Preface

This preface provides an overview of the *Cisco Wireless LAN Controller Configuration Guide*, *Release 6.0*, references related publications, and explains how to obtain other documentation and technical assistance, if necessary. It contains these sections:

Audience

This guide describes Cisco Wireless LAN Controllers and Cisco Lightweight Access Points. This guide is for the networking professional who installs and manages these devices. To use this guide, you should be familiar with the concepts and terminology of wireless LANs.

Purpose

This guide provides the information you need to set up and configure wireless LAN controllers.

Note This version of the *Cisco Wireless LAN Controller Configuration Guide* pertains specifically to controller software release 6.0. If you are using an earlier version of software, you will notice differences in features, functionality, and GUI pages.

Organization

This guide is organized into these chapters:

Chapter 1, "Overview," provides an overview of the network roles and features of wireless LAN controllers.

Chapter 2, "Getting Started," describes how to initially configure and log into the controller.

Chapter 3, "Configuring Ports and Interfaces," describes the controller's physical ports and interfaces and provides instructions for configuring them.

Chapter 4, "Configuring Controller Settings," describes how to configure settings on the controllers.

Chapter 5, "Configuring Security Solutions," describes application-specific solutions for wireless LANs.

Chapter 6, "Configuring WLANs," describes how to configure wireless LANs and SSIDs on your system.

Chapter 7, "Controlling Lightweight Access Points," explains how to connect lightweight access points to the controller and manage access point settings.

Chapter 8, "Controlling Mesh Access Points," explains how to connect mesh access points to the controller and manage access point settings.

Chapter 9, "Managing Controller Software and Configurations," describes how to upgrade and manage controller software and configurations.

Chapter 10, "Managing User Accounts," explains how to create and manage guest user accounts, describes the web authentication process, and provides instructions for customizing the web authentication login.

Chapter 11, "Configuring Radio Resource Management," describes radio resource management (RRM) and explains how to configure it on the controllers.

Chapter 12, "Configuring Mobility Groups," describes mobility groups and explains how to configure them on the controllers.

Chapter 13, "Configuring Hybrid REAP," describes hybrid REAP and explains how to configure this feature on controllers and access points.

Appendix A, "Safety Considerations and Translated Safety Warnings," lists safety considerations and translations of the safety warnings that apply to the Cisco Unified Wireless Network Solution products.

Appendix B, "Declarations of Conformity and Regulatory Information," provides declarations of conformity and regulatory information for the products in the Cisco Unified Wireless Network Solution.

Appendix C, "End User License and Warranty," describes the end user license and warranty that apply to the Cisco Unified Wireless Network Solution products.

Appendix D, "Troubleshooting," describes the LED patterns on controllers and lightweight access points, lists system messages that can appear on the Cisco Unified Wireless Network Solution interfaces, and provides CLI commands that can be used to troubleshoot problems on the controller.

Appendix E, "Logical Connectivity Diagrams," provides logical connectivity diagrams and related software commands for controllers that are integrated into other Cisco products.

Conventions

This publication uses these conventions to convey instructions and information:

Command descriptions use these conventions:

- Commands and keywords are in boldface text.
- Arguments for which you supply values are in italic.
- Square brackets ([ ]) mean optional elements.
- Braces ({ }) group required choices, and vertical bars (|) separate the alternative elements.
- Braces and vertical bars within square brackets ([{ | }]) mean a required choice within an optional element.

Interactive examples use these conventions:

- Terminal sessions and system displays are in `screen` font.
- Information you enter is in **boldface**.
- Nonprinting characters, such as passwords or tabs, are in angle brackets (< >).

Notes, cautions, and timesavers use these conventions and symbols:

Note Means reader take note. Notes contain helpful suggestions or references to materials not contained in this manual.

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

Warning **This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. (To see translations of the warnings that appear in this publication, refer to the appendix "Translated Safety Warnings.")**

Waarschuwing **Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van standaard maatregelen om ongelukken te voorkomen. (Voor vertalingen van de waarschuwingen die in deze publicatie verschijnen, kunt u het aanhangsel "Translated Safety Warnings" (Vertalingen van veiligheidsvoorschriften) raadplegen.)**

Varoitus **Tämä varoitusmerkki merkitsee vaaraa. Olet tilanteessa, joka voi johtaa ruumiinvammaan. Ennen kuin työskentelet minkään laitteiston parissa, ota selvää sähkökytkentöihin liittyvistä vaaroista ja tavanomaisista onnettomuuksien ehkäisykeinoista. (Tässä julkaisussa esiintyvien varoitusten käännökset löydät liitteestä "Translated Safety Warnings" (käännetyt turvallisuutta koskevat varoitukset).)**

Attention **Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures. Avant d'accéder à cet équipement, soyez conscient des dangers posés par les circuits électriques et familiarisez-vous avec les procédures courantes de prévention des accidents. Pour obtenir les traductions des mises en garde figurant dans cette publication, veuillez consulter l'annexe intitulée « Translated Safety Warnings » (Traduction des avis de sécurité).**

Warnung **Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu einer Körperverletzung führen könnte. Bevor Sie mit der Arbeit an irgendeinem Gerät beginnen, seien Sie sich der mit elektrischen Stromkreisen verbundenen Gefahren und der Standardpraktiken zur Vermeidung von Unfällen bewußt. (Übersetzungen der in dieser Veröffentlichung enthaltenen Warnhinweise finden Sie im Anhang mit dem Titel "Translated Safety Warnings" (Übersetzung der Warnhinweise).)**

Avvertenza **Questo simbolo di avvertenza indica un pericolo. Si è in una situazione che può causare infortuni. Prima di lavorare su qualsiasi apparecchiatura, occorre conoscere i pericoli relativi ai circuiti elettrici ed essere al corrente delle pratiche standard per la prevenzione di incidenti. La traduzione delle avvertenze riportate in questa pubblicazione si trova nell'appendice, "Translated Safety Warnings" (Traduzione delle avvertenze di sicurezza).**

Advarsel **Dette varselsymbolet betyr fare. Du befinner deg i en situasjon som kan føre til personskade. Før du utfører arbeid på utstyr, må du være oppmerksom på de faremomentene som elektriske kretser innebærer, samt gjøre deg kjent med vanlig praksis når det gjelder å unngå ulykker. (Hvis du vil se oversettelser av de advarslene som finnes i denne publikasjonen, kan du se i vedlegget "Translated Safety Warnings" [Oversatte sikkerhetsadvarsler].)**

Aviso **Este símbolo de aviso indica perigo. Encontra-se numa situação que lhe poderá causar danos fisicos. Antes de começar a trabalhar com qualquer equipamento, familiarize-se com os perigos relacionados com circuitos eléctricos, e com quaisquer práticas comuns que possam prevenir possíveis acidentes. (Para ver as traduções dos avisos que constam desta publicação, consulte o apêndice "Translated Safety Warnings" - "Traduções dos Avisos de Segurança").**

¡Advertencia! **Este símbolo de aviso significa peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considerar los riesgos que entraña la corriente eléctrica y familiarizarse con los procedimientos estándar de prevención de accidentes. (Para ver traducciones de las advertencias que aparecen en esta publicación, consultar el apéndice titulado "Translated Safety Warnings.")**

Varning! **Denna varningssymbol signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanligt förfarande för att förebygga skador. (Se förklaringar av de varningar som förekommer i denna publikation i appendix "Translated Safety Warnings" [Översatta säkerhetsvarningar].)**

Related Publications

These documents provide complete information about the Cisco Unified Wireless Network Solution:

- *Quick Start Guide*: *Cisco 2100 Series Wireless LAN Controllers*
- *Quick Start Guide*: *Cisco 4400 Series Wireless LAN Controllers*
- *Cisco 5500 Series Wireless Controller Installation Guide*
- *Cisco Wireless LAN Controller Command Reference*
- *Cisco Wireless Control System Configuration Guide*
- *Quick Start Guide: Cisco Wireless Control System*
- Quick start guide and hardware installation guide for your specific lightweight access point

