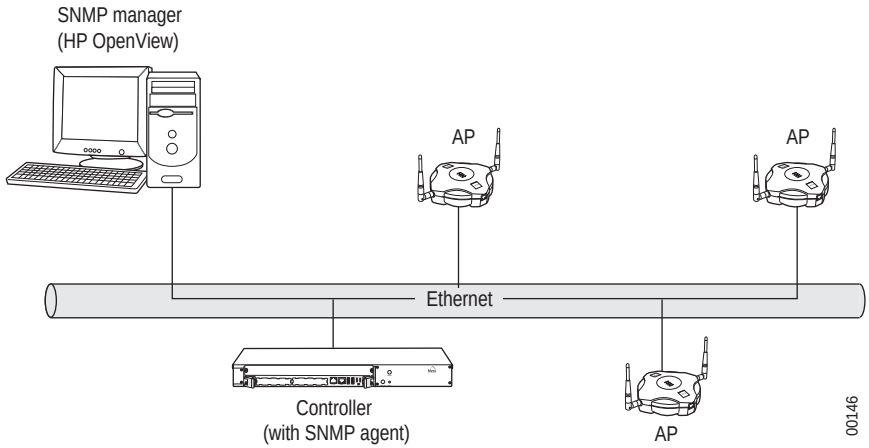
The following protocols are supported for the read function only (not write):

- RFC-1214
- SNMPv1/v2c/v3

- Fortinet WLAN systems

SNMP Architecture

Figure 96: *SNMP Network Management Architecture*



The Wireless LAN System SNMP network management architecture follows the client-server architecture as illustrated in the diagram. The SNMP model of a managed network consists of the following elements:

- One or more managed nodes. In the illustration, the controller is among the managed nodes in the SNMP-based managed network. The SNMP agent is resident in the managed node. It collects statistics from the access points and combines them before sending them to the SNMP manager via MIB variables. Configuration information set via SNMP is also propagated to the access points by the SNMP agent.
- At least one management station containing management applications.
- Management information in each managed node, that describes the configuration, state, statistics, and that controls the actions of the managed node.
- A management protocol, which the managers and agents use to exchange management messages. In an SNMP managed network, the management protocol is SNMP (Simple Network Management Protocol). This defines the format and meaning of the messages communicated between the managers and agents. Fortinet Wireless LAN System provides support for traps, gets, and MIB walk functions only.

Neither read nor write privilege gives the SNMP manager access to the community strings. The controller can have an unlimited number of read and read/write community strings.

MIB Tables

The MIB tables supported by the Wireless LAN System SNMP implementation can be downloaded from the controller and then copied to an off-box location. The MIB Tables are also available on the Fortinet web site. A summary of the Wireless LAN System MIB Enterprise tables are:

mwstatistics.1	mwTop10ApStationProblemTable.1
mwGlobalStatistics.1 *	mwTop10ApStationProblemEntry.1
mwIf80211StatsTable.1	mwTop10Statistics.2
mwGlobalStatistics.2 *	mwTop10ApStationRxtxTable.1
mwIfStatsTable.1	mwTop10ApStationRxtxEntry.1
mwIfStatsEntry.1	mwTop10Statistics.3
mwGlobalStatistics.6 *	mwTop10ApProblemTable.1
mwStationStatsTable.1	mwTop10ApProblemEntry.1
mwStationStatsEntry.1	mwGlobalStatistics.4
mwGlobalStatistics.7 *	mwTop10ApRxtxTable.1
mwApStationStatsTable.1	mwTop10ApRxtxEntry.1
mwApStationStatsEntry.1	mwStatistics.1
mwGlobalStatistics.8 *	mwPhoneTable.1
mwCacApStatsTable.1	mwPhoneEntry.1
mwCacApStatsEntry.1	mwStatistics.2
mwGlobalStatistics.9 *	mwPhoneCallTable.1
mwCacBssStatsTable.1	mwPhoneCallEntry.1
mwCacBssStatsEntry.1	mwStatistics.3
mwStatistics.2 *	mwStatusTable.1
mwTop10Statistics.1	mwStatusEntry.1

Global statistics use 64 bit counters in FortiWLC (SD) 4.0 and later

Download the MIB Tables for Management Applications

If you are using a third-party SNMP-based Network Manager program, you will need to integrate the Fortinet Wireless LAN System proprietary MIB tables that allow the manager program to manage controllers and APs. The MIB tables are available in a compressed (zipped) file that can be copied from the controller to an off-box location.

To download the enterprise MIB Tables, contained in the file mibs.tar.gz, located in the images directory, use the following CLI commands:

```
controller# cd image
   controller# copy mibs.tar.gz off-box_location
```

To download the enterprise MIB Tables using the Web UI, follow these steps:

1. Open a Web Browser(IE or Firefox), enter the system IP address (example: https://172.29.0.133) and then enter a user name and password (factory default user name/password is admin/admin).
2. Click Configuration > Wired > SNMP > Download MIB Files.
3. When the download is done, you will see the file listed in the Downloads list.
4. Save the file mibs(x).tar.gz.

SNMP Configuration

The SNMP agent in the controller must be properly configured for the following:

1. The read and write community strings must be configured before the Web UI can be used to view and update any of the components of the controller.
2. The trap manager must be configured so that traps are sent to the correct SNMP manager.
3. The contact and location information should also be correctly configured so that the SNMP manager can access this information and know who to contact in case of problems.

SNMP Community Strings

SNMP community strings authenticate access to MIB objects. They determine whether the SNMP manager has read and/or write access to particular MIB objects, if at all. Before the SNMP manager can access a controller, it must supply a community string that matches at least one of the community string definitions of the controller, with the same access privileges.

A community string can have one of these attributes:

- Read-only. Management stations with the community string can view all objects in the MIB, but cannot modify them.
- Read-write. This gives read and write access to authorized management stations to all objects in the MIB.

To configure community strings, enter privileged EXEC mode, and follow these steps:

TABLE 26: *Configuring SNMP Community Strings*

Command	Purpose
configure terminal	Enter global configuration mode.
snmp-server community string host {ro|rw}	Creates a new SNMP community string with the specified host and privileges. The host can either be a host name or an IP address in the format 255.255.255.255. The access privileges can be either read-only (ro) or read-write (rw).
end	Return to privileged EXEC mode
show running-config	Verify your entries.
copy running-config startup-config	(Optional) Save your entries in the configuration file.

Trap Managers

A trap manager is a management station that receives and processes traps. The controller can have an unlimited number of trap managers. Trap managers are grouped into communities. A single community may have one or more hosts, which are specified as IP addresses.

TABLE 27: *Configure SNMP Trap Managers*

Command	Purpose
configure terminal	Enter global configuration mode.
snmp-server trap community-string hostIP	Specify the recipient of the trap message: For community-string, specify the string to send with the notification operation. For hostIP, specify the name or address of the host (the targeted recipient).
end	Return to privileged EXEC mode.
show running-config	Verify your entries.
copy running-config startup-config	(Optional) Save your entries in the configuration file.

SNMP Traps

These are important traps for the Fortinet Wireless LAN System:

No	Case	Trap ID	Scenario
1	Controller Down	SNMP Poll	When a controller goes down or loses IP connectivity, SNMP Manager detects that the controller is down with an SNMP polling mechanism.
2	Controller Up	Cold Start trap	When a controller comes up, the SNMP Agent generates a <Cold Start> trap on the SNMP server.
3	NPlus1 Master Down	mwlMasterDown in meru-wlanmib. my	When a master controller with NPlus1 goes down, SNMP generates a MasterDown trap.
4	NPlus1 Master Up	mwlMasterUp in meru-wlan-mib. my	When a master controller with NPlus1 comes up, SNMP generates a MasterUp trap.
5	AP Down	mwlAtsDown in meru-wlan-mib. my	When an AP goes down, SNMP generates an AP_DOWN trap.
6	AP Up	mwlAtsUp in meru-wlanmib. my	When an AP comes up, SNMP generates an AP_UP trap.
7	Rogue AP detected	mwlRogueApDetected in meru-wlanmib.my	When the system detects a rogue device, SNMP generates a <RogueAPDetected> trap.
8	Rogue AP Removed	mwlRogueApRemoved in meru-wlanmib.my	When the system detects a rogue device has disappeared from the network, SNMP generates a <RogueAPRemoved> trap.

The following chart lists all traps that exist for the Fortinet Wireless LAN System:

mwlRogueApDetected	New in version 3.6:
mwlRogueApRemoved	mwlCacLimitReached
mwlAtsDown	mwlRadarDetected
mwlAtsUp	mwlMasterDown
mwlWatchdogFailure	mwlMasterUp
mwlWatchdogUp	mwlSoftwareLicenseExpired
mwlCertificateError	mwlSoftwareLicenseInstalled
mwlCertificateInstalled	mwlTopoStaAtsAdd
mwlApSoftwareVersionMismatch	mwlAtsNeighborLoss
mwlApSoftwareVersionMatch	mwlAtsNeighborLossCleared
mwlApInitFailure	mwlHandoffFail
mwlApInitFailureCleared	mwlHandoffFailCleared
mwlApRadioCardFailure	mwlResourceThresholdExceed
mwlApRadioCardFailureCleared	mwlResourceThresholdExceedCleared
mwlAuthFailure	mwlSystemFailure
mwlRadiusServerSwitchover	mwlSystemFailureCleared
mwlRadiusServerSwitchoverFailure	mwlApBootimageVersionMismatch
mwlRadiusServerRestored	mwlApBootimageVersionMatch
mwlAcctRadiusServerSwitchover	mwlMacFilterDeny
mwlAcctRadiusServerSwitchoverFailure	mwlMacFilterDenyCleared
mwlMicFailure	mwlApTemperature
mwlMicCounterMeasureActivated	mwlApTemperatureCleared
mwlHardwareDiagnostic	
mwlHardwareDiagnosticCleared	
mwlCacLimitReached	
mwlRadarDetected	
mwlOperationalChannelChange	

Objects That Monitor System Status Through SNMP/OID

Use the SNMP get operation to monitor these objects:

No	Case	OID	Shows
1	System Uptime	mwWncVarsUpTime in mwConfigController.my	system uptime
2	System Operational Status	mwWncVarsOperationalS tate in mwConfigController.my	system's current operational status
3	System Availability Status	mwWncVarsAvailabilityStatus in mwConfigController.my	system's current available status.
4	AP Uptime	mwApUpTime in mwConfigAp.my	AP's uptime
5	AP Operational Status	mwApOperationalState in mwConfigAp.my	AP's current operational status
6	AP Availability Status	mwApAvailabilityStatus in mwConfigAp.my	AP's current available status

Agent Contact and Location Commands

The following are the commands to set the system description, contact and location of the SNMP agent:

TABLE 28: *Configure SNMP Description, Contact and Location*

Command	Purpose
configure terminal	Enter global configuration mode.
snmp-server contact text	Sets the system contact string. For example: snmp-server contact support@fortinet.com
snmp-server location text	Sets the system location string. For example: snmp-server location Tower Building, IT Department
snmp-server description text	Sets the system description string. For example: snmp-server description main controller
end	Return to privileged EXEC mode

TABLE 28: *Configure SNMP Description, Contact and Location*

Command	Purpose
show running-config	Verify your entries.
copy running-config startup-config	(Optional) Save your entries in the configuration file.

Configure SNMP Service on a Forti WLC With the CLI

Set up the SNMP server community with a specific IP address with these commands:

```
default# configure terminal
  default(config)#
  default(config)# snmp-server community public 0.0.0.0 rw
  default(config)# end
  default# show snmp-community
  SNMP Community Client IP Privilege
  public 0.0.0.0 read-write
  SNMP Community Management(1 entry)
  default#
```

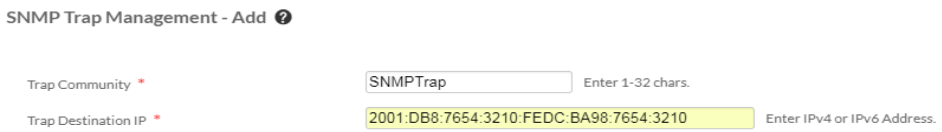
Set up the trap community with a specific IP address with these commands:

```
default# configure terminal
  default(config)# snmp-server trap public 10.0.220.30
  default(config)# end
  default# show snmp-trap
  Trap Community Destination IP
  public 10.0.220.30
  SNMP Trap Management(1 entry)
```

Configure SNMP Service on a FortiWLC With the Web UI

Set up the SNMP server community with a specific IP address by following these steps:

1. Click Configuration > Wired > SNMP > SNMP Community Management > Add.
2. Provide an SNMP Community Name, Client IP Address (IPv4/IPv6), and select a privilege level such as read-write.
3. Click OK.



Set up the trap community with a specific IP address.

1. Click Configuration > Wired > SNMP > SNMP Trap Management > Add.
2. Provide a Trap Community and Trap Destination IP Address (IPv4/IPv6).
3. Click OK.