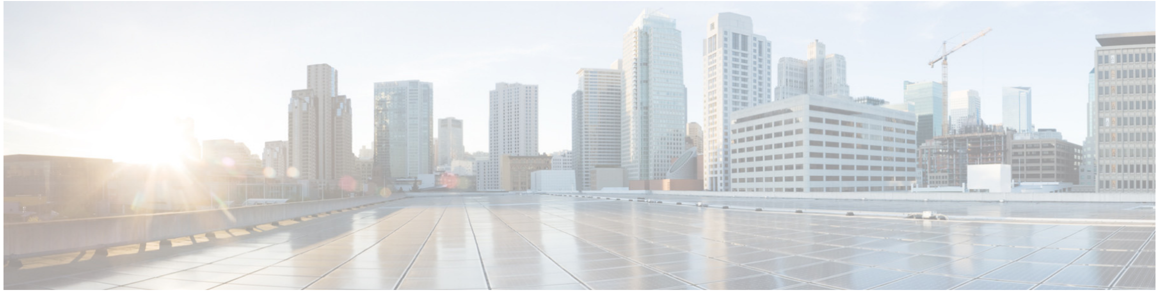
Click this link to browse to user documentation for the Cisco Unified Wireless Network Solution:
http://www.cisco.com/cisco/web/psa/default.html?mode=prod

Obtaining Documentation and Submitting a Service Request

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

http://www.cisco.com/cisco/web/psa/default.html?mode=prod

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



1

Overview

This chapter describes the controller components and features. Its contains these sections:

Americas Headquarters:
Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA

Cisco Unified Wireless Network Solution Overview

The Cisco Unified Wireless Network (Cisco UWN) Solution is designed to provide 802.11 wireless networking solutions for enterprises and service providers. The Cisco UWN Solution simplifies deploying and managing large-scale wireless LANs and enables a unique best-in-class security infrastructure. The operating system manages all data client, communications, and system administration functions, performs radio resource management (RRM) functions, manages system-wide mobility policies using the operating system security solution, and coordinates all security functions using the operating system security framework.

The Cisco UWN Solution consists of Cisco Wireless LAN Controllers and their associated lightweight access points controlled by the operating system, all concurrently managed by any or all of the operating system user interfaces:

- An HTTP and/or HTTPS full-featured Web User Interface hosted by Cisco Wireless LAN Controllers can be used to configure and monitor individual controllers. See Chapter 2.
- A full-featured command-line interface (CLI) can be used to configure and monitor individual Cisco Wireless LAN Controllers. See Chapter 2.
- The Cisco Wireless Control System (WCS), which you use to configure and monitor one or more Cisco Wireless LAN Controllers and associated access points. WCS has tools to facilitate large-system monitoring and control. WCS runs on Windows 2000, Windows 2003, and Red Hat Enterprise Linux ES servers.

  Note WCS software release 6.0 must be used with controllers running controller software release 6.0. Do not attempt to use older versions of WCS software with controllers running controller software release 6.0.

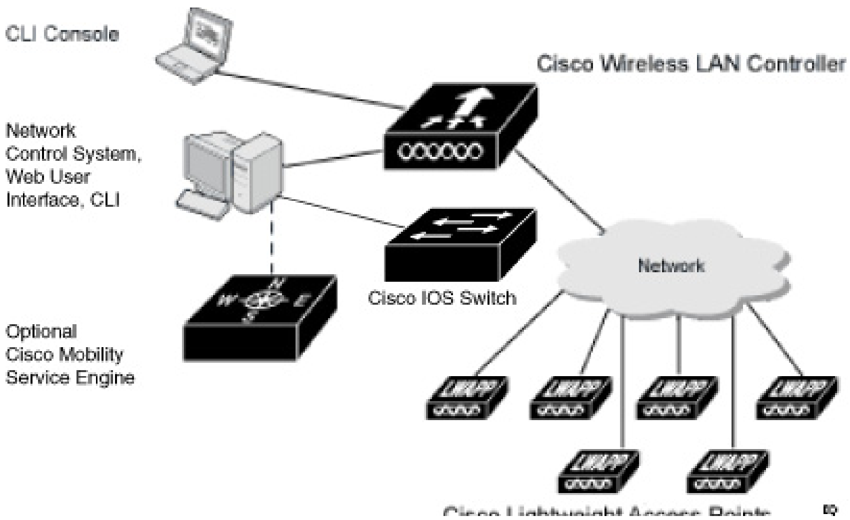
- An industry-standard SNMP V1, V2c, and V3 interface can be used with any SNMP-compliant third-party network management system.

The Cisco UWN Solution supports client data services, client monitoring and control, and all rogue access point detection, monitoring, and containment functions. It uses lightweight access points, Cisco Wireless LAN Controllers, and the optional Cisco WCS to provide wireless services to enterprises and service providers.

Note Unless otherwise noted, all of the Cisco wireless LAN controllers are hereafter referred to as *controllers*, and all of the Cisco lightweight access points are hereafter referred to as *access points*.

Figure 1-1 shows the Cisco Wireless LAN Solution components, which can be simultaneously deployed across multiple floors and buildings.

Figure 1 Cisco UWN Solution Components



Single-Controller Deployments

A standalone controller can support lightweight access points across multiple floors and buildings simultaneously, and supports the following features:

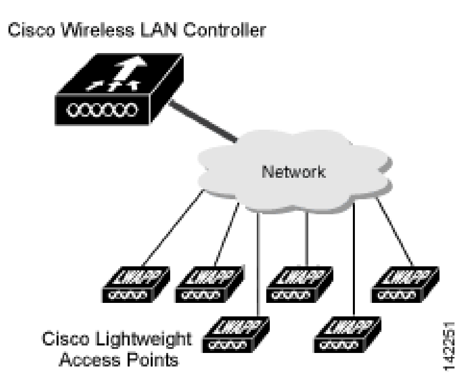
- Autodetecting and autoconfiguring lightweight access points as they are added to the network.
- Full control of lightweight access points.
- Lightweight access points connect to controllers through the network. The network equipment may or may not provide Power over Ethernet to the access points.

Note that some controllers use redundant Gigabit Ethernet connections to bypass single network failures.

Note Some controllers can connect through multiple physical ports to multiple subnets in the network. This feature can be helpful when operators want to confine multiple VLANs to separate subnets.

Figure 1-2 shows a typical single-controller deployment.