Set up 3rd Party Vendors

Fortinet MIB files should be compiled and loaded on SNMP manager to be used with Forti WLC. SNMP Manager has to have Fortinet MIB file and compile to access Fortinet OIDs through SNMP. To download the Fortinet MIB file from the controller, follow these steps:

1. Open an MIB Compiler. Load and compile all MIBs.
2. Access the Forti WLC from the Web UI.
3. From the MIB tree browser expand ios -> org -> dod -> internet -> private -> enterprise -> meru -> meru-wlan -> mwConfiguration -> mwWncVars>.
4. Activate a walk operation. This will query all OIDs under mwWncVars tree.

Enabling, Disabling, and Reloading SNMP

Once an SNMP configuration is complete, enable it with the command snmp start:

```
controller# snmp start
```

To turn off SNMP messaging, use the command snmp stop:

```
controller# snmp stop
```

To reload the SNMP module, use the command reload-snmp:

```
controller# reload-snmp
```

SNMP Version 3 Support

The SNMPv3 architecture, supported by FortiWLC (SD) 4.0 and later, incorporates new descriptions for SNMP Entities (Managers, Agents, Proxy Forwarders), updated message formats, and standard MIBs used to configure access to entities. The SNMP Agent on Forti WLC is multi-lingual with simultaneous support for SNMPv1/v2c/v3 if configurations such as snmp-community for SNMPv1/v2c or SNMPv3-user for SNMPv3 are correct. New features include:

- Security levels for user authentication using entity shared secret keys
- Message time stamps
- Data secrecy using encryption
- Control of user access to MIB information based on the need to know

Security Levels

SNMPv3 provides both security levels and security models. A security level is the permitted level of security within a security model. A combination of a security level and a security model determine which security mechanism is employed when handling an SNMP packet. (See **Combinations of Security Levels and Security Models** in this document.) SNMPv3 messages can be sent at any of the following three security levels:

- No Authentication and No Encryption This is also called noAuth/noPriv. Priv refers to privacy. With this security, only a valid user name is required to access data or to send a trap.
- Authentication and No Encryption This is also called Auth/noPriv. With this security, you must be authenticated as a valid user for a message to be accepted. Authentication is accomplished by sharing a secret key and using that key to produce a message-hashed authentication code sent with each message.
- Authentication and Encryption This is also called Auth/Priv. With this security, you are authenticated and the data payload is encrypted using a second shared secret key.

Security Models

SNMPv3 provides for both security levels and security models. A security model is an authentication strategy that is set up the group in which a user resides. Three security models are now available:

- SNMPv1
- SNMPv2c

- SNMPv3

A combination of a security model and a security level will determine which security mechanism is employed when handling an SNMP packet. See **Combinations of Security Levels and Security Models** in this document.

Combinations of Security Levels and Security Models

The table below identifies the combinations of security models and levels and describes how security is handled with each combination.

Model	Level	Authentication	Encryption	What Happens
v1	noAuthNoPriv	Community String	No	Uses a community string match for authentication
v2c	noAuthNoPriv	Community String	No	Uses a community string match for authentication
v3	noAuthNoPriv	Username	No	Uses a username match for authentication
v3	authNoPriv	MD5 or SHA	No	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms
v3	authPriv	MD5 or SHA	DES	Provides authentication based on the HMAC-MD5 or HMAC-SHA algorithms. Provides DES 56-bit encryption in addition to authentication based on the CBC-DES (DES-56) standard

SNMP Version 3 Commands

The ***FortiWLC (SD) Command Reference*** has detailed descriptions of these commands.

- snmpv3-user
- snmpv3-user auth-key
- snmpv3-user auth-protocol
- snmpv3-user priv-key
- snmpv3-user priv-protocol
- snmpv3-user target ip-address

SNMP Version 3 Support Limitations

Currently, Fortinet does not support the following SNMPv3 features.

- Since Forti WLC do not support write access for SNMP MIBS, all users belong to the Read View Access Control table and they are handled as Read View with a group internally. View the Access Control Model (VACM) to determine if a user belonging to a specific group has access (Read, Write, Notify) to the management entity. Access Policy is defined by associating the respective read, write or notify view with a group.
- SNMPv3 Notifications: Fortinet does not support SNMPv3 trap/inform. Along with the supported SNMPv3 feature (read only), Fortinet Network controllers still provide both SNMPv1/v2c accessibility using the existing snmp-community table and SNMPv1 trap using snmp-trap community table.

18 Troubleshooting

Where Do I Start?

We recommend that you start troubleshooting as follows:

Web UI or CLI?	Problem Involves?	Strategy
Web UI	stations	View station log history by clicking Monitor > Diagnostics > Station
Web UI	radios	View radio log history by clicking Monitor > Diagnostics > Radio

Web UI or CLI?	Problem Involves?	Strategy
CLI	stations	View station-log history with one of these commands: station-log show-mac=<affected MAC address> station-log show (if the MAC is not known) If the problem is reproducible/occurring continually, log your terminal session, enter the station-log interface and add the affected MAC address using the command station add <MAC>. If you DON'T know the MAC address, enter event all all to capture all events for all MAC addresses.
CLI	controller	View controller-log history with the command diagnostics-controller If the problem is reproducible/occurring continually, log your terminal session, enter the station-log interface with the command station-log, and add the affected MAC address using the command station add <MAC>. If you DON'T know the MAC address, type event all all to capture all events for all MAC addresses.

Error Messages

The following are common error messages that may occur either at the controller or at an AP.

Message Text	Explanation
[07/20 13:02:11.122] 1m[35m**Warning**[0m WMAC: Wif(0):SetTsf() TSF[00000000:000006e3] -> [00000033:77491cfd]thr[00000000:03938700]	May be observed on the AP command line or in trace log output from an AP after a full diagnostics gather. The SetTsf() messages indicate that the AP has adjusted its TSF (TSF stands for Time Synchronization Function and is really the AP's clock) forward by more than a certain threshold (the threshold is 5 seconds). The specific case above indicates that the AP has just booted up and adjusted its TSF value to its neighboring AP's TSF value. You can tell that the AP just booted because its current TSF is a low value (i.e. 6e3 microseconds). During initialization, the AP will synchronize its TSF to the TSF of its neighbors whenever the neighbors support a BSSID in common with this AP. That is a requirement to support Virtual Cell.
[07/31 14:01:33.506] *****ERROR***** QOS: FlowMgr failed while processing flow request, reason= 5, srcMac[00:23:33:41:ed:27], dstMac[00:00:00:00:00:00].	May be observed in the controller's CLI interface. This error occurs when there is an attempt to either set up or remove an AP flow on a station that has started a phone call. "reason=5" means the cited station is not assigned to the AP where the attempt to set up/ remove the flow was made. The presumed impact is that the stations (presumably phones) get lower than normal call quality since there are no QoS flows established on behalf of the MAC address.
Received non-local pkt on AP!	This message may be observed on the serial console of a controller or in the dmesg.txt output included with a controller's diagnostics. This message indicates that a Ethernet type 0x4001 or UDP port 5000 packet (L2 and L3 COMM respectively) was received by the controller's Ethernet, but was not actually destined for the controller's MAC or IP address.

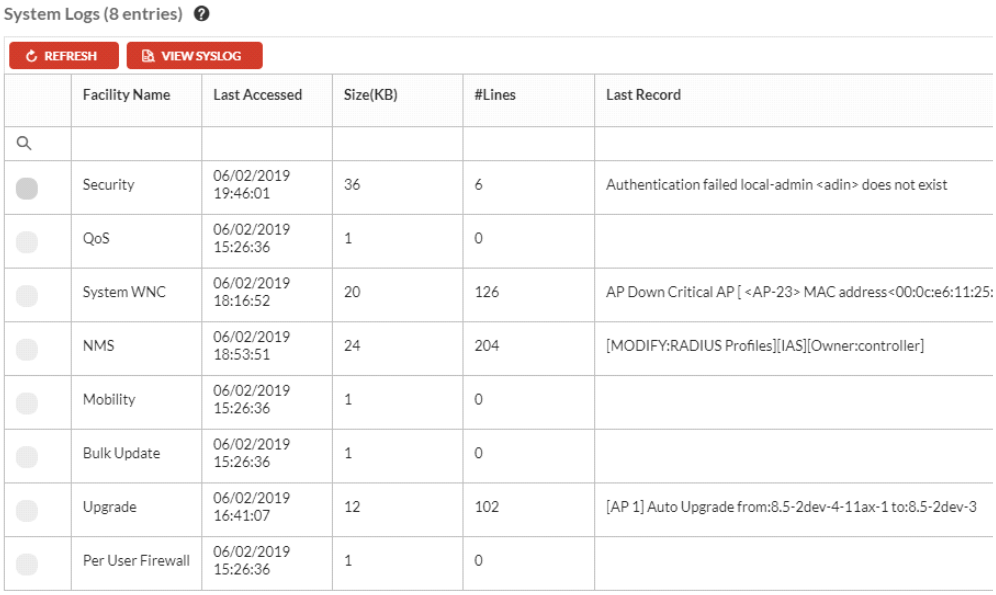
System Logs

The system log records the following:

- Configuration changes (CLI or GUI)
- Key commands
- Events and operations
- Errors

The CLI command show log lists the entire log. To view the system log files from the Web UI, click Maintenance > Syslog > View Syslog Files.

Figure 97: *Syslog Files Table*



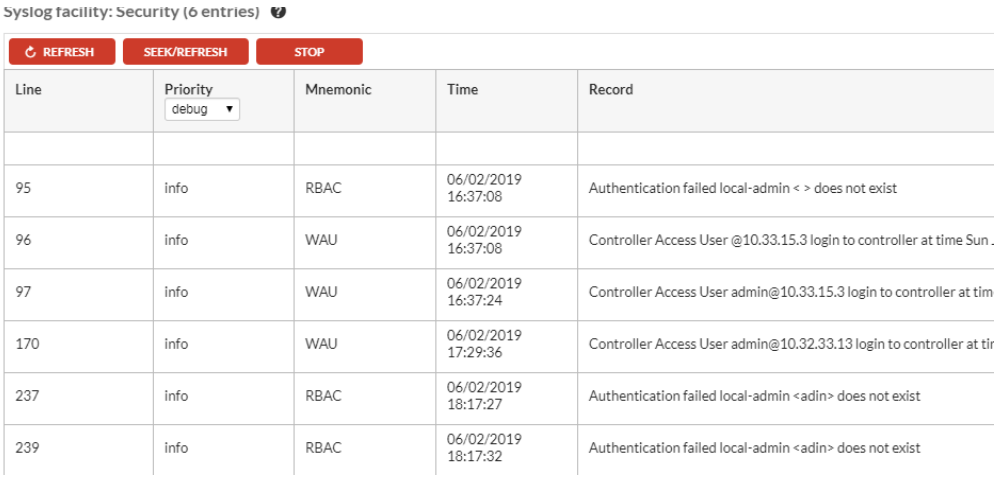
Facility Name can be one of these eight sources of information:

Facility	Messages contain...
Security	Creation and violation of security configuration, including User logins and Captive Portal activity
QoS	Quality of Service messages for both creation and violation of QoS rules created on this controller
System WNC	Rogue AP syslog messages
NMS	Network Manager Server syslog messages
Mobility	Handoff or redirect messages
Bulk Update	Any use of the bulk update commands available from the GUI are noted here. The Bulk Update function, accessed from the AP Configuration, Wireless Interfaces Configuration, and Antenna Property pages, updates a group of selected APs. Bulk Update works the same in each of these areas, but the items to be updated are specific to the page where the bulk update is being initiated.

Facility	Messages contain...
Upgrade	Any use of the CLI command upgrade
Per-user Firewall	Creation and violation of per-user firewalls

Select one of the Facilities listed in the above chart and then click View Syslog to see these details:

Figure 98: *Security System Log Details*



Entry	Meaning
Line	Line number of the syslog file where the entry is located
Priority	Severity of the entry. Possible priorities are: debug, info, notice, warning, error, err, crit, alert, emerg, panic.
Mnemonic	Three-letter mnemonic assigned to the entry: CAP = Captive Portal RED = redirect FOR = forward WAU = WebAuth user authentication WST = Web Server Event WPW = Web UI user password administration

Entry	Meaning
Time	Date and time when the entry was logged.
Record	The details of the syslog event depend on the category of the message: Security: User logins, Captive Portal activity QoS: Creation and violation of QoS rules System WNC: Rogue activity NMS: If this controller is part of Network Manager, all activity initiated by the Network Manager Server Mobility: This consists primarily of RED (redirect) messages Bulk Update: AP updates done in groups Upgrade: FortiWLC (SD) upgrades Per-User Firewall: Creation and violation of firewalls

To search for information on any column of a Facility screen like the one in **Figure 98**, do the following. In the box at the top of any column (Line, Priority, Mnemonic, Time, Record), provide search data to filter the messages. You then see only messages that fit that filter. For Priority, you see messages of the selected priority level and higher; for example, a search for debug shows every message because debug is the lowest priority level. A search for info shows the messages info and higher: notice, warning, error, err, crit, alert emerg, panic (highest priority).

You can also click the calendar icon above the Time column to enter a specific date or time to filter syslog messages in this category.

Station Log Events

The triggered station log event messages are consolidated, captured and displayed in the station logs. Run the **`station log> enable`** command to enable logging of events on the console. Note that when you disable station logs, they are still collected and are dumped on the console when you enable station logging again.

See the *Fortinet Event Logging Facility (Station Log)* document for more details.

System Diagnostics

There are four sets of diagnostics for a controller:

- Radio diagnostics
- Station diagnostics
- Inferences

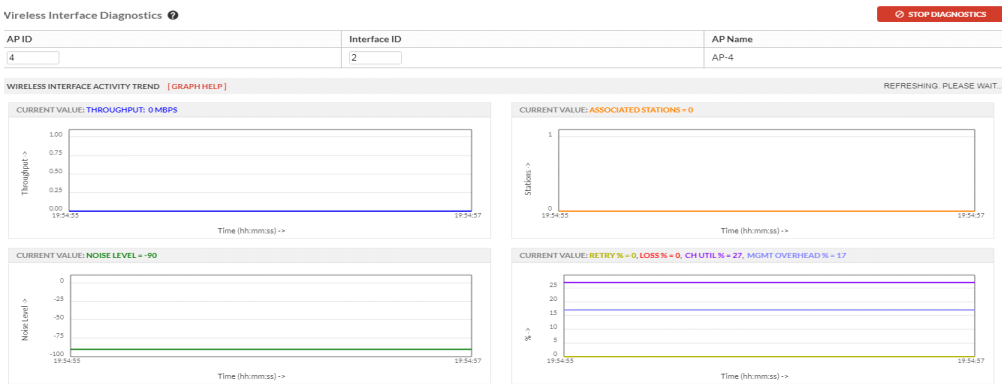
- Station Connection Diagnostics (Serviceability)

Radio diagnostics

Each AP has either one or two radios that can be configured individually (Configuration > Wireless > Radio). You can check on the wireless activity trends for these radios by looking at the diagnostic information:

1. Click Monitor > Diagnostics > Radio.
2. Provide an AP number and an interface ID (Radio 1 or 2).
3. Click Start Diagnostics in the upper right corner of the screen.

Figure 99: *Radio Diagnostics*



1. Check the four charts for these radio trends:

Chart	What it tells you	Why you might want to know this
Throughput	Sum of upstream and downstream traffic for the radio	Users are experiencing slow response in the area covered by this AP
Noise Level	How much unwanted energy is present in the received radio signals	Users are experiencing connection problems or low transmission speeds in the region covered by this AP

Chart	What it tells you	Why you might want to know this
Associated Stations	How many clients are using this AP	Find out if you need to add another AP (consult your reseller for specific AP deployment recommendations)
Current Value	Packet retries, loss %, channel utilization, and management overhead for the radio	Users are experiencing slow response in the area covered by this AP

Station diagnostics

Each client on an AP can be studied individually by looking at the station diagnostic information:

1. Click Monitor > Diagnostics > Station.
2. Provide a MAC address for the client. One way to determine the client MAC address on Windows XP is to open the Command Prompt by clicking Programs > Accessories > Command Prompt and then entering the command ipconfig /all - this gives you physical addresses for the wireless connections.
3. Click Start Diagnostics in the upper right corner of the screen.

Figure 100: *Station Diagnostics*

1. Check the four charts for these station trends:

- Throughput
- Loss %
- Signal Strength

- Airtime Utilization

2. Click Help for explanations for the charts.

Inferences

Inferences are best guesses as to what could be wrong with your wireless network. Check a controller, AP, and station by looking at the diagnostic inferences:

1. Click Monitor > Diagnostics > Inferences.
2. Optionally narrow down the list by providing a MAC address for a controller, AP, or station.
   A list of recent events is listed along with corresponding details.

Figure 101: *Diagnostic Inferences*

TIMESTAMP	MAC ADDRESS	SOURCE	Details
2019-06-02 15:29:33.799	00:0d:48:30:8f:c1	0	
2019-06-02 15:35:58.097	00:0d:48:30:8f:c1	0	
2019-06-02 15:39:16.251	00:0d:48:30:8f:c1	0	
2019-06-02 15:40:54.327	00:0d:48:30:8f:c1	0	
2019-06-02 16:20:31.181	00:0d:48:30:8f:c1	0	
2019-06-02 16:27:06.488	00:0d:48:30:8f:c1	0	
2019-06-02 16:38:36.028	00:0d:48:30:8f:c1	0	
2019-06-02 16:38:37.030	00:0d:48:30:8f:c1	0	
2019-06-02 16:40:23.112	00:0d:48:30:8f:c1	0	
2019-06-02 16:42:02.189	00:0d:48:30:8f:c1	0	
2019-06-02 16:43:40.265	00:0d:48:30:8f:c1	0	

The first part of the message is the issue and level of severity. In the example above, there is an IP conflict which is a critical issue. The information in a Station Entry is listed below. You can read it or alternately cut and paste the MAC address into the Station Diagnostics window.

Figure 102: *Decoding a Station Entry*

Sample Station Entry

Inference Rule #8 matched : IP Address Update 32 times within 360 seconds.
[IP 172.27.0.198] [dhcp] [data] [AP-3 AP-3] [BSSID 00:0c:e6:3d:0b:45] [ESSID rcomm_diag]
[Vlan Tag 0] [L2 State clear] [L3 State clear] [First Seen @ UTC Jun 9 13:50:22]

Inference Rule #12 matched : Soft Handoff 21 times within 360 seconds.
[IP 172.27.0.198] [dhcp] [data] [AP-2 AP-2] [BSSID 00:0c:e6:3d:0b:45] [ESSID rcomm_diag]
[Vlan Tag 0] [L2 State clear] [L3 State clear] [First Seen @ UTC Jun 9 13:50:22]

Information Provided

- Rule that triggered entry
- Latest IP address of station
- DHCP used
- Type of traffic (data or SIP)
- AP updated
- BSSID of Station
- ESSID of Station
- VLAN tag number
- Authentication used on L2
- Authentication used on L3
- Date problem was first seen

Station Inference Messages

Some possible station rules and messages are:

ID #	Station Message	Remarks
1	MAC Filter ACL Success	Station executed MAC filtering ACL authentication
2	MAC Filter ACL Failure	Station exceeded threshold of MAC filtering ACL authentication attempts
3	RADIUS Auth Success	Station executed MAC filtering RADIUS authentication
4	RADIUS Auth Failure	Station exceeded threshold of MAC filtering RADIUS authentication attempts
5	Assignment Failure	Station exceeded threshold of 802.11 assignment attempts. This could be caused by any of the following: Associated AP is not found in AP table Maximum number of stations, which varies with AP models, is exceeded Maximum number of licensed stations is exceeded Controller has not received configuration of the AP yet BSSID for a client to be assigned is not found in the BSS table AP does not have a free slot for the station RSSI is not appropriate for the station
6	Association Success	Station executed 802.11 association
7	Key Exchange Success	Station executed 802.1x key exchange
8	Key Exchange Failure	Station exceeded threshold of 802.1x key exchange attempts. An AP detected either of the following conditions of 1X authentication failure between the AP and the client; EAPoL handshaking failed EAPoL handshaking timed out Another possible cause is that Hostapd detected one of the following conditions of 1X authentication and 802.1x key exchange failure: Invalid RADIUS VLAN tag detected EAP packet failed to reach the station MIC failure occurred and both the counts of MIC failure and 802.1x key exchange failure are increased 4-way handshake timed out Group key update timed out EAP key replay counter is mismatched
9	MIC Failure	Station exceeded threshold of 802.1x MIC attempts
10	IP Address Update	IP address changed from valid to 0, 0 to valid, or valid to valid

ID #	Station Message	Remarks
11	Data Decryption Failure	Data decryption failure of RX packet occurred; attempt threshold was exceeded. Hostapd detected that Ess.MicCountermeasureData.Mic-Counter exceeded 1 within the MIC_COUNTERMEASURE_PERIOD (60 seconds). When this occurs, Hostapd notifies the AP to stop accepting communication from that station and disassociate the station.
12	CP Guest User Success	Station authenticated a Captive-Portal guest
13	CP Guest User Failure	Station exceeded threshold of Captive-Portal guest authentication attempts
14	Soft-Handoff	Station executed soft-handoff

Some possible controller inference messages are:

Controller Message	What it tells you
DHCP server reached	DHCP Server required for IP address assignment is reachable
DHCP server unreachable	DHCP Server required for IP address assignment is unreachable
Gateway reached	Default gateway for client sub-network is reachable
Gateway unreachable	Default gateway for client sub-network is unreachable
RADIUS server reached	RADIUS server required for client authentication is reachable
RADIUS server unreachable	RADIUS server required for client authentication is unreachable
VLAN gateway reached	VLAN gateway in the path for client communication is reachable
VLAN gateway unreachable	VLAN gateway in the path for client communication is unreachable
IP Address conflict between wireless clients or between wired and wireless clients or between wireless client and controller	At least two wireless clients or controllers have been assigned (or have specified) the same IP address, which is causing network confusion.
IP un-assignment of client by failure of DHCP IP assignment	An IP address has been removed from the client due to the DHCP server failing to provide an assignment.

Serviceability

In addition to the existing diagnostic tools to troubleshoot stations connectivity issues, you can use the station-log issues command to get more definitive reasons on stations connectivity. Two additional columns (Issue Observed and Reason) in the station-log issues command provide specific details of an issue and plausible cause.

```
default(15)# station-log issues
```

```
Time stamp           | Client MAC address | AP MAC address   | Issue observed
  | Reason

2014-03-14 07:15:13.342 | 00:00:00:00:00:00 | 00:0c:e6:0e:00:21 | AP radio
  reset          | Reset of radio interface 0

2014-03-14 07:17:58.851 | a8:86:dd:db:6a:c9 | 00:0c:e6:0e:00:21 | Handoff retry
  failure  | Handoff retry failed for BSSID 00:0c:e6:02:4c:45
```

The following are pre-defined list of issues:

TABLE 29: *Connectivity Issues*

Issues	Description
Frequent change in associated AP	This will be observed by comparing the current AP to previously associated APs (3 associations to different APs in 3 minutes.)
AP radio reset	This will be observed in the APs whenever an AP radio is reset
Long queuing delay	This will be observed in the AP queue manager, when the packets to the sent to clients remain in the queue was more than the expected time (5s)
Connected to distant AP	Observed when the client doesn't connect to the closest AP with a higher RSSI value but to an AP further away with a lower RSSI value
Good RSSI value but low data rate	Observed when the RSSI value of the associated AP is considered good (above -70), but the wireless data rate is below the expected performance
High AP throughput but high retry count	Observed when the AP throughput is high, but the retry percentage is also high
Frequent associations and dissociations	Observed when the client associates and dissociates continuously to the same AP. (3 associations to the same AP in 3 minutes)
Back-and-forth handoff	Observed when 3 handoff acknowledgement messages are received with 12s between 2 APs. Eg. AP1 to AP2 back to AP1
Handoff retry failure	Observed when an initiated handoff fails repeatedly for 5 times

Station Log Issues Filter

By default the station-log issues command will display all issues on the screen. The following filter options are available to view specific issues:

- By Mac address:

Use the *-mac* filter to view issues specific to a particular mac address.

```
default(15)# station-log issues -mac a8:86:dd:db:6a:c9
```

- By AP Mac address:

  Use the *-apmac* filter to view issues related to a specific AP.

```
default(15)# station-log issues -apmac 00:0c:e6:0e:00:21
```

- By Issue ID:

  Use *-is <IssueID1>,<IssueID2>* to view specific issues from the list of issues printed on the screen. The following example, will list issues that match issues IDs 2 and 9 .

```
default(15)# station-log issues -is 2,9
```

- Last Entries:

  To view the last set of issues, use *-last <x>* filter, where x is an integer.

```
default(15)# station-log issues -last 2
```

- Using Search Pattern

  To view issues that match a text pattern, use the -search “text” option.

```
station-log issues -search "Reset of radio"
```

- Help

  To view all available options, use the help keyword.

```
default(15)# station-log issues help

Usage: station-log issues <Arguments>
<Arguments>
help Display this help and exit
all  Display all logs
-is <Issue ID>[,<Issue ID>]  Display issues matching issue ID
   (Example) -is 2,3 : filtering for AP radio reset and Long queuing
   delay
 -mac <MAC>  Display issues for this client MAC address
   (Example) -mac 00:90:0b:23:2e:b7 : filtering '00:90:0b:23:2e:b7'
-apmac <MAC> Display issues for this AP MAC address
   (Example) -apmac 00:90:0b:23:2e:b7  : filtering
   '00:90:0b:23:2e:b7'
-search "<PATTERN>" Display issues matching this pattern. PATTERN is
   case-sensitive
   (Example) -search "Reset of radio" : filtering matching string
   'Reset of radio'
-last <NUM> Display the last <NUM> issues. NUM should be greater than
   0
   (Example) -last 5: print the last 5 issues
```

List of Issue IDs

TABLE 30: *List of Station Log Issues ID*

Issue ID	Description
1	Frequent change in associated AP
2	AP radio reset
3	Long queuing delay
4	Connected to distant AP
5	Good RSSI value but low data rate
6	High AP throughput but high retry count
7	Frequent associations and dissociations
8	Back-and-forth hand-off
9	Hand-off retries failure

What Else Can I learn From A Diagnostic Event?

To see Controller Diagnostic Inferences with the CLI, turn on controller diagnostic inferences with the diag-log command admin controller on.