Figure 2 Single-Controller Deployment



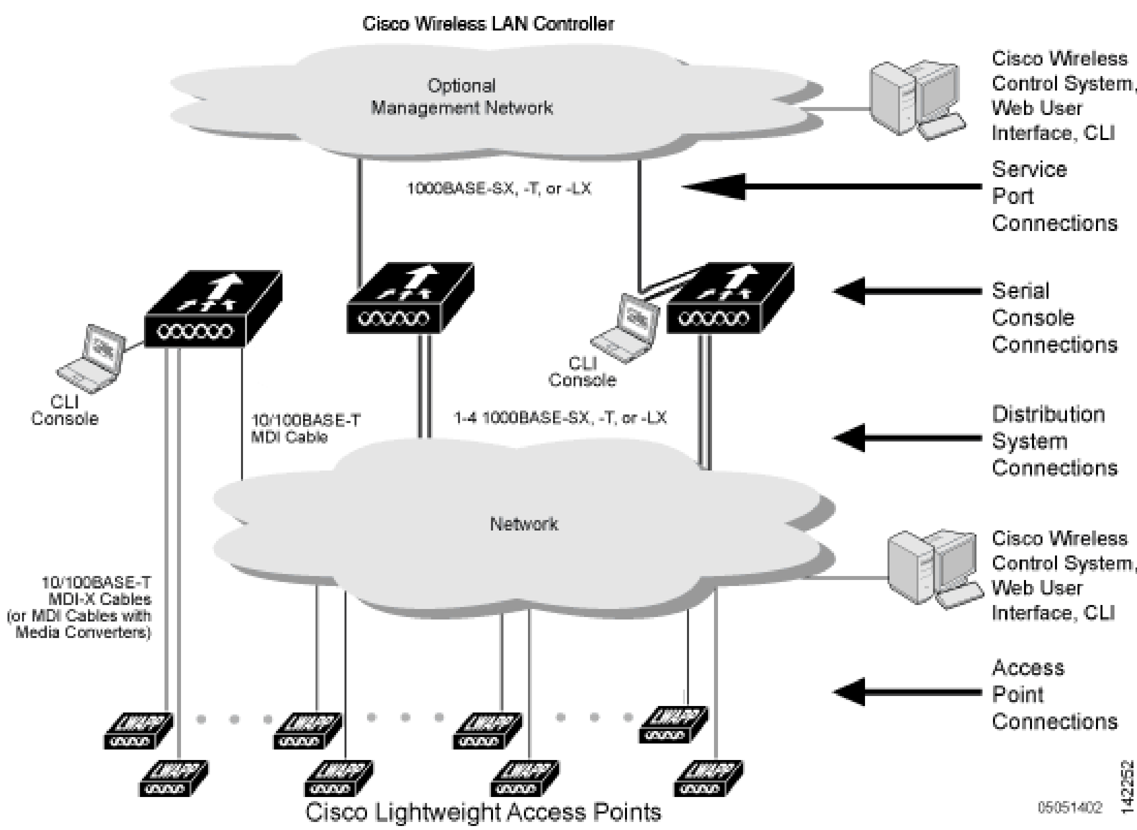
Multiple-Controller Deployments

Each controller can support lightweight access points across multiple floors and buildings simultaneously. However, full functionality of the Cisco Wireless LAN Solution is realized when it includes multiple controllers. A multiple-controller system has the following additional features:

- Autodetecting and autoconfiguring RF parameters as the controllers are added to the network.
- Same-Subnet (Layer 2) Roaming and Inter-Subnet (Layer 3) Roaming.
- Automatic access point failover to any redundant controller with a reduced access point load (refer to the "Cisco Wireless LAN Controller Failover Protection" section on page 1-16).

Figure 1-3 shows a typical multiple-controller deployment. The figure also shows an optional dedicated Management Network and the three physical connection types between the network and the controllers.

Figure 3 Typical Multi-Controller Deployment



Operating System Software

The operating system software controls controllers and lightweight access points. It includes full operating system security and radio resource management (RRM) features.

Operating System Security

Operating system security bundles Layer 1, Layer 2, and Layer 3 security components into a simple, Cisco WLAN Solution-wide policy manager that creates independent security policies for each of up to 16 wireless LANs. (Refer to the "Cisco UWN Solution WLANs" section on page 1-13.)

The 802.11 Static WEP weaknesses can be overcome using robust industry-standard security solutions, such as:

- 802.1X dynamic keys with extensible authentication protocol (EAP).
- Wi-Fi protected access (WPA) dynamic keys. The Cisco WLAN Solution WPA implementation includes:
  - Temporal key integrity protocol (TKIP) + message integrity code checksum (Michael) dynamic keys, or
  - WEP keys, with or without Pre-Shared key Passphrase.
- RSN with or without Pre-Shared key.
- Optional MAC filtering.

The WEP problem can be further solved using industry-standard Layer 3 security solutions, such as:

- Passthrough VPNs
- The Cisco Wireless LAN Solution supports local and RADIUS MAC address filtering.
- The Cisco Wireless LAN Solution supports local and RADIUS user/password authentication.
- The Cisco Wireless LAN Solution also uses manual and automated disabling to block access to network services. In manual disabling, the operator blocks access using client MAC addresses. In automated disabling, which is always active, the operating system software automatically blocks access to network services for an operator-defined period of time when a client fails to authenticate for a fixed number of consecutive attempts. This can be used to deter brute-force login attacks.

These and other security features use industry-standard authorization and authentication methods to ensure the highest possible security for your business-critical wireless LAN traffic.

Cisco WLAN Solution Wired Security

Many traditional access point vendors concentrate on security for the Wireless interface similar to that described in the "Operating System Security" section on page 1-5. However, for secure Cisco Wireless LAN Controller Service Interfaces, Cisco Wireless LAN Controller to access point, and inter-Cisco Wireless LAN Controller communications during device servicing and client roaming, the operating system includes built-in security.

Each Cisco Wireless LAN Controller and lightweight access point is manufactured with a unique, signed X.509 certificate. These signed certificates are used to verify downloaded code before it is loaded, ensuring that hackers do not download malicious code into any Cisco Wireless LAN Controller or lightweight access point.

Cisco Wireless LAN Controllers and lightweight access points also use the signed certificates to verify downloaded code before it is loaded, ensuring that hackers do not download malicious code into any Cisco Wireless LAN Controller or lightweight access point.

Layer 2 and Layer 3 Operation

Lightweight Access Point Protocol (LWAPP) communications between the controller and lightweight access points can be conducted at ISO Data Link Layer 2 or Network Layer 3. Control and Provisioning of Wireless Access Points protocol (CAPWAP) communications between the controller and lightweight access points are conducted at Network Layer 3. Layer 2 mode does not support CAPWAP.

Note Controller software release 5.2 or later supports only Layer 3 CAPWAP mode, controller software releases 5.0 and 5.1 support only Layer 3 LWAPP mode, and controller software releases prior to 5.0 support Layer 2 or Layer 3 LWAPP mode.

Note The IPv4 network layer protocol is supported for transport through a CAPWAP or LWAPP controller system. IPv6 (for clients only) and Appletalk are also supported but only on 5500 series controllers, 4400 series controllers, and the Cisco WiSM. Other Layer 3 protocols (such as IPX, DECnet Phase IV, OSI CLNP, and so on) and Layer 2 (bridged) protocols (such as LAT and NetBeui) are not supported.

Operational Requirements

The requirement for Layer 3 LWAPP communications is that the controller and lightweight access points can be connected through Layer 2 devices on the same subnet or connected through Layer 3 devices across subnets. Another requirement is that the IP addresses of access points should be either statically assigned or dynamically assigned through an external DHCP server.

The requirement for Layer 3 CAPWAP communications across subnets is that the controller and lightweight access points are connected through Layer 3 devices. Another requirement is that the IP addresses of access points should be either statically assigned or dynamically assigned through an external DHCP server.

Configuration Requirements

When you are operating the Cisco Wireless LAN Solution in Layer 2 mode, you must configure a management interface to control your Layer 2 communications.

When you are operating the Cisco Wireless LAN Solution in Layer 3 mode, you must configure an AP-manager interface to control lightweight access points and a management interface as configured for Layer 2 mode.

Cisco Wireless LAN Controllers

When you are adding lightweight access points to a multiple Cisco Wireless LAN Controller deployment network, it is convenient to have all lightweight access points associate with one master controller on the same subnet. That way, the operator does not have to log into multiple controllers to find out which controller newly-added lightweight access points associated with.

One controller in each subnet can be assigned as the master controller while adding lightweight access points. As long as a master controller is active on the same subnet, all new access points without a primary, secondary, and tertiary controller assigned automatically attempt to associate with the master Cisco Wireless LAN Controller. This process is described in the "Cisco Wireless LAN Controller Failover Protection" section on page 1-16.

The operator can monitor the master controller using the WCS Web User Interface and watch as access points associate with the master controller. The operator can then verify access point configuration and assign a primary, secondary, and tertiary controller to the access point, and reboot the access point so it reassociates with its primary, secondary, or tertiary controller.

Note Lightweight access points without a primary, secondary, and tertiary controller assigned always search for a master controller first upon reboot. After adding lightweight access points through the master controller, assign primary, secondary, and tertiary controllers to each access point. Cisco recommends that you disable the master setting on all controllers after initial configuration.

Client Location

When you use Cisco WCS in your Cisco Wireless LAN Solution, controllers periodically determine client, rogue access point, rogue access point client, radio frequency ID (RFID) tag location and store the locations in the Cisco WCS database. For more information on location solutions, refer to these documents:

Cisco Wireless Control System Configuration Guide:

http://www.cisco.com/c/en/us/support/wireless/wireless-control-system/products-installation-and-configuration-guides-list.html

Cisco Location Appliance Configuration Guide:

http://www.cisco.com/c/en/us/support/wireless/wireless-location-appliance/products-installation-and-configuration-guides-list.html

Cisco 3300 Series Mobility Services Engine Configuration Guide:

http://www.cisco.com/c/en/us/support/wireless/mobility-services-engine/products-installation-and-configuration-guides-list.html

Controller Platforms

Controllers are enterprise-class high-performance wireless switching platforms that support 802.11a/n and 802.11b/g/n protocols. They operate under control of the operating system, which includes the radio resource management (RRM), creating a Cisco UWN Solution that can automatically adjust to real-time changes in the 802.11 RF environment. The controllers are built around high-performance network and security hardware, resulting in highly-reliable 802.11 enterprise networks with unparalleled security.