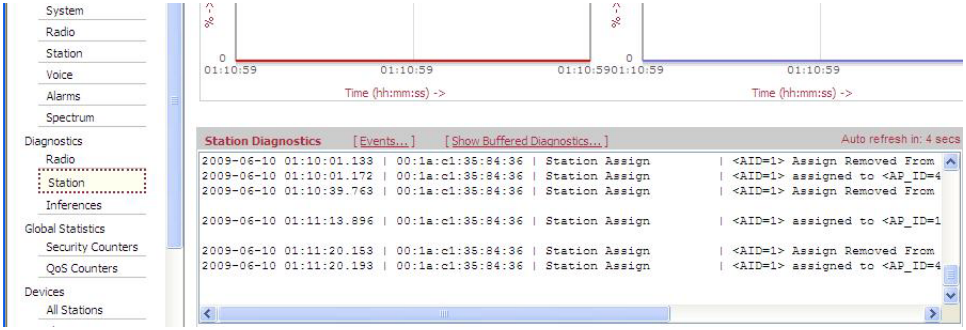
```
Forti01# configure terminal
   Forti01(config)# diag-log
   Forti01(config-diag-log)# admin controller on
```

Turn on station diagnostic inferences with the diag-log command admin station on.

```
Forti01# configure terminal
Forti01(config)# diag-log
Forti01(config-diag-log)# admin station on
```

Examine the details of a particular event by copying a MAC address from a Web UI screen such as **Figure 101**, pasting it into the Station Diagnostics window (Monitor > Diagnostics > Station) and then clicking Start Diagnostics.

Figure 103: *Results of pasting a MAC address into the Station Diagnostics window*



Scroll down to the bottom of the screen and click Show Buffered Diagnostics.

Capturing Packets

With the packet-capture-profile commands, you can capture packets from either a controller's local interface or capture over the air from access points. Once packets are captured, you have three options for using them. You can see packet captures in real time, save them to a file for future offline analysis, or send them to an IDS program or device.

The CLI command packet-capture-profile supports a capture of a file up to 10Mb. Make sure that the directory captive is empty before using the command packet-capture-profile. With the packet-capture-profile commands, you can forward packet captures from APs directly to external devices without storing packets locally on the controller. This eliminates the restriction on the file size of the packet capture (you are not limited by controller memory) and also allows the captured information to be stored and archived externally. Use these CLI commands to

send captured packets from APs to a hardware device or program. This command is required to use Location Manager.

To Do this:	Using this command:
Enter pcap mode and create a packet capture profile.	packet-capture-profile either updates an existing profile or creates a new profile and then enters pcap mode where the rest of these commands are used.
Determine which APs will send packets.	ap-list determines which APs will send packets. You must type each AP name one by one, separated by commas. At this time there is no all option or range ability. This list is limited by buffer space; you can enter 1, 2, 3,...90 without exceeding the limit. We recommend that you create the list in an application such as Notepad and then paste it into the command because if you exceed the buffer size, the command fails and you have to retype the entire list of APs again. If your list of APs exceeds the buffer size, you can create another profile that covers the rest of the APs.
Indicate packet destination. Indicate which port to use.	mode sets the transmit mode to layer2 or layer3, names the destination IP and names the port that should be used. Port 9177 is used for Location Manager and 17777 (PPI encapsulation) can be used for debugging. *PPI = Per-Packet Information
Determine the biggest packet size that you want an AP to send.	packet-truncation-length sets packet capture truncation length. Default is 0 for troubleshooting and operation with WIPS. 82 is used for Location Manager.
Decide if you want to limit the rate at which packets are sent.	rate-limiting sets the packet capture rate limit to per-station or cumulative. ! Note: Currently, if rate limiting is on, packets are limited only for per-station.
Determine whether you want to capture packets going to the AP, coming from the AP, or both.	rxtx sets traffic intrusion detection to received traffic, sent traffic, or both. .
Limit bandwidth used.	token-bucket-rate sets the token bucket rate.
Limit bandwidth used.	token-bucket-size sets the token bucket size.
Download the configuration to the APs and start capturing packets.	enable-profile turns on a packet capture profile.

For a detailed explanation of all packet capture commands, see the Troubleshooting chapter of the ***FortiWLC (SD) Command Reference***.

Packet Capture Profile Example - WireShark

To do this, you need an external system running WireShark. This example creates the packet-capture-profile named Sniffer on a controller and then forwards the captured packets in layer 3 mode from AP-5 to WireShark on port #17777. Port 17777 is the ppi encapsulation port where WireShark is listening for incoming packets in L3 mode on a remote machine with IP address 1.1.1.1.

```
controller(15)# configure terminal
   controller(15)(config)# packet-capture-profile sniffer
   controller(15)(config-pcap)# mode l3 destination-ip 1.1.1.1 port 17777
   controller(15)(config-pcap)# ap-list 5
   controller(15)(config-pcap)# enable
   controller(15)(config-pcap)# packet-truncation-length 0
   controller(15)(config-pcap)# exit
   controller(15)(config)# end
   controller(15)# sh packet-capture-profile sniffer
   AP Packet Capture
   Profile Name                              : sniffer
   Enable/Disable                            : enable
   Encapsulation                             : ppi
   L2/L3 Mode                                : l3
   Destination IP Address                    : 1.1.1.1
   UDP Destination Port                      : 17777
   Destination MAC for L2 Mode               : 00:00:00:00:00:00
   Rx only/Tx only/Both                      : rx
   Rate Limiting per station or cumulative : station
   Token Bucket Rate                         : 10
   Token Bucket Size                         : 10
   AP Selection (ID)                         : 5
   Extended Filter String                    :
   Interface Index                           :
   Packet Truncation Length                  : 0
   Rate Limiting                             : off
   Capture Sibling Frames                    : on
   controller(15)#
   controller(15)#

   For a detailed explanation of the packet capture profile commands, see the
   Troubleshooting chapter of the FortiWLC (SD) Command Reference.
```

What to Look For In Capture-Packet Results

When discovery is via L3, the results of capture-packet should be a UDP port 9292 packet from the AP to the controller followed by a second UDP 9292 packet from the controller to the AP.

After the two UDP packets, there should be about nine UDP port 5000 packets. Check the time deltas between packets; there should only be tenths of a second between packets. Usually, the fifth UDP 5000 packet is from the AP to the controller and is the first one to contain the certificate used for authentication. Immediately following the certificate packet should be a packet from controller to the AP using UDP port 5000 that also contains a certificate.

What to Look For In the Discovery Log

The key messages from a successful discovery message trace are:

```
COMM: CSDS_REQUEST_DISCOVERY message
   COMM: Discovery request from <AP MAC address>/<AP IP Address> received
   [skip unimportant messages]
   COMM: Searching redirect entry for ipAddr 192.168.10.53
   [skip unimportant messages]
   COMM: Trying to check-out <n> licenses for feature "ap".
   COMM: lc_checkout OK for feature "ap". Now, <n> licenses have been checked
   out
   COMM: Response msg to ATS <AP MAC address>/<AP IP Address>
   [skip unimportant messages]
   COMM: Starting ATS script as: /opt/meru/bin/meru-wnc-ats start 3 8 1 1
   Result: Registered virtual device '<AP MAC address>'
   COMM: State file /opt/meru/var/run/discovery.state successfully written.
   [skip unimportant messages]
   COMM: authentication message 0 with payload type 0 from --- 3:8:37
   COMM: /CN=meru AP/ST=California/C=US/Email=support@merunetworks.com - OK
   [skip unimportant messages]
   COMM: AuthMgr::ProcessAccept: 3:8 new key 8f 8e eb ...
   One example of the messages you would see when discovery failed because of a
   licensing issue is:
   COMM: Trying to check-out 1 licenses for feature "ap".
   COMM: Checking out one more license for AP failed. FlexRetCode = -9
   COMM: lc_checkout FAIL
   COMM: AP-1 00:0C:E6:00:2C:96 failed licensing
```

Also, check the following in the discovery log:

- Does the output of the command sh license show the same or more licenses than there are APs?
- Does the output of the command show license-file active show a system ID something like HOSTID=COMPOSITE=<controller system id> that agrees with the system ID outputted by the command sh controller?

FTP Error Codes

This section lists the possible error codes for FTP downloads. The codes are industry standard reporting codes.

- 100 Codes—The requested action is being taken. Expect a reply before proceeding with a new command.
  110 Restart marker reply.In this case, the text is exact and not left to the particular implementation; it must read: MARK yyyy = mmmm Where yyyy is User-process data stream marker, and mmmm server's equivalent marker (note the spaces between markers and "=").
  120 Service ready in (n) minutes.
  125 Data connection already open, transfer starting.
  150 File status okay, about to open data connection.
  150 File status okay; about to open data connection.
- 200 Codes—The requested action has been successfully completed.
  200 Command okay.
  202 Command not implemented, superfluous at this site.
  211 System status, or system help reply.
  212 Directory status.
  213 File status.
  214 Help message. On how to use the server or the meaning of a particular non-standard command. This reply is useful only to the human user.
  215 NAME system type. Where NAME is an official system name from the list in the Assigned Numbers document.
  220 Service ready for new user.
  221 Service closing control connection. Logged out if appropriate.
  225 Data connection open; no transfer in progress.
  226 Closing data connection. Requested file action successful (for example, file transfer or file abort).
  227 Entering Passive Mode (h1,h2,h3,h4,p1,p2).
  230 User logged in, proceed.
  250 Requested file action okay, completed.
  257 "PATHNAME" created.
- 300 Codes—The command has been accepted, but the requested action is being held pending receipt of further information.
  331 User name okay, need password.
  332 Need account for login.
  350 Requested file action pending further information.
- 400 Codes—The command was not accepted and the requested action did not take place. The error condition is temporary, however, and the action may be requested again.
  421 Service not available, closing control connection. (May be a reply to any command if the service knows it must shut down.)`
  425 Can't open data connection.
  426 Connection closed; transfer aborted.

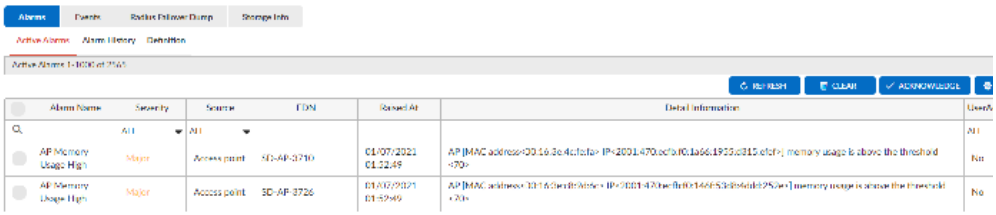
450 Requested file action not taken. File unavailable (e.g., file busy).
451 Requested action aborted: local error in processing.
452 Requested action not taken. Insufficient storage space in system.

- 500 Codes—The command was not accepted and the requested action did not take place.
500 Syntax error, command unrecognized. This may include errors such as command line too long.
501 Syntax error in parameters or arguments.
502 Command not implemented.
503 Bad sequence of commands.
504 Command not implemented for that parameter.
530 User not logged in.
532 Need account for storing files.
550 Requested action not taken. File unavailable (e.g., file not found, no access).
551 Requested action aborted: page type unknown.
552 Requested file action aborted. Exceeded storage allocation (for current directory or dataset).
553 Requested action not taken. Illegal file name.

19 Fault Management

Alarm and event information can be found on the Monitor > Fault Management page. By default, the Active Alarms table is displayed, which indicates any alarms that have been recently triggered.

Figure 104: *Fault Management Table*



The Fault Management page provides information regarding two major types of events in FortiWLC (SD): Alarms and Events. Refer to their respective sections below for additional details.

Alarms

When alarms are generated, the user has the option to either Acknowledge or Clear them by simply checking the box alongside the desired alarm and clicking the appropriate button towards the bottom of the window.

- Clear—Moves the alarm from the Active Alarms table into the Alarm History table.
- Acknowledge—Marks the alarm as acknowledged in the UserAcknowledged column.

As seen in the figure above, the Active Alarms table provides several columns, as described below.

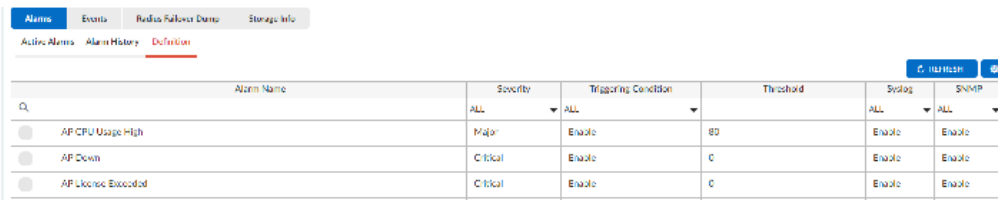
TABLE 31: *Active Alarm Columns*

Column	Description
Alarm Name	The name of the alarm triggered.
Severity	The severity level; can range from Information, Minor, Major, Critical.
Source	The type of device that triggered the alarm (controller, AP).
FDN	The name of the device that triggered the alarm.
Raised At	The date and time at which the alarm was triggered.
Detail	Detailed information regarding the alarm, including identifying device details.
UserAcknowledged	Indicates whether the alarm has been flagged as Acknowledged.

Modifying Alarm Definitions

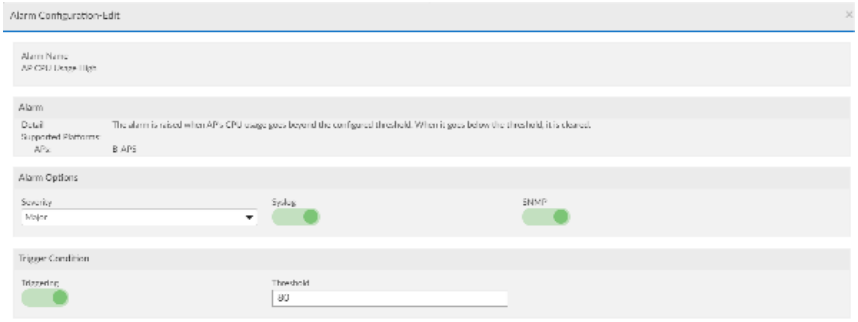
While FortiWLC (SD) provides a list of pre-configured alarms, users can also customize the alarms to the needs of their environment via the Alarms > Definition tab.

Figure 105: *Alarm Definitions*



As shown above, each alarm has a predetermined severity level, trigger condition, and threshold, but these values can be modified by clicking the small pencil icon next to the desired alarm. This will pop up the Alarm Configuration window, as seen in *Figure 106 on* ***page 511***.

Figure 106: *Editing an Alarm*



Use the drop-downs provided in the window to tailor the alarm to the deployment's needs and click Save when finished. If desired, the user can click Reload Default to reset the alarm's configuration to its original values.

The Threshold field's units will vary depending on the alarm selected—for example, when modifying AP Memory Usage High, the Threshold is measured in percentage of overall system memory (and defaults to 70%). However, in an alarm such as Link Down, no threshold is needed at all, as it is a binary alarm (i.e., it is triggered when a link to an AP goes down—there is no percentage involved).

List of Alarms

No.	Alarm	Severity	Source	Explanation
1.	Alarm link up	information	all controller models	Physical link on controller is up.
2.	Alarm link down	critical	all controller models	Physical link on the controller is down; check the connection.
3.	Alarm auth fail	information	controller models	An administrator failed to log in to the GUI due to an authentication failure.
4.	AP down	critical	all AP models	An AP is down. Possible reasons for this are an AP reboot, an AP crash, or an Ethernet cable from the controller may be down. Also the AP may have connected to another controller.
5.	Radio Failure	critical	all AP models	An alarm is generated when the Radio fails to turn operational during Initial bootup. This is occurred due to some Hardware issue on the AP Radio.

No.	Alarm	Severity	Source	Explanation
6.	Rogue AP detected	critical	all controller models	A rogue AP has been detected on the network. The message looks something like this: Rogue AP Detected Critical 06/04/2010 10:04:51 CONTROLLER (1:24194) ROGUE AP DETECTED. Station mac=0c:60:76:2d:fe:d9 bss=00:02:6f:3a:fd:89 by AP Ben-Cubei (18) See the chapter **Rogue AP Detection and Mitigation**.
7.	AP software version mismatch	critical	all AP models	The software version on the AP does not match the version on the controller. Automatic AP upgrade must have been turned off. Update the AP from the controller with either the CLI command upgrade ap same <ap id> force or upgrade ap same all force. You can also turn automatic upgrade back on by with the CLI command auto-ap-upgrade enable.
8.	AP init failure	major	all AP models	AP initialization failed.
9.	Software license expired	major	all controller models	Controller software license has expired. To obtain additional licenses, see www.Fortinetworks.com/license.
10.	802.1X auth failure	major, minor, information	all controller models	RADIUS server authentication failed. To find out why, look at the RADIUS server log for the error message and also check the station log. If this happens only occasionally, you can ignore it. However, if this message appears repeatedly, the authentication failures could prevent a station from entering the network. In this case, check the RADIUS server to make sure the client and server have the same credentials.
11.	MIC failure AP	major	all controller models	The Michael MIC Authenticator Tx/Rx Keys provided in the Group Key Handshake are only used if the network is using TKIP to encrypt the data. A failure of the Michael MIC in a packet usually indicates that the WPA WPSK password is wrong.
12.	MIC countermeasure activation	major	all controller models	Two consecutive MIC failures have occurred (see above).

No.	Alarm	Severity	Source	Explanation
13.	RADIUS Server Switchover	major	all controller models	A switchover from the Primary Authentication RADIUS Server to the Secondary Authentication RADIUS Server occurred. When this message occurs, the Primary RADIUS server is configured but not reachable and the Secondary RADIUS server is both configured and reachable. This message is generated only for 802.1x switchover, not for Captive Portal switchover. An example looks like this: RADIUS Server Switchover Major 06/07/2010 14:09:57 RADIUS Server switches over from Primary <172.18.1.7> to Secondary <172.18.1.3> for Profile <wpa>
14.	RADIUS Server Switchover Failed	major	all controller models	A switchover from the Primary Authentication RADIUS Server to the Secondary Authentication RADIUS Server failed because the secondary server is not configured. When this message occurs, the Primary RADIUS server is configured but not reachable and the Secondary RADIUS server is not configured. This message is generated only for 802.1x switchover failure, not for Captive Portal switchover failure. An example looks like this: RADIUS Server Switchover Failed Major 06/07/2010 14:02:47 Primary RADIUS Server <172.18.1.7> failed. No valid Secondary RADIUS Server present. Switchover FAILED for Profile <wpa> Alarms Table(1 entry)

No.	Alarm	Severity	Source	Explanation
15.	Restore Primary RADIUS Server	major	all controller models	A switchover from the Secondary Authentication RADIUS Server to the Primary Authentication RADIUS Server occurred. This alarm was generated while doing RADIUS fall back to the primary server after 15 minutes. This message is generated only for 802.1x primary RADIUS restore, not for Captive Portal restore. An example looks like this: Restore Primary RADIUS Server Major 06/07/2010 15:54:10 Security Profile <wpa> restored back to the Primary RADIUS server <172.18.1.7>
16.	Acct RADIUS server switchover	major	all controller models	A switchover from either Accounting RADIUS Server (primary or secondary) to the other one occurred. This message is generated only for 802.1x switchover, not for Captive Portal switchover. An example when the primary to secondary switch occurred looks like this: Accounting RADIUS Server Switch Major 06/07/2010 14:39:00 Accounting RADIUS Server switches over from Primary <172.18.1.7> to Secondary <172.18.1.3> for Profile <wpa>
17.	Acct RADIUS server switchover failed	major	all controller models	An attempted switchover from one Accounting RADIUS Server to the other server failed.When this message occurs, the Primary Accounting RADIUS server is configured but not reachable and the Secondary Accounting RADIUS server is not configured. This message is generated only for 802.1x switchover failure, not for Captive Portal switchover fail lure. An example looks like this: Accounting RADIUS Server Switch Major 06/07/2010 14:22:26 Primary Accounting RADIUS Server <172.18.1.7> failed. No valid Secondary Accounting RADIUS Server present. Switchover FAILED for Profile <wpa>

No.	Alarm	Severity	Source	Explanation
18.	Master down	critical	all controller models	N+1 Master controller is down and no longer in control; the slave controller will now take over.
19.	Master up	critical	all controller models	N+1 Master controller is up and running; this controller will now take control away from the slave controller.
20.	CAC limit reached	major	all controller models	Admission control in ATM networks is known as Connection Admission Control (CAC) - this process determines which traffic is admitted into a network. If this message occurs, the maximum amount of traffic is now occurring on the network and no more can be added.

Events

Events are similar to alarms in that they indicate that a specific action has taken place. However, while alarms typically require some form of user intervention to resolve the problem, events simply provide an indication that a change has been made. As such, this tab provides a reference to actions on the system.

Figure 107: *Events Table*

The table below provides a brief description of the columns provided in the Events table.

TABLE 32: *Events Table Columns*

Column	Description
Event Name	The name of the event triggered.
Severity	The severity level; can range from Information, Minor, Major, Critical.
Source	The type of device that triggered the event (controller, AP).
FDN	The name of the device that triggered the event.
Raised At	The date and time at which the event was triggered.
Detail	Detailed information regarding the event, including identifying device details.

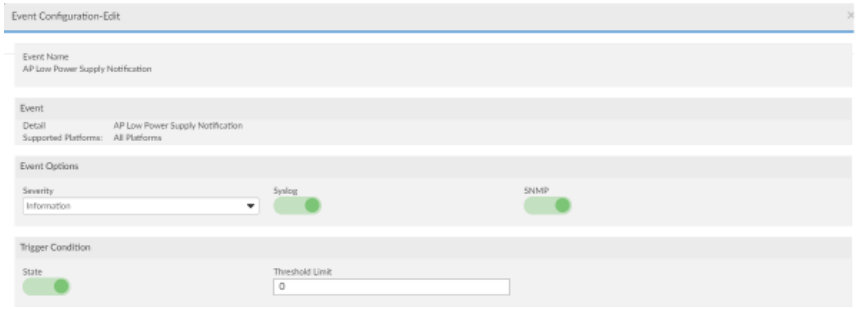
Modifying Event Definitions

While FortiWLC (SD) provides a list of pre-configured events, users can also customize the events to the needs of their environment via the Events > Definition tab.

Figure 108: *Event Definitions*

As shown above, each event has a predetermined severity level, trigger condition, and threshold, but these values can be modified by clicking the small pencil icon next to the desired alarm. This will pop up the Alarm Configuration window, as seen in *Figure 106 on* ***page 511***.

Figure 109: *Editing an Event*

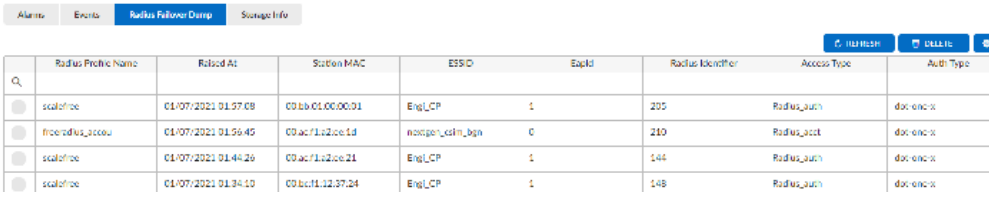


Use the drop-downs provided in the window to tailor the event to the deployment's needs and click Save when finished. If desired, the user can click Reload Default to reset the event's configuration to its original values.

The Threshold field's units will vary depending on the event selected—for example, when modifying Alarm History Reaches Threshold, the Threshold is measured in percentage of overall alarm table history (and defaults to 90%). However, in an event such as RADIUS Server Switchover, no threshold is needed at all, as it is a binary alarm (i.e., it is triggered when the RADIUS server is switched—there is no percentage involved).

RADIUS Failover Dump

The Radius Failover Dump tab displays the RADIUS failover messages for L2 802.1x authentication.



The following failover message details are displayed.

- The associated RADIUS profile name.
- The date and time at which the failover occurred, in mm/dd/yyyy and hh:mm:ss format.
- The MAC address of the station where the failover was triggered.
- The associated ESSID where the failover occurred.

- The EAP ID associated with the RADIUS message sent after exceeding the configured number of retries. The EAP ID is sent only for authentication packets and not for accounting packets. Hence, the EAP ID for
- *Radius_acct* access type is always 0.
- The RADIUS message identifier.
- The RADIUS access type can be the RADIUS authentication type or accounting type. When the failover happens during RADIUS Dot1x authentication, the access type is *Radius_auth* and when the failover happens during Dot1x accounting, the access type is *Radius_acct.*
- The RADIUS authentication type.

Note: These dump entries are NOT for RADIUS MAC filtering and RADIUS Captive Portal authentication.
Run the *sh radius-failover-details-1x* command to view the RADIUS failover details in the CLI mode.

20 Syslog Messages

This Appendix provides a brief listing of all Syslog messages currently implemented in Forti-WLC (SD).

Controller Management

Event	System Log Example	Description	Action
CONTROLLER REBOOT	Oct 13 11:11:32 172.18.37.201 ALARM: 1255432836l | system | notice | NOT | Controller administrative reboot requested	A controller reboot is requested.	