The following controllers are supported for use with software release 6.0:

- Cisco 2100 series controllers
- Cisco 4400 series controllers
- Cisco 5500 series controllers
- Catalyst 6500 Series Wireless Services Module (WiSM)
- Cisco 7600 Series Router Wireless Services Module (WiSM)
- Cisco 28/37/38xx Series Integrated Services Router with Controller Network Module
- Catalyst 3750G Integrated Wireless LAN Controller Switch

The first three controllers are stand-alone platforms. The remaining four controllers are integrated into Cisco switch and router products.

Cisco 2100 Series Controllers

The Cisco 2100 Series Wireless LAN Controllers work in conjunction with Cisco lightweight access points and the Cisco Wireless Control System (WCS) to provide system-wide wireless LAN functions. Each 2100 series controller controls up to 6, 12, or 25 lightweight access points for multi-controller architectures typical of enterprise branch deployments. It may also be used for single controller deployments for small and medium-sized environments.

Caution Do not connect a Power-over-Ethernet (PoE) cable to the controller's console port. Doing so may damage the controller.

Note Wait at least 20 seconds before reconnecting an access point to the controller. Otherwise, the controller may fail to detect the device.

Features Not Supported

This hardware feature is not supported on 2100 series controllers:

- Service port (separate out-of-band management 10/100-Mbps Ethernet interface)

These software features are not supported on 2100 series controllers:

- VPN termination (such as IPSec and L2TP)
- VPN passthrough option

Note You can replicate this functionality on a 2100 series controller by creating an open WLAN using an ACL.

- Termination of guest controller tunnels (origination of guest controller tunnels is supported)
- External web authentication web server list
- Spanning Tree Protocol (STP)
- Port mirroring
- AppleTalk
- QoS per-user bandwidth contracts
- IPv6 pass-through
- Link aggregation (LAG)
- Multicast-unicast mode

Cisco 4400 Series Controllers

The Cisco 4400 Series Wireless LAN Controller is available in two models: 4402 and 4404. The 4402 supports up to 50 lightweight access points while the 4404 supports up to 100, making it ideal for large enterprises and high-density applications.

Figure - Cisco 4400 Series Wireless LAN Controller

The Cisco 4400 Series Wireless LAN Controller can be factory-ordered with a VPN/Enhanced Security Module (Crypto Card) to support VPN, IPSec and other processor-intensive tasks. The VPN/Enhanced Security Module can also be installed in the field.

The 4400 series controller can be equipped with one or two Cisco 4400 series power supplies. When the controller is equipped with two Cisco 4400 series power supplies, the power supplies are redundant, and either power supply can continue to power the controller if the other power supply fails.

Cisco 5500 Series Controllers

The Cisco 5500 Series Wireless LAN Controller is currently available in one model: 5508. The 5508 controller supports up to 250 lightweight access points and 7000 wireless clients (or 5000 wireless clients and 2500 RFID tags when using the client location feature), making it ideal for large enterprises and high-density applications.

Figure - Cisco 4400 Series Wireless LAN Controller

The Cisco 4400 Series Wireless LAN Controller can be factory-ordered with a VPN/Enhanced Security Module (Crypto Card) to support VPN, IPSec and other processor-intensive tasks. The VPN/Enhanced Security Module can also be installed in the field.

The 5500 series controller can be equipped with one or two Cisco 5500 series power supplies. When the controller is equipped with two Cisco 5500 series power supplies, the power supplies are redundant, and either power supply can continue to power the controller if the other power supply fails.

Features Not Supported

These software features are not supported on 5500 series controllers:

- Static AP-manager interface

> **Note** For 5500 series controllers, you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default, and the access points can join on this interface.

- Asymmetric mobility tunneling
- Spanning Tree Protocol (STP)
- Port mirroring
- Layer 2 access control list (ACL) support
- VPN termination (such as IPSec and L2TP)
- VPN passthrough option

> **Note** You can replicate this functionality on a 5500 series controller by creating an open WLAN using an ACL.

- Configuration of 802.3 bridging, AppleTalk, and Point-to-Point Protocol over Ethernet (PPPoE)

> **Note** The 5500 series controllers bridge these packets by default. If desired, you can use ACLs to block the bridging of these protocols.

Catalyst 6500 Series Wireless Services Module

The Catalyst 6500 Series Wireless Services Module (WiSM) is an integrated Catalyst 6500 switch and two Cisco 4404 controllers that supports up to 300 lightweight access points. The switch has eight internal Gigabit Ethernet ports that connect the switch and the controller. The switch and the internal controller run separate software versions, which must be upgraded separately.

> **Note** Without any other service module installed, the Catalyst 6509 switch chassis can support up to seven Cisco WiSMs, and the Catalyst 6506 with a Supervisor 720 can support up to four Cisco WiSMs. If one or more service modules are installed, the chassis can support up to a maximum of four service modules (WiSMs included). Redundant supervisors cannot be used with these maximum configurations.

> **Note** The Cisco WiSM controllers do not support port mirroring.

Refer to the following documents for additional information:

- *Catalyst 6500 Series Switch Installation Guide*
- *Catalyst 6500 Series Switch Wireless Services Module Installation and Configuration Note*
- *Release Notes for Catalyst 6500 Series Switch Wireless LAN Services Module*

- *Configuring a Cisco Wireless Services Module and Wireless Control System*
- *Catalyst 6500 Series Switch and Cisco 7600 Series Router Wireless Services Module Installation and Verification Note*

You can find these documents at these URLs:

http://www.cisco.com/c/en/us/support/switches/catalyst-6500-series-switches/tsd-products-support-series-home.html

http://www.cisco.com/c/en/us/td/docs/wireless/technology/wism/technical/reference/appnote.html

http://www.cisco.com/c/en/us/td/docs/wireless/technology/wism/installation/note/78_17121.html

Cisco 7600 Series Router Wireless Services Module

The Cisco 7600 Series Router Wireless Services Module (WiSM) is an integrated Cisco 7600 router and two Cisco 4404 controllers that supports up to 300 lightweight access points. The router has eight internal Gigabit Ethernet ports that connect the router and the controller. The router and the internal controller run separate software versions, which must be upgraded separately.

Note The WiSM is supported on Cisco 7600 series routers running only Cisco IOS Release 12.2(18)SXF5 or later.

Note Without any other service module installed, the Cisco 7609 router chassis can support up to seven Cisco WiSMs, and any other Cisco 7600 series router chassis can support up to six Cisco WiSMs. If one or more service modules are installed, the chassis can support up to a maximum of four service modules (WiSMs included). Redundant supervisors cannot be used with these maximum configurations.

Note The Cisco WiSM controllers do not support port mirroring.

Refer to the following documents for additional information:

- *Cisco 7600 Series Router Installation Guide*
- *Cisco 7600 Series Router Software Configuration Guide*
- *Cisco 7600 Series Router Command Reference*
- *Configuring a Cisco Wireless Services Module and Wireless Control System*
- *Catalyst 6500 Series Switch and Cisco 7600 Series Router Wireless Services Module Installation and Verification Note*

You can find these documents at these URLs:

http://www.cisco.com/c/en/us/support/routers/7600-series-routers/tsd-products-support-series-home.html

http://www.cisco.com/c/en/us/td/docs/wireless/technology/wism/technical/reference/appnote.html

http://www.cisco.com/c/en/us/td/docs/wireless/technology/wism/installation/note/78_17121.html

Cisco 28/37/38xx Series Integrated Services Router

The Cisco 28/37/38xx Series Integrated Services Router is an integrated 28/37/38xx router and Cisco controller network module that supports up to 6, 8, 12, or 25 lightweight access points, depending on the version of the network module. The versions that support 8, 12, or 25 access points and the NME-AIR-WLC6-K9 6-access-point version feature a high-speed processor and more on-board memory than the NM-AIR-WLC6-K9 6-access-point version. An internal Fast Ethernet port (on the NM-AIR-WLC6-K9 6-access-point version) or an internal Gigabit Ethernet port (on the 8-, 12-, and 25-access-point versions and on the NME-AIR-WLC6-K9 6-access-point version) connects the router and the integrated controller. The router and the internal controller run separate software versions, which must be upgraded separately. Refer to the following documents for additional information:

- *Cisco Wireless LAN Controller Network Module Feature Guide*
- *Cisco 28/37/38xx Series Hardware Installation Guide*

You can find these documents at this URL:

http://www.cisco.com/c/en/us/products/wireless/product-listing.html

Note The controller network module does not support port mirroring.