Event	System Log Example	Description	Action
CONTROLLER BOOT	Oct 13 11:12:55 172.18.37.201 syslog: syslogd startup succeeded	Controller boot sequence showing different processes and WLAN services getting started.	
PROCESS START	Oct 13 11:12:55 172.18.37.201 syslog: klogd startup succeeded		
	Oct 13 11:12:58 172.18.37.201 sysctl: net.ipv4.ip_forward = 1		
	Oct 13 11:12:58 172.18.37.201 sysctl: net.ipv4.conf.default.rp_filter = 1		
	Oct 13 11:12:58 172.18.37.201 sysctl: kernel.sysrq = 0		
	Oct 13 11:12:58 172.18.37.201 sysctl: kernel.core_uses_pid = 1		
	Oct 13 11:12:58 172.18.37.201 network: Setting network parameters: succeeded		
	Oct 13 11:12:58 172.18.37.201 network: Bringing up loopback interface: succeeded		
	Oct 13 11:12:58 172.18.37.201 crond: crond startup succeeded		
	Oct 13 11:12:58 172.18.37.201 sshd: succeeded		
	Oct 13 11:12:58 172.18.37.201 sshd[303]: Server listening on 0.0.0.0 port 22.		
	Oct 13 11:12:58 172.18.37.201 network: Bringing up interface eth0: succeeded		
	Oct 13 11:12:59 172.18.37.201 xinetd: xinetd startup succeeded		
	Oct 13 11:12:59 172.18.37.201 root: Start WLAN Services ...		
	Oct 13 11:13:01 172.18.37.201 meru: /etc/init.d/ceflog: /opt/meru/var/run/running-db/ceflog.conf: No such file or directory		
	Oct 13 11:13:01 172.18.37.201 meru: Setting up swapspace version 0, size = 43446272 bytes		
	Oct 13 11:13:01 172.18.37.201 meru: Using /lib/modules/2.4.18-3-meruenabled/kernel/drivers/dump/dump.o		
	Oct 13 11:13:01 172.18.37.201 meru: Kernel data gathering phase complete		
	Oct 13 11:13:05 172.18.37.201 meru: Warning: loading /opt/meru/kernel/ipt_vlan_routing.mod will taint the kernel: non-GPL license - Proprietary		
	Oct 13 11:13:37 172.18.37.201 meru: Process RemoteUpgrade did not come up. Will retry again		
	Oct 13 11:13:37 172.18.37.201 root: Controller Up on Tue		

Event	System Log Example	Description	Action
CONTROLLER SHUTDOWN	Oct 13 11:11:33 172.18.37.201 root: Stop WLAN Services ...	Controller shutdown sequence, showing different processes and WLAN services getting stopped.	
PROCESS STOP	Oct 13 11:11:33 172.18.37.201 meru: icrd stopped. Oct 13 11:11:33 172.18.37.201 meru: RIos stopped. Oct 13 11:11:37 172.18.37.201 meru: discovery stopped. Oct 13 11:11:37 172.18.37.201 meru: WncDhcpRelay stopped. Oct 13 11:11:37 172.18.37.201 meru: nmsagent stopped. Oct 13 11:11:38 172.18.37.201 meru: melfd stopped. Oct 13 11:11:38 172.18.37.201 meru: igmp-snoop-daemon stopped. Oct 13 11:11:44 172.18.37.201 meru: dfsd stopped. Oct 13 11:11:45 172.18.37.201 meru: aeroscoutd stopped. Oct 13 11:11:45 172.18.37.201 meru: snmp stopped. Oct 13 11:11:46 172.18.37.201 meru: cmdd stopped. Oct 13 11:11:47 172.18.37.201 meru: rfsmgr stopped. Oct 13 11:11:49 172.18.37.201 meru: wncclid stopped. Oct 13 11:11:50 172.18.37.201 meru: sipfd stopped. Oct 13 11:11:51 172.18.37.201 meru: rulefd stopped. Oct 13 11:11:52 172.18.37.201 meru: watchdog stopped. Oct 13 11:11:52 172.18.37.201 meru: oct_watchdog stopped. Oct 13 11:11:52 172.18.37.201 meru: h323fd stopped. Oct 13 11:11:53 172.18.37.201 meru: sccpfd stopped. Oct 13 11:11:54 172.18.37.201 meru: coordinator stopped. Oct 13 11:11:54 172.18.37.201 meru: security-mm stopped. Oct 13 11:11:56 172.18.37.201 meru: hostapd stopped. Oct 13 11:11:57 172.18.37.201 meru: rogueapd stopped. Oct 13 11:11:58 172.18.37.201 meru: xems stopped. Oct 13 11:11:58 172.18.37.201 meru: apache stopped. Oct 13 11:12:01 172.18.37.201 meru: xclid stopped. Oct 13 11:12:07 172.18.37.201 meru: wncagent stopped. Oct 13 11:12:07 172.18.37.201 meru: Removed VLAN -:vlan133:- Oct 13 11:12:08 172.18.37.201 meru: vlan stopped.		

Event	System Log Example	Description	Action
	Oct 13 11:12:15 172.18.37.201 meru: Oct 13 11:12:18 172.18.37.201 root: WLAN Services stopped Oct 13 11:12:18 172.18.37.201 rc: Stopping meru: succeeded Oct 13 11:12:18 172.18.37.201 sshd[317]: Received signal 15; terminating. Oct 13 11:12:18 172.18.37.201 sshd: sshd -TERM succeeded Oct 13 11:12:18 172.18.37.201 xinetd: xinetd shutdown succeeded Oct 13 11:12:18 172.18.37.201 crond: crond shutdown succeeded Oct 13 11:12:19 172.18.37.201 syslog: klogd shutdown succeeded		

Event	System Log Example	Description	Action
SSH LOGIN SESSION	Oct 13 11:13:58 172.18.37.201 sshd[4874]: PAM _pam_init_handlers: no default config /etc/pam.d/other Oct 13 11:14:00 172.18.37.201 sshd[4874]: PAM _pam_init_handlers: no default config /etc/pam.d/other Oct 13 11:14:00 172.18.37.201 sshd[4874]: Accepted password for admin from 172.18.37.12 port 1891 ssh2 Oct 13 11:14:00 172.18.37.201 sshd(pam_unix)[4876]: session opened for user admin by (uid=0) Oct 13 11:14:00 172.18.37.201 PAM-env[4876]: Unable to open config file: No such file or directory Oct 13 11:14:00 172.18.37.201 sshd[4876]: lastlog_perform_login: Couldn't stat /var/log/lastlog: No such file or directory Oct 13 11:14:00 172.18.37.201 sshd[4876]: lastlog_openseek: /var/log/lastlog is not a file or directory! Apr 09 12:00:22 172.18.49.14 -- admin[19814]: LOGIN ON pts/3 BY admin FROM xp.merunetworks.com Apr 09 15:23:07 172.18.37.203 sshd(pam_unix)[23750]: session closed for user admin Apr 09 15:07:53 172.18.37.203 su(pam_unix)[28060]: session opened for user root by admin(uid=0) Apr 09 15:08:09 172.18.37.203 su(pam_unix)[28060]: session closed for user root Apr 09 17:48:48 172.18.37.203 sshd[28588]: Received disconnect from 172.18.37.15: 11: Disconnect requested by Windows SSH Client.	A controller user logged in, using an SSH connection.	
WEB ADMIN LOGIN	Oct 13 11:15:07 172.18.37.201 xems: 1255433051l | security | info | WAU | Controller Access User admin@172.18.37.12 login to controller at time Tue Oct 13 11:24:11 2017 is OK	Admin logged in to controller GUI.	

Event	System Log Example	Description	Action
NTP SERVER NOT ACCESSIBLE	Apr 12 18:01:10 172.18.49.14 root: NTP server time.windows.com did not respond.	NTP server is not accessible.	Check to see if NTP server is down, or verify that the NTP server is correctly configured on the controller. If the configuration is wrong, use the “Setup” command to correct the configuration.
User Management: RADIUS request sent	Mar 29 13:43:40 172.18.86.229 SecurityMM: 1269866620l | security | info | RBAC | Sending RADIUS Access-Request message for user : pat	For RADIUS-based controller user management, RADIUS access request is being sent to RADIUS server.	
User Management: Group ID not available	Mar 29 13:46:32 172.18.86.229 xems: 1269866791l | security | info | RBAC | Group Id not available for Group Num 700 and User Id pat	Group ID configured for controller user is not available.	Create group with this group ID, or change the group ID for this user.
User Management: RADIUS Success	Mar 29 13:49:18 172.18.86.229 SecurityMM: 1269866959l | security | info | RBAC | RADIUS Access succeed for user <pat>	For RADIUS-based controller user management, RADIUS authentication succeeded.	
User Management: Group Number received from RADIUS	Mar 29 13:49:18 172.18.86.229 SecurityMM: 1269866959l | security | info | RBAC | Group Num <700> received from RADIUS server for user <pat>	RADIUS server returned group number for user logged in.	

Event	System Log Example	Description	Action
User Management: User Login Success	Mar 29 13:49:18 172.18.86.229 xems: 1269866959l | security | info | WAU | Controller Access User pat@172.18.45.17 login to controller at time Mon Mar 29 18:19:19 2017 is OK	Controller user logged in.	
User Management: RADIUS Failure	Mar 29 13:50:42 172.18.86.229 SecurityMM: 1269867043l | security | info | RBAC | RADIUS Access failed for user <local1234>	RADIUS authentication for controller user failed.	
User Management: User Login Failure	Mar 29 13:50:43 172.18.86.229 xems: 1269867043l | security | info | WAU | Controller Access User local1234@172.18.45.17 login to controller at time Mon Mar 29 18:20:43 2017 is FAILED	Controller user login failed.	
DUAL ETHERNET	info NOT 10/08/2017 00:12:42 <00:90:0b:0a:81:b0> 1st interface link up.	Controller's first interface link is up.	
DUAL ETHERNET	info NOT 10/08/2017 00:16:14 <00:90:0b:0a:81:b0> 1st interface link down.	Controller's first interface link is down.	
DUAL ETHERNET	info NOT 10/08/2017 00:25:55 <00:90:0b:0a:81:af> 2nd interface link up.	Controller's second interface link is up.	
DUAL ETHERNET	info NOT 10/08/2017 00:26:16 <00:90:0b:0a:81:af> 2nd interface link down.	Controller's second interface link is down.	
DUAL ETHERNET	info NOT 10/08/2017 00:25:56 <00:90:0b:0a:81:af> switch to 2nd interface done.	Controller is configured in redundant mode for dual Ethernet. The first interface went down, so the second interface has taken over.	

Event	System Log Example	Description	Action
DUAL ETHERNET	info NOT 10/08/2017 00:26:19 <00:90:0b:0a:81:af> switch to 1st interface done.	Controller is configured in redundant mode for dual Ethernet. The second interface went down, so the first interface has taken over.	
DUAL ETHERNET: STANDALONE MODE EXAMPLE	info NOT 10/08/2017 00:12:42 <00:90:0b:0a:81:b0> 1st interface link up. info NOT 10/08/2017 00:16:14 <00:90:0b:0a:81:b0> 1st interface link down.	Sequence shown when the controller is configured in standalone mode, and the first interface goes down.	If first interface link down message is seen, check the connectivity to first interface.

Event	System Log Example	Description	Action
DUAL ETHERNET: REDUNDANT MODE EXAMPLE	info NOT 10/08/2017 00:24:26 <00:90:0b:0a:81:af> 1st interface link up. info NOT 10/08/2017 00:25:52 <00:90:0b:0a:81:af> 1st interface link down. info NOT 10/08/2017 00:25:55 <00:90:0b:0a:81:af> 2nd interface link up. info NOT 10/08/2017 00:25:56 <00:90:0b:0a:81:af> switch to 2nd interface done. info NOT 10/08/2017 00:26:16 <00:90:0b:0a:81:af> 2nd interface link down. info NOT 10/08/2017 00:26:19 <00:90:0b:0a:81:af> 1st interface link up. info NOT 10/08/2017 00:26:19 <00:90:0b:0a:81:af> switch to 1st interface done.	Sequence shown when the controller is configured in redundant mode. When the first interface goes down, and the second interface takes over.	Check the connectivity on the interface that has gone down.
DUAL ETHERNET: ACTIVE MODE EXAMPLE	info NOT 10/08/2017 00:37:29 <00:90:0b:0a:81:b0> 1st interface link up. info NOT 10/08/2017 00:37:29 <00:90:0b:0a:81:af> 2nd interface link up. info NOT 10/08/2017 00:38:34 <00:90:0b:0a:81:af> 2nd interface link down. info NOT 10/08/2017 00:38:39 <00:90:0b:0a:81:b0> 1st interface link down. info NOT 10/08/2017 00:38:43 <00:90:0b:0a:81:b0> 1st interface link up. info NOT 10/08/2017 00:38:45 <00:90:0b:0a:81:af> 2nd interface link up.	Sequence shown when the controller is configured in active mode.	Check the connectivity on the interface that has gone down.

AP System

Event	System Log Example	Description	Action
AP Down	Mar 21 12:56:51 172.18.65.202 ALARM: 1206084411l | system | info | ALR | AP DOWN CRITICAL Access Point Pat-AP822 (2) at time Fri Mar 21 07:26:51 2017	This message is generated when the controller detects an AP Down event. An AP Down event can be reported for many reasons: AP upgrading Power failure Network failure, AP not accessible. AP crash	If an AP crash is occurring due to an unknown issue, contact Customer Support.
AP Up	Mar 21 12:57:20 172.18.65.202 ALARM: 1206084440l | system | info | ALR | AP UP Access Point Pat-AP822 (2) is up at time Fri Mar 21 07:27:20 2017	This message is generated when the controller detects an AP Up event.	
AP Software Version Mismatch	Mar 21 15:19:05 172.18.65.202 ALARM: 1206092945l | system | info | ALR | AP SOFTWARE VERSION MISMATCH CRITICAL AP Pat-AP822 (2) - Software Version Mismatch : AP version is 8.0.0 and Controller version is 8.4.0	This message is generated when the AP software version does not match the controller software version.	If Auto-AP-Upgrade is enabled, the controller will automatically upgrade AP software to the same version. Otherwise, manually upgrade the AP to the version same as the controller.

Event	System Log Example	Description	Action
AP Upgrade	Apr 09 12:41:18 172.18.37.203 ALARM: 1270817859l | system | notice | NOT | Software version of AP 4 is being changed from 8.3-3 to 8.4.0	The AP software is being upgraded.	
Boot Image Version Mismatch	Apr 28 14:03:35 172.18.65.202 ALARM: 1209371615l | system | info | ALR | AP BOOTIMAGE VERSION MISMATCH CRITICAL BootImage_Version_MisMatch_for_AP1	This message is generated when the AP has an incompatible boot image.	
Boot Image Match	Apr 28 14:03:51 172.18.65.202 ALARM: 1209371631l | system | info | ALR | AP BOOTIMAGE VERSION MISMATCH CLEAR BootImage_Version_Match_for_AP1	The message is generated when the AP's incompatible boot image has been replaced by a compatible boot image.	
AP Neighbor Loss	Apr 28 14:01:12 172.18.65.202 ALARM: 1209371472l | system | info | ALR | AP NEIGHBOR LOSS CRITICAL Neighbor_Loss_for_AP1	This message is generated when an AP has lost its neighbor AP.	
AP Neighbor Loss Cleared	Apr 28 14:01:18 172.18.65.202 ALARM: 1209371478l | system | info | ALR | AP NEIGHBOR LOSS CLEAR Neighbor_Loss_for_AP1	This message is generated when then the AP Neighbor loss alarm is cleared.	
Hardware Diagnostics Error	Mar 21 13:49:53 172.18.65.202 ALARM: 1206087593l | system | info | ALR | AP HARDWARE DIAGNOSTIC ERROR CRITICAL HardwareDiagnostics	This message is generated when an AP has an incompatible FPGA version.	
Hardware Diagnostics Error Cleared	Mar 21 13:49:47 172.18.65.202 ALARM: 1206087587l | system | info | ALR | AP HARDWARE DIAGNOSTIC ERROR CLEAR HardwareDiagnostics	This message is generated when an AP's incompatible FPGA version is replaced with a compatible version.	

Event	System Log Example	Description	Action
Handoff Fail	Apr 28 14:02:04 172.18.65.202 ALARM: 1209371524l | system | info | ALR | HAND OFF FAIL CRITICAL Hand-Off_Fail_for_AP1	This message is generated when handoff fails.	
Handoff Fail Cleared	Apr 28 14:02:21 172.18.65.202 ALARM: 1209371541l | system | info | ALR | HAND OFF FAIL CLEAR HandOff_-Fail_Cleared_for_AP1	This message is generated when the handoff fail alarm is cleared.	
Resource Threshold Exceeded	Mar 21 13:56:27 172.18.65.202 ALARM: 1206087987l | system | info | ALR | RESOURCE THRESHOLD EXCEED CRITICAL ResourceThreshold	This message is generated when the resource (CPU & Mem-ory) threshold is exceeded.	
Resource Threshold Exceed Cleared	Mar 21 13:57:17 172.18.65.202 ALARM: 1206088037l | system | info | ALR | RESOURCE THRESHOLD EXCEED CLEAR ResourceThreshold	This message is generated when the resource threshold exceed alarm is cleared.	
System Failure	Mar 21 14:18:29 172.18.65.202 ALARM: 1206089309l | system | info | ALR | SYSTEM FAILURE CRITICAL Sys-temFailure	This message is generated when the system.	
System Failure Cleared	Mar 21 14:19:04 172.18.65.202 ALARM: 1206089344l | system | info | ALR | SYSTEM FAILURE CLEAR System-Failure	This message is generated when the system fail-ure alarm is cleared.	
Watchdog Fail-ure	Mar 21 14:27:28 172.18.65.202 ALARM: 1206089848l | system | info | ALR | WATCHDOG FAILURE CRITICAL WatchDog_Failure	This message is generated when the Watchdog process is termi-nated.	
Watchdog Fail-ure Cleared	Mar 21 14:27:59 172.18.65.202 ALARM: 1206089879l | system | info | ALR | WATCHDOG FAILURE CLEAR WatchDog_Failure	This message is generated when the Watchdog process resumes.	

Event	System Log Example	Description	Action
Certificate Error	Mar 21 15:04:10 172.18.65.202 ALARM: 1206092050l | system | info | ALR | CERTIFICATE ERROR CRITICAL Certificare_Error	This message is generated when a certificate error occurs.	
Certificate Error Cleared	Mar 21 15:04:38 172.18.65.202 ALARM: 1206092078l | system | info | ALR | CERTIFICATE ERROR CLEAR Certificate_Error	This message is generated when the certificate error alarm is cleared.	
AP Init Failure	Apr 28 12:55:58 172.18.65.202 ALARM: 1209367557l | system | info | ALR | AP INIT FAILURE CRITICAL Init_Failure_for_AP1	This message is generated when an AP initialization fails.	
AP Init Failure Cleared	Apr 28 12:55:45 172.18.65.202 ALARM: 1209367545l | system | info | ALR | AP INIT FAILURE CLEAR Init_Failure_for_AP1	This message is generated when the AP initialization failure alarm is cleared.	
AP Radio Card Failure	Apr 28 13:01:00 172.18.65.202 ALARM: 1209367860l | system | info | ALR | AP RADIO CARD FAILURE CRITICAL Radio_Card_Failure_for_AP1	This message is generated when an AP radio card stops working.	
AP Radio Card Failure Cleared	Apr 28 13:01:08 172.18.65.202 ALARM: 1209367868l | system | info | ALR | AP RADIO CARD FAILURE CLEAR Radio_Card_Failure_for_AP1	This message is generated when an AP radio card failure alarm is cleared.	
Primary RADIUS Server Restored	Mar 21 15:50:53 172.18.65.202 ALARM: 1206094852l | system | info | ALR | PRIMARY RADIUS SERVER RESTORED CRITICAL RADIUS_Server_Restored	This message is generated when the primary RADIUS server that was down is restored.	

Event	System Log Example	Description	Action
RADAR Detected	Mar 21 15:12:08 172.18.65.202 ALARM: 1206092528l | system | info | ALR | RADAR DETECTED CRITICAL Radar Detected	This message is generated when DFS Manager detects RADAR.	
MIC Counter Measure Activation	Apr 28 13:57:36 172.18.65.202 ALARM: 1209371256l | system | info | ALR | MIC COUNTERMEASURE ACTIVATION CRITICAL MIC_CounterMeasure_Activation_for_AP1	This message is generated when there are two subsequent MIC failures.	
AP MIC Failure	Apr 28 13:13:12 172.18.65.202 ALARM: 1209368592l | system | info | ALR | AP MIC FAILURE CRITICAL MIC_Failure_for_AP1	This message is generated when there is a MIC failure.	

802.11

Event	System Log Example	Description	Action
Station Unassociated	Apr 09 13:25:28 172.18.37.203 coordinator: Wireless Associations, Unassociated for STA 00:1f:3b:6c:62:e7 in BSSID 00:0c:e6:56:dd:3b ESS 4088clear AP_ID 1 at Time Fri Apr 9 13:41:49 2017	802.11 station disassociation.	
Station Associated	Apr 09 14:05:04 172.18.37.203 coordinator: Wireless Associations, Associated for STA 00:1f:3b:6c:62:e7 in BSSID 00:0c:e6:56:dd:3b ESS 4088clear AP_ID 1 at Time Fri Apr 9 14:21:25 2017 Mar 22 13:23:34 172.18.65.202 ALARM: 1206127090l | system | info | ALR | Station Info Update : MacAddress : 00:40:96:ae:20:7a, UserName : pat, AP-Id : 1, AP-Name : AP-1, BSSID : 00:0c:e6:8f:01:01, ESSID : pat, Ip-Type : dynamic dhcp, Ip-Address : 172.18.65.11, L2mode : clear, L3-mode : clear, Vlan-Name : VLAN-111, Vlan-Tag : 111 Apr 06 11:59:24 172.18.65.202 ALARM: 1270535364l | system | info | ALR | Station Disconnected : MacAddress : 00:40:96:ae:20:7a	802.11 station association. Station connection. Station disconnected.	

Security System

Event	System Log Example	Description	Action
RADIUS ACCESS REQUEST	Mar 29 13:14:06 172.18.98.221 RADIUSInfo: RADIUS Access-Request Message sent for Client (00:1e:37:0e:98:3e).	RADIUS request message has been sent to RADIUS server.	
RADIUS ACCESS ACCEPT	Mar 29 13:14:06 172.18.98.221 RADIUSInfo: RADIUS Access-Accept message received for Client (00:1e:37:0e:98:3e).	RADIUS server responded with Access-Accept message for RADIUS request (success scenario).	
802.1X RADIUS ACCESS REQUEST	Apr 09 15:05:58 172.18.37.203 ALARM: 1270826539l | system | info | ALR | 802.1x Authentication Attempt INFO RADIUS Access Attempt by station with MAC address 00:1f:3b:6c:62:e7 and user is NULL , AP Id: <1>	As part of 802.1X authentication, RADIUS request message has been sent to RADIUS server from controller.	
802.1X RADIUS ACCESS REJECT WITH BAD USERNAME	Apr 13 19:48:23 172.18.48.151 ALARM: 1271169441l | system | info | ALR | 802.1X AUTHENTICATION FAILURE INFO Access Request rejected for User: <harsh>, NAS IP: <172.18.48.151>, SSID: <wpa2h>, Calling Station ID: <00:1f:3b:83:21:13>, Called Station ID: <00:90:0b:0a:82:48>, Authentication Type: <802.1X>, Reason: <Bad Username or Password>, AP Id: <1>	As part of 802.1X authentication, RADIUS server has responded with Access-Reject message, with the reason “Username or password is not correct.” (Failure scenario).	Check for correct username or password.

Event	System Log Example	Description	Action
RADIUS SWITCHOVER FAILURE	Apr 09 15:07:54 172.18.37.203 ALARM: 1270826655l | system | info | ALR | RADIUS SERVER SWITCHOVER FAILED MAJOR Primary RADIUS Server <172.18.1.3> failed. No valid Secondary RADIUS Server present. Switchover FAILED for Profile <4089wpa2>	During RADIUS authentication, primary RADIUS server was not accessible, and secondary RADIUS server is not configured.	Check for connectivity to primary RADIUS server from controller. If another RADIUS server is available, configure it as secondary server.
ACCOUNTING RADIUS SWITCHOVER	Mar 22 16:38:19 172.18.65.202 ALARM: 1206061018l | system | info | ALR | ACCOUNT RADIUS SERVER SWITCHOVER MAJOR Accounting RADIUS Server switches over from Primary <1.1.1.1> to Secondary <2.2.2.2> for Profile <WPA2>	For accounting, primary RADIUS server is not accessible, and switchover to secondary RADIUS server is attempted.	Check for connectivity between primary RADIUS server and controller.
ACCOUNTING RADIUS SWITCHOVER FAILURE	Mar 22 16:41:51 172.18.65.202 ALARM: 1206061230l | system | info | ALR | ACCOUNT RADIUS SERVER SWITCHOVER FAILED MAJOR Primary Accounting RADIUS Server <1.1.1.1> failed. No valid Secondary Accounting RADIUS Server present. Switchover FAILED for Profile <WPA2>	For accounting, primary RADIUS server is not accessible, and switchover secondary RADIUS server is not configured.	Check for connectivity to primary RADIUS server from controller. If another RADIUS server is available, configure it as secondary server.
MAC FILTERING: RADIUS SWITCHOVER	Mar 21 16:38:57 172.18.65.202 ALARM: 1206097736l | system | info | ALR | RADIUS SERVER SWITCHOVER MAJOR RADIUS Server switched over from Primary < 1.1.1.1 > to Secondary < 172.18.1.7 > for Mac Filtering	For MAC filtering, primary RADIUS server is not accessible, and switchover to secondary RADIUS is attempted.	Check for connectivity between configured primary RADIUS server and controller.

Captive Portal

Event	System Log Example	Description	Action
Captive Portal Login Request	Mar 29 14:11:53 172.18.98.221 xems: 1269867812l | security | info | CAP | Captive Portal User(pat@172.18.98.41) login Request Received.	Login request for Captive Portal User has been received.	
Captive Portal: RADIUS Login Success	Mar 29 14:11:53 172.18.98.221 SecurityMM: 1269867812l | security | info | CAP | pat@172.18.98.41 StationMac[00:1b:77:af:dc:6e] RADIUS User logged in OK	Captive Portal RADIUS user has successfully logged in.	
Captive Portal: Redirection	Mar 29 13:39:16 172.18.86.229 xems: 1269866356l | security | info | CAP | Captive Portal User(172.18.86.14) Redirected. Sending login (https://secsol:8081/vpn/loginformWebAuth.html)	Complete Captive Portal login.	