Note The Cisco 2801 Integrated Services Router does not support the controller network module.

Catalyst 3750G Integrated Wireless LAN Controller Switch

The Catalyst 3750G Integrated Wireless LAN Controller Switch is an integrated Catalyst 3750 switch and Cisco 4400 series controller that supports up to 25 or 50 lightweight access points. The switch has two internal Gigabit Ethernet ports that connect the switch and the controller. The switch and the internal controller run separate software versions, which must be upgraded separately.

Note The controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch does not support Spanning Tree Protocol (STP).

Refer to the following documents for additional information:

- *Catalyst 3750G Integrated Wireless LAN Controller Switch Getting Started Guide*
- *Catalyst 3750 Switch Hardware Installation Guide*
- *Release Notes for the Catalyst 3750 Integrated Wireless LAN Controller Switch, Cisco IOS Release 12.2(25)FZ*

You can find these documents at this URL:

http://www.cisco.com/c/en/us/support/switches/catalyst-3750-series-switches/tsd-products-support-series-home.html

Cisco UWN Solution Wired Connections

The Cisco UWN Solution components communicate with each other using industry-standard Ethernet cables and connectors. The following paragraphs contain details of the wired connections.

- The 2100 series controller connects to the network using from one to six 10/100BASE-T Ethernet cables.
- The 4402 controller connects to the network using one or two fiber-optic Gigabit Ethernet cables, and the 4404 controller connects to the network using up to four fiber-optic Gigabit Ethernet cables.
- The 5508 controller connects to the network using up to eight fiber-optic Gigabit Ethernet cables.
- The controllers in the Wireless Services Module (WiSM), installed in a Cisco Catalyst 6500 Series Switch or a Cisco 7600 Series Router, connect to the network through ports on the switch or router.
- The Wireless LAN Controller Network Module, installed in a Cisco Integrated Services Router, connects to the network through the ports on the router.
- The controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch connects to the network through the ports on the switch.
- Cisco lightweight access points connects to the network using 10/100BASE-T Ethernet cables. The standard CAT-5 cable can also be used to conduct power for the lightweight access points from a network device equipped with Power over Ethernet (PoE) capability. This power distribution plan can be used to reduce the cost of individual AP power supplies and related cabling.

Cisco UWN Solution WLANs

The Cisco UWN Solution can control up to 512 WLANs for lightweight access points. Each WLAN has a separate WLAN ID (1 through 512), a separate profile name, and a WLAN SSID and can be assigned unique security policies. The lightweight access points broadcast all active Cisco UWN Solution WLAN SSIDs and enforce the policies defined for each WLAN.

Note Cisco 2106, 2112, and 2125 controllers support only up to 16 WLANs.

Note Cisco recommends that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that controllers operate with optimum performance and ease of management.

If management over wireless is enabled across the Cisco UWN Solution, the operator can manage the system across the enabled WLAN using CLI and Telnet, http/https, and SNMP.

To configure WLANs, refer to Chapter 6.

File Transfers

The Cisco UWN Solution operator can upload and download operating system code, configuration, and certificate files to and from the controller using the GUI, CLI, or Cisco WCS.

- To use the controller GUI or CLI, refer to Chapter 9, "Managing Controller Software and Configurations".
- To use Cisco WCS to upgrade software, refer to the *Cisco Wireless Control System Configuration Guide*. Click this URL to browse to this document:

  http://www.cisco.com/c/en/us/support/wireless/wireless-control-system/products-installation-and-configuration-guides-list.html

Power over Ethernet

Lightweight access points can receive power via their Ethernet cables from 802.3af-compatible Power over Ethernet (PoE) devices, which can reduce the cost of discrete power supplies, additional wiring, conduits, outlets, and installer time. PoE also frees installers from having to mount lightweight access points or other powered equipment near AC outlets, providing greater flexibility in positioning the access points for maximum coverage.

When you are using PoE, the installer runs a single CAT-5 cable from each lightweight access point to PoE-equipped network elements, such as a PoE power hub or a Cisco WLAN Solution Single-Line PoE Injector. When the PoE equipment determines that the lightweight access point is PoE-enabled, it sends 48 VDC over the unused pairs in the Ethernet cable to power the access point.

The PoE cable length is limited by the 100BASE-T or 10BASE-T specification to 100 m or 200 m, respectively.

Lightweight access points can receive power from an 802.3af-compliant device or from the external power supply.

Cisco Wireless LAN Controller Memory

The controller contains two kinds of memory: volatile RAM, which holds the current, active controller configuration, and NVRAM (non-volatile RAM), which holds the reboot configuration. When you are configuring the operating system in controller, you are modifying volatile RAM; you must save the configuration from the volatile RAM to the NVRAM to ensure that the controller reboots in the current configuration.

Knowing which memory you are modifying is important when you are:

- Using the Configuration Wizard
- Clearing the Controller Configuration
- Saving Configurations
- Resetting the Controller
- Logging Out of the CLI

Cisco Wireless LAN Controller Failover Protection

Each controller has a defined number of communication ports for lightweight access points. This means that when multiple controllers with unused access point ports are deployed on the same network, if one controller fails, the dropped access points automatically poll for unused controller ports and associate with them.

During installation, Cisco recommends that you connect all lightweight access points to a dedicated controller, and configure each lightweight access point for final operation. This step configures each lightweight access point for a primary, secondary, and tertiary controller and allows it to store the configured mobility group information.

During failover recovery, the configured lightweight access points obtain an IP address from the local DHCP server (only in Layer 3 operation), attempt to contact their primary, secondary, and tertiary controllers, and then attempt to contact the IP addresses of the other controllers in the mobility group. This prevents the access points from spending time sending out blind polling messages, resulting in a faster recovery period.

In multiple-controller deployments, this means that if one controller fails, its dropped access points reboot and do the following under direction of the radio resource management (RRM):

- Obtain an IP address from a local DHCP server (one on the local subnet).
- If the lightweight access point has a primary, secondary, and tertiary controller assigned, it attempts to associate with that controller.
- If the access point has no primary, secondary, or tertiary controllers assigned or if its primary, secondary, or tertiary controllers are unavailable, it attempts to associate with a master controller on the same subnet.
- If the access point finds no master controller on the same subnet, it attempts to contact stored mobility group members by IP address.
- Should none of the mobility group members be available, and if the lightweight access point has no primary, secondary, and tertiary controllers assigned and there is no master controller active, it attempts to associate with the least-loaded controller on the same subnet to respond to its discovery messages with unused ports.

This means that when sufficient controllers are deployed, should one controller fail, active access point client sessions are momentarily dropped while the dropped access point associates with an unused port on another controller, allowing the client device to immediately reassociate and reauthenticate.

Network Connections to Cisco Wireless LAN Controllers

Regardless of operating mode, all controllers use the network as an 802.11 distribution system. Regardless of the Ethernet port type or speed, each controller monitors and communicates with its related controllers across the network. The following sections give details of these network connections:

- Cisco 2100 Series Wireless LAN Controllers, page 1-17
- Cisco 4400 Series Wireless LAN Controllers, page 1-17
- Cisco 5500 Series Wireless LAN Controllers, page 1-18

Note Chapter 3 provides information on configuring the controller's ports and assigning interfaces to them.

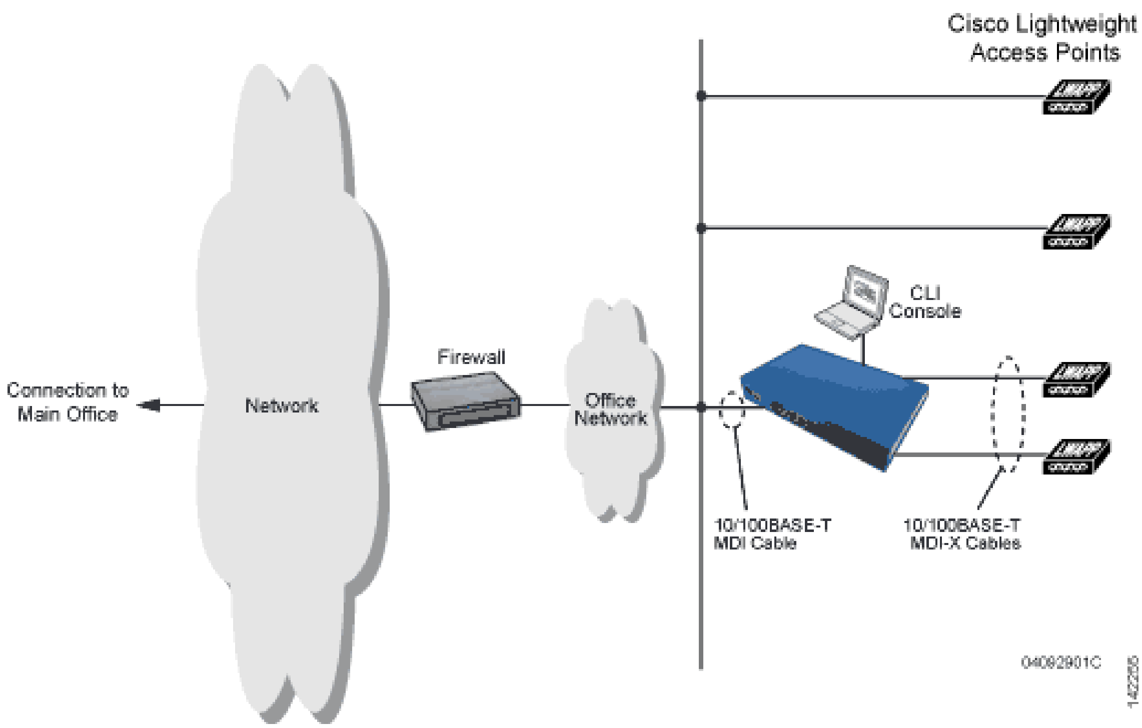
Cisco 2100 Series Wireless LAN Controllers

Cisco 2100 series controllers can communicate with the network through any one of their physical data ports, as the logical management interface can be assigned to one of the ports. The physical port description is as follows:

- Up to six 10/100BASE-T cables can plug into the six back-panel data ports on the 2100 series controller chassis. The 2100 series also has two PoE ports (ports 7 and 8).

Figure 1-4 shows connections to the 2100 series controllers.

Figure 4 Physical Network Connections to the 2100 Series Controller



Cisco 4400 Series Wireless LAN Controllers

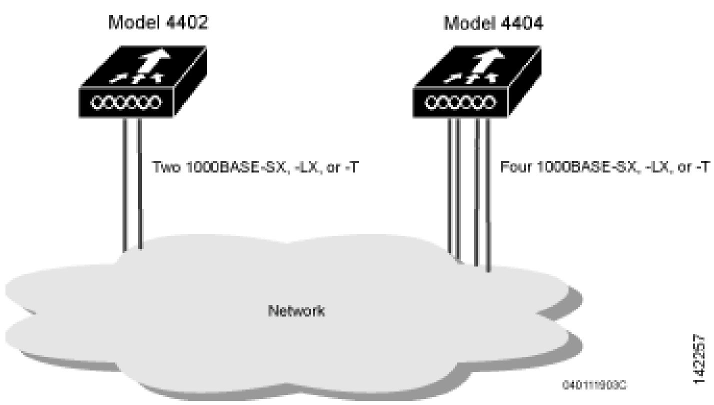
Cisco 4400 series controllers can communicate with the network through one or two pairs of physical data ports, and the logical management interface can be assigned to the ports.

- For the 4402 controller, up to two of the following connections are supported in any combination:
  - 1000BASE-T (Gigabit Ethernet, front panel, RJ-45 physical port, UTP cable).
  - 1000BASE-SX (Gigabit Ethernet, front panel, LC physical port, multi-mode 850nM (SX) fiber-optic links using LC physical connectors).
  - 1000BASE-LX (Gigabit Ethernet, front panel, LC physical port, multi-mode 1300nM (LX/LH) fiber-optic links using LC physical connectors).

- For the 4404 controller, up to four of the following connections are supported in any combination:
  - 1000BASE-T (Gigabit Ethernet, front panel, RJ-45 physical port, UTP cable).
  - 1000BASE-SX (Gigabit Ethernet, front panel, LC physical port, multi-mode 850nM (SX) fiber-optic links using LC physical connectors).
  - 1000BASE-LX (Gigabit Ethernet, front panel, LX physical port, multi-mode 1300nM (LX/LH) fiber-optic links using LC physical connectors).

Figure 1-5 shows connections to the 4400 series controller.

Figure 5 Physical Network Connections to 4402 and 4404 Series Controllers

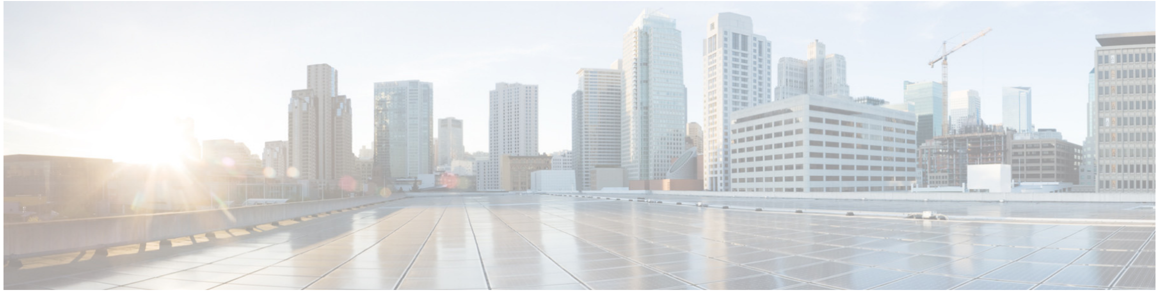


Cisco 5500 Series Wireless LAN Controllers

Cisco 5500 series controllers can communicate with the network through up to eight physical data ports, and the logical management interface can be assigned to the ports.

For the 5508 controller, up to eight of the following connections are supported in any combination:

- 1000BASE-T (Gigabit Ethernet, front panel, RJ-45 physical port, UTP cable).
- 1000BASE-SX (Gigabit Ethernet, front panel, LC physical port, multi-mode 850nM (SX) fiber-optic links using LC physical connectors).
- 1000BASE-LX (Gigabit Ethernet, front panel, LX physical port, multi-mode 1300nM (LX/LH) fiber-optic links using LC physical connectors).



2

Getting Started

This chapter describes how to initially configure and log into the controller. It contains these sections:

Americas Headquarters:
Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA

Using the Configuration Wizard

Note Before you configure your controller for basic operation, refer to the quick start guide or installation guide for your controller to complete any necessary hardware procedures.

The configuration wizard enables you to configure basic settings on the controller. You can run the wizard after you receive the controller from the factory or after the controller has been reset to factory defaults. The configuration wizard is available in GUI or CLI format.

Note To configure the controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch, Cisco recommends that you use the GUI configuration wizard that launches from the 3750 Device Manager. Refer to the *Catalyst 3750G Integrated Wireless LAN Controller Switch Getting Started Guide* for instructions.

Note Refer to the "Resetting the Controller to Default Settings" section on page 117 for instructions on returning the controller to factory defaults.