Event	System Log Example	Description	Action
Captive Portal: Login Sequence	Mar 22 13:23:47 172.18.65.202 httpd: 1206127103l | 802.mobility | info | CAP | 172.18.111.11:8080 1 http://www.google.com/webhp?complete=1&hl=en Mar 22 13:23:47 172.18.65.202 xems: 1206127103l | 802.mobility | info | RED | 172.18.111.11:8080 1 Mar 22 13:23:47 172.18.65.202 xems: 1206127103l | 802.mobility | info | RED | 172.18.111.11:8080 2 Mar 22 13:23:47 172.18.65.202 httpd: 1206127103l | 802.mobility | info | CAP | 172.18.111.11:8080 2 Mar 22 13:23:49 172.18.65.202 httpd: 1206127105l | 802.mobility | info | CAP | 172.18.111.11:8081 1 http://172.18.111.211:8081/vpn/loginformWebAuth.html Mar 22 13:23:49 172.18.65.202 xems: 1206127105l | 802.mobility | info | CNT | 172.18.111.11:8081 1 Mar 22 13:23:49 172.18.65.202 xems: 1206127105l | 802.mobility | info | CNT | 172.18.111.11:8081 2 Mar 22 13:23:49 172.18.65.202 httpd: 1206127105l | 802.mobility | info | CAP | 172.18.111.11:8081 2 Mar 22 13:23:49 172.18.65.202 httpd: 1206127105l | 802.mobility | info | CAP | 172.18.111.11:8081 1 http://172.18.111.211:8081/vpn/Images.vpn/newlogo.gif Mar 22 13:23:49 172.18.65.202 xems: 1206127105l | 802.mobility | info | CNT | 172.18.111.11:8081 1 Mar 22 13:23:49 172.18.65.202 xems: 1206127105l | 802.mobility | info | CNT | 172.18.111.11:8081 2 Mar 22 13:23:49 172.18.65.202 httpd: 1206127105l | 802.mobility | info | CAP | 172.18.111.11:8081 2 Mar 22 13:23:49 172.18.65.202 httpd: 1206127105l | 802.mobility | info | CAP | 172.18.111.11:8081 1 http://172.18.111.211:8081/favicon.ico Mar 22 13:23:49 172.18.65.202 httpd: 1206127105l | 802.mobility | info | CAP | 172.18.111.11:8081 2 Mar 22 13:23:49 172.18.65.202 httpd: 1206127105l | 802.mobility | info | CAP | 172.18.111.11:8081 1 http://172.18.111.211:8081/favicon.ico Mar 22 13:23:49 172.18.65.202 httpd: 1206127105l | 802.mobility | info | CAP | 172.18.111.11:8081 2		

Event	System Log Example	Description	Action
	Mar 22 13:23:55 172.18.65.202 httpd: 1206127110l | 802.mobility | info | CAP | 172.18.111.11:8081 1 http://172.18.111.211:8081/vpn/loginUser Mar 22 13:23:55 172.18.65.202 xems: 1206127110l | 802.mobility | info | LOG | 172.18.111.11:8081 1 Mar 22 13:23:55 172.18.65.202 xems: 1206127110l | security | info | CAP | ramesh@172.18.111.11 logged in OK Mar 22 13:23:55 172.18.65.202 xems: 1206127110l | 802.mobility | info | LOG | 172.18.111.11:8081 2 Mar 22 13:23:55 172.18.65.202 httpd: 1206127110l | 802.mobility | info | CAP | 172.18.111.11:8081 2		

QoS

Event	System Log Example	Description	Action
QoS: Action Drop	Apr 13 18:14:23 172.18.117.217 kernel: 1271193480 | system | info | ALR | Network Traffic, Flow of Traffic MAC: 00:40:96:ad:49:b0->MAC: 00:90:0b:0a:81:ae src_ip:172.18.117.27-> dst_ip:69.147.125.65:[dst_port:0], rule id: 23, action: Drop. AP MAC Address : 00:0c:e6:05:c5:14	This message is generated when packets match the QoS rule based on the configured parameters Packets are dropped.	
QoS: Action Forward	Apr 13 18:21:54 172.18.117.217 kernel: 1271193932 | system | info | ALR | Network Traffic, Flow of Traffic MAC: 00:14:a8:59:c8:80->MAC: 00:90:0b:0a:81:ae src_ip:172.18.117.1-> dst_ip:172.18.117.217:[dst_port:0], rule id: 23, action: Forward. AP MAC Address : 00:00:00:00:00:00	This message is generated when packets match the QoS rule based on the configured parameters. The packets that match the configured QoS rules are forwarded for further processing.	
QoS: Action Capture	Apr 13 18:30:47 172.18.117.217 kernel: 1271194465 | system | info | ALR | Network Traffic, Flow of Traffic MAC: 00:40:96:ad:49:b0->MAC: 00:90:0b:0a:81:ae src_ip:172.18.117.27-> dst_ip:172.18.122.122:[dst_port:5060], rule id: 3, action: Capture. AP MAC Address : 00:0c:e6:07:5d:71	This message is generated when packets match the QoS rule based on the configured parameters. The packets are captured and sent to respective Flow Detector for further processing.	

Event	System Log Example	Description	Action
CAC Per BSSID > CAC Per AP	info ALR 05/04/2017 13:39:20 CAC LIMIT REACHED MAJOR CAC/Global Bssid Limit Reached (1): call Rejected for STA [00:03:2a:00:d8:55] on AP [00:0c:e6:07:5d:7e] in BSSID [00:0c:e6:de:a2:ef]	This message is generated when the CAC limit is reached (based on BSSID). Calls will not go through.	
CAC Per AP > CAC Per BSSID	info ALR 05/04/2017 14:42:39 CAC LIMIT REACHED MAJOR CAC/AP Limit Reached (1): call Rejected for STA [00:03:2a:00:d8:55] on AP [00:0c:e6:07:5d:7e]	This message is generated when the CAC limit is reached (based on AP). Calls will not go through.	
CAC Per AP = CAC Per BSSID	info ALR 05/04/2017 15:03:22 CAC LIMIT REACHED MAJOR CAC/AP Limit Reached (1): call Rejected for STA [00:03:2a:00:d8:55] on AP [00:0c:e6:07:5d:7e]	This message is generated when the CAC limit is reached (based on AP=BSSID). Calls will not go through.	
CAC PER Interference	info ALR 05/04/2017 15:09:01 CAC LIMIT REACHED MAJOR CAC/Interference Limit Reached (1): call Rejected for STA [00:03:2a:00:d8:55] on AP [00:0c:e6:07:5d:7e]	This message is generated when the CAC limit is reached (based on CAC per interference region). Calls will not go through.	

Rogue AP

Event	System Log Example	Description	Action
ROGUE AP DETECTED	Oct 13 11:11:31 172.18.37.201 ALARM: 1255432835l | system | info | ALR | ROGUE AP DETECTED CRITICAL CONTROLLER (1:13) ROGUE AP DETECTED. AP mac=00:1f:28:57:fa:b7 bss=00:1f:28:57:fa:b7 cch= 6 ess=Integral by AP AP-204 (204)	A rogue AP has been detected.	
ROGUE AP REMOVED	Mar 29 13:12:43 172.18.86.229 ALARM: 1269864763l | system | info | ALR | ROGUE AP REMOVED CONTROL-LER (1:24490) ROGUE AP DETECTED. AP mac=00:12:f2:00:17:63 bss=00:12:f2:00:17:63 cch=161 ess=rogue-35	A rogue AP has been removed.	

Licensing

Event	System Log Example	Description	Action
LICENSE EXPIRE WARN-ING	Mar 22 15:27:42 172.18.65.202 ALARM: 1205970893l | system | notice | NOT | controller license expires in 1 day	Notification that license expires in one day.	Install a license for the software.
LICENSE EXPIRE WARN-ING	Mar 22 15:33:46 172.18.65.202 ALARM: 1205971257l | system | notice | NOT | controller license expires tonight at midnight.	Notification that license expires by midnight.	Install a license for the software.
LICENSE EXPIRED	Mar 22 15:42:17 172.18.65.202 ALARM: 1206057655l | system | info | ALR | SOFTWARE LICENSE EXPIRED MAJOR controller license has already expired.	License has expired.	Install a license for the software.
LICENSE EXPIRED ALARM CLEAR	Mar 22 15:52:23 172.18.65.202 ALARM: 1206058262l | system | info | ALR | SOFTWARE LICENSE EXPIRED CLEAR controller	License alarm cleared.	

N+1 Redundancy

Event	System Log Example	Description	Action
MASTER CONTROLLER DOWN	Apr 19 14:24:26 172.18.253.203 nplus1_Slave: ALERT: Master Controller has timed out: Regression1 172.18.253.201	Slave detects that master controller is not reachable. Slave moves to active state.	Diagnose the master controller.
PASSIVE TO ACTIVE SLAVE STATE TRANSITION	Apr 19 14:24:26 172.18.253.203 nplus1_Slave: Slave State: Passive->Active	Passive slave in transition to becoming active slave.	
ACTIVE SLAVE	May 15 16:07:49 172.18.32.201 nplus1_Slave: Slave State: Active	Slave in active state.	
ACTIVE TO PASSIVE SLAVE TRANSITION	May 15 16:07:59 172.18.32.201 nplus1_Slave: Slave State: Active->Passive	Slave detected that master controller is reachable, so slave becomes passive again.	
ACTIVE TO PASSIVE SLAVE TRANSITION	Apr 19 14:40:21 172.18.253.203 nplus1_Slave: NOTICE: Active Slave Controller (Regression1 172.18.253.201) -> Passive Slave (RegressionSlave 172.18.253.203)	Slave detected that master controller is reachable, so slave becomes passive again.	
PASSIVE SLAVE	Apr 19 14:40:21 172.18.253.203 nplus1_Slave: Slave State: Passive	Slave in passive state.	
MASTER CONTROLLER DOWN ALARM	May 15 16:07:49 172.18.32.201 ALARM: 1210847902l | system | info | ALR | MASTER CONTROLER DOWN INFO	Master controller down alarm.	

Event	System Log Example	Description	Action
MASTER CONTROLLER UP ALARM	May 15 16:07:59 172.18.32.201 ALARM: 1210847912l | system | info | ALR | MASTER CONTROLER UP INFO	Master controller up alarm.	
SLAVE CONFIG SYNC	Apr 19 14:51:07 172.18.253.201 sshd[7465]: PAM _pam_init_handlers: no default config /etc/pam.d/other Apr 19 14:51:07 172.18.253.201 sshd[7465]: PAM _pam_init_handlers: no default config /etc/pam.d/other Apr 19 14:51:07 172.18.253.201 sshd[7465]: Accepted publickey for root from 172.18.253.203 port 34674 ssh2 Apr 19 14:51:07 172.18.253.201 PAM-env[7465]: Unable to open config file: No such file or directory	SSH system log messages are shown while slave is syncing certain configuration files with the master controller using scp.	

21 Appendix

Captive Portal and Fortinet Connect Deployment Recommendations

These are the deployment recommendations.

DNS Entry

It is mandatory to enter the DNS while creating internal DHCP profile.

External Portal IP Configuration

If a NAT device is located between the controller and the Fortinet Connect, the IP address with which Fortinet Connect sees the controller should be configured under Device > RADIUS Clients page in Fortinet Connect Admin portal (*http://<fortinetconnect-ip-address>/admin*) . Select the RADIUS client and enter the controller IP address in the Client tab. The Fortinet Connect Automatic Setup then configures the controller correctly and ensures that the correct controller IP address is configured on Fortinet Connect.

Remember Me settings

In the Portal Settings step of the Guest Portal configuration wizard, if you choose to enable

Remember Credentials, then select "Initially attempt to use a cookie, if this fails try the MAC address" option. This removes the dependency on the client's browser and security settings.

SmartConnect Certificate download

In the Certificates step of the Smart Connect Profile Wizard, ensure that you select the complete certificate chain of your uploaded certificate. If all certificates in the chain (from root to server) have been uploaded, then selecting the server certificate will automatically select the entire certificate chain.

- To upload the server certificates, go to **Server > SSL Settings > Server Certificate** tab.
- To upload rest of the chain, go to **Server > SSL Settings > Trusted CA Certificates** tab.

IP Prefix Validation

In a situation where a station with an IP address from a different subnet connects to the controller, it can result in various network issues including outage. The IP Prefix Validation field in the ***ESS Profile*** and ***Port Profile*** configuration page, when enabled, stations with different subnet are prevented from connecting to the controller. By default, IP Prefix Validation in **ESS Profile is ON** and in **Port Profile it is OFF**.

IP prefix validation is not supported for clients with IPv6 addresses (supported for IPv4 address). When a client obtains an IPv6 address, IP prefix validation is done based on the controller's IPv6 address.
Hence the controller needs to obtain a valid IPv6 address either through RA (Router Advertisement) or through DHCPv6 for the client to pass traffic without any packet drop.

IP Prefix Validation must be disabled if the ESS profile is used for RAC.

Number of Clients per Controller

The maximum number of clients supported per controller is listed.

FortiWLC Hardware Controllers	
Model	**Maximum number of clients**
FortiWLC-50D	1500
FortiWLC-200D	2500
FortiWLC-500D	7500
FortiWLC-1000D	20000
FortiWLC-3000D	45000
FortiWLC Virtual Controllers	
Model	**Maximum number of clients**
FWC-VM-50	1250
FWC-VM-200	2500
FWC-VM-500	6250
FWC-VM-1000	10000
FWC-VM-3000	30000