Connecting the Controller's Console Port

Before you can configure the controller for basic operations, you need to connect it to a PC that uses a VT-100 terminal emulation program (such as HyperTerminal, ProComm, Minicom, or Tip).

Step 1 Connect one end of a null-modem serial cable to the controller's console port and the other end to your PC's serial port.

Note On 5500 series controllers, you can use either the RJ-45 console port or the USB console port. If you use the USB console port, plug the 5-pin mini Type B connector into the controller's USB console port and the other end of the cable into the PC's USB Type A port. The first time that you connect a Windows PC to the USB console port, you are prompted to install the USB console driver. Follow the installation prompts to install the driver. The USB console driver maps to a COM port on your PC; you then need to map the terminal emulator application to the COM port.

Step 2 Start the PC's VT-100 terminal emulation program.

Step 3 Configure the terminal emulation program for these parameters:

- 9600 baud
- 8 data bits
- 1 stop bit
- No parity
- No hardware flow control

Step 4 Plug the AC power cord into the controller and a grounded 100 to 240 VAC, 50/60-Hz electrical outlet.

Step 5 Turn on the power supply. The bootup script displays operating system software initialization (code download and power-on self test verification) and basic configuration.

If the controller passes the power-on self test, the bootup script runs the configuration wizard, which prompts you for basic configuration input.

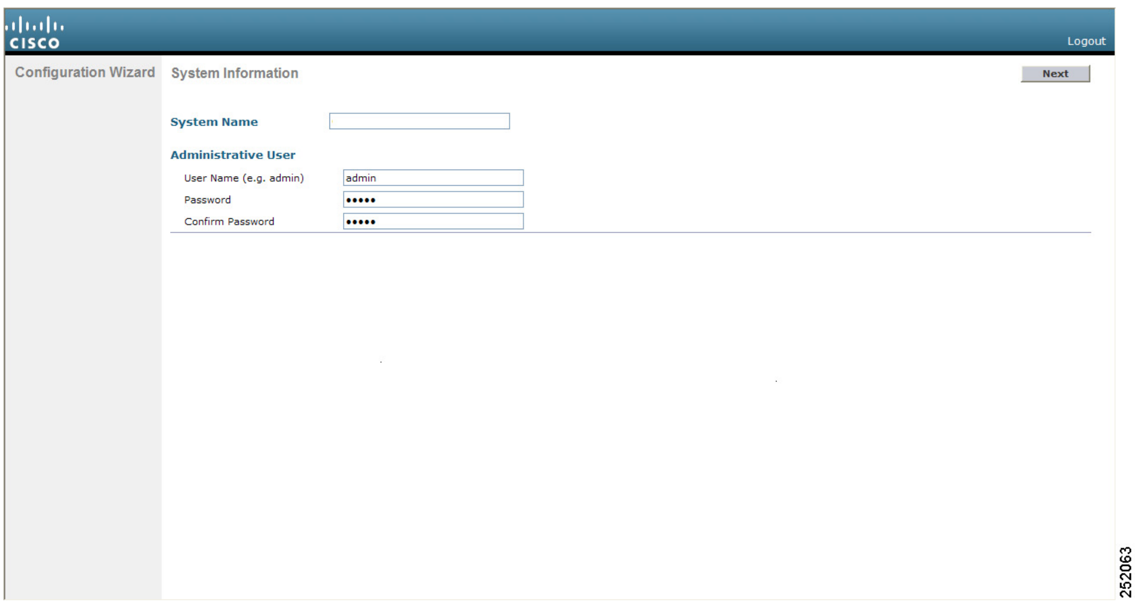
Using the GUI Configuration Wizard

Follow these steps to configure the controller using the GUI configuration wizard.

Step 1 Connect your PC to the service port and configure it to use the same subnet as the controller (for example, 192.168.10.1).

Step 2 Start Internet Explorer 6.0 SP1 (or later) or Firefox 2.0.0.11 (or later) on your PC and browse to http://192.168.1.1. The configuration wizard appears (see Figure 1).

Figure 1 Configuration Wizard — System Information Page



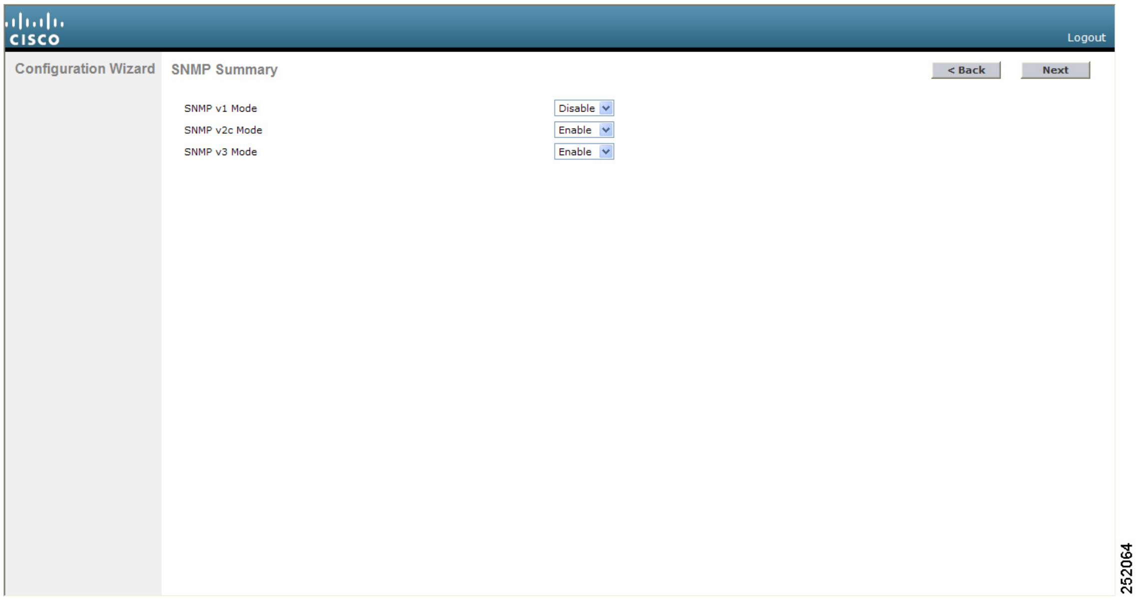
Step 3 In the System Name field, enter the name that you want to assign to this controller. You can enter up to 31 ASCII characters.

Step 4 In the User Name field, enter the administrative username to be assigned to this controller. You can enter up to 24 ASCII characters. The default username is *admin*.

Step 5 In the Password and Confirm Password fields, enter the administrative password to be assigned to this controller. You can enter up to 24 ASCII characters. The default password is *admin*.

Step 6 Click **Next**. The SNMP Summary page appears (see Figure 2).

Figure 2 Configuration Wizard — SNMP Summary Page



Step 7 If you want to enable Simple Network Management Protocol (SNMP) v1 mode for this controller, choose **Enable** from the SNMP v1 Mode drop-down box. Otherwise, leave this parameter set to **Disable**.

Note SNMP is a protocol that manages nodes (servers, workstations, routers, switches, and so on) on an IP network. Currently, there are three versions of SNMP: SNMPv1, SNMPv2c, and SNMPv3.

Step 8 If you want to enable SNMPv2c mode for this controller, leave this parameter set to **Enable**. Otherwise, choose **Disable** from the SNVP v2c Mode drop-down box.

Step 9 If you want to enable SNMPv3 mode for this controller, leave this parameter set to **Enable**. Otherwise, choose **Disable** from the SNVP v3 Mode drop-down box.

Step 10 Click **Next**.

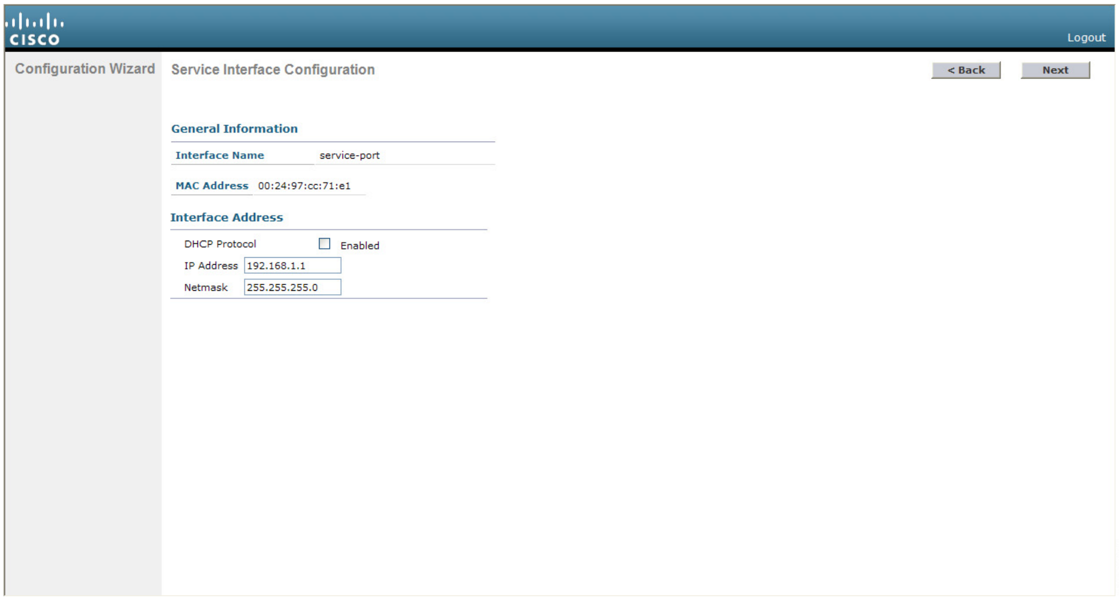
Step 11 When the following message appears, click **OK**:

```
Default values are present for v1/v2c community strings. Please make sure to create new
v1/v2c community strings once the system comes up. Please make sure to create new v3 users
once the system comes up.
```

Note Refer to the "Changing the Default Values of SNMP Community Strings" section on page 44 and the "Changing the Default Values for SNMP v3 Users" section on page 46 for instructions.

The Service Interface Configuration page appears (see Figure 3).

Figure 3 Configuration Wizard — Service Interface Configuration Page



252065

Step 12 If you want the controller’s service-port interface to obtain an IP address from a DHCP server, check the **DHCP Protocol Enabled** check box. If you do not want to use the service port or if you want to assign a static IP address to the service port, leave the check box unchecked.

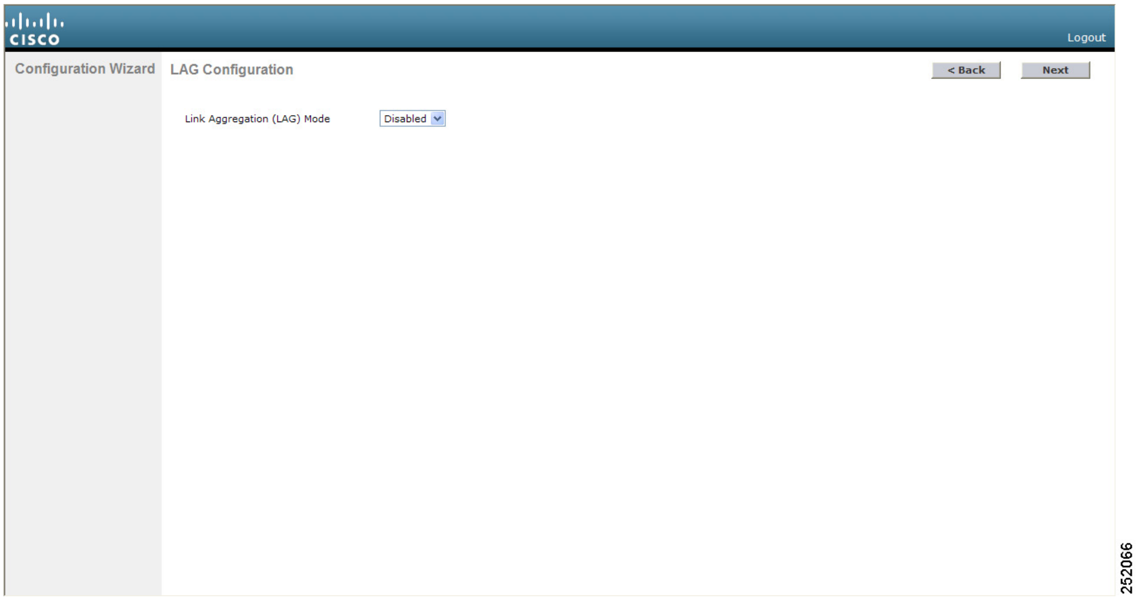
> **Note** The service-port interface controls communications through the service port. Its IP address must be on a different subnet from the management interface. This configuration enables you to manage the controller directly or through a dedicated management network to ensure service access during network downtime.

Step 13 Perform one of the following:

- If you enabled DHCP in Step 12, clear out any entries in the IP Address and Netmask fields, leaving them blank.
- If you disabled DHCP in Step 12, enter the static IP address and netmask for the service port in the IP Address and Netmask fields.

Step 14 Click **Next**. The LAG Configuration page appears (see Figure 4).

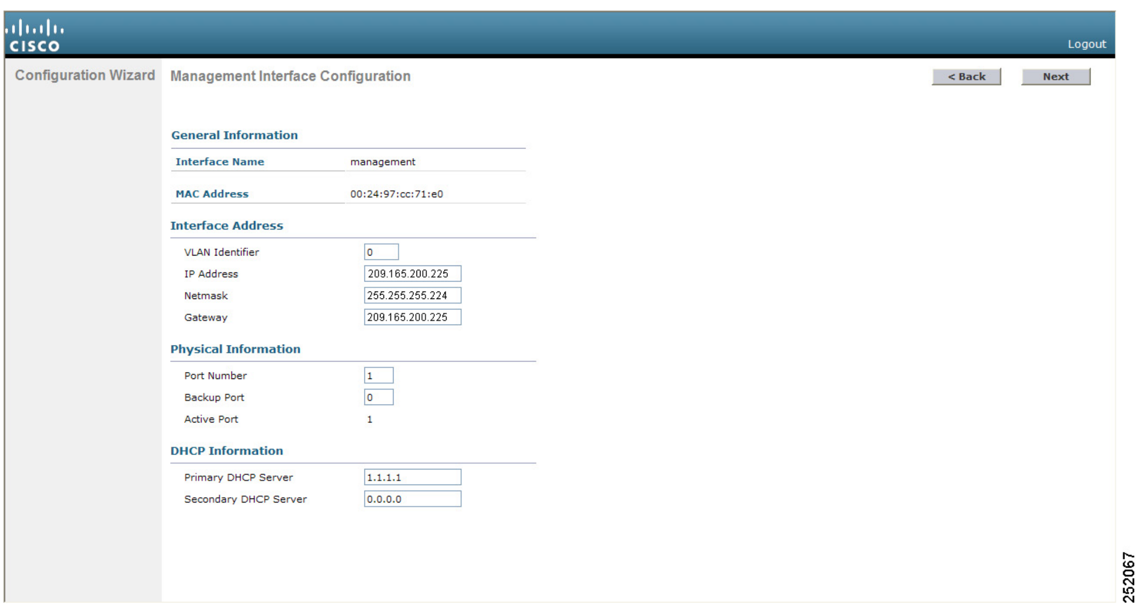
Figure 4 Configuration Wizard — LAG Configuration Page



Step 15 To enable link aggregation (LAG), choose **Enabled** from the Link Aggregation (LAG) Mode drop-down box. To disable LAG, leave this field set to **Disabled**.

Step 16 Click **Next**. The Management Interface Configuration page appears (see Figure 5).

Figure 5 Configuration Wizard — Management Interface Configuration Page



Note The management interface is the default interface for in-band management of the controller and connectivity to enterprise services such as AAA servers.

Step 17 In the VLAN Identifier field, enter VLAN identifier of the management interface (either a valid VLAN identifier or **0** for an untagged VLAN). The VLAN identifier should be set to match the switch interface configuration.

Step 18 In the IP Address field, enter the IP address of the management interface.

Step 19 In the Netmask field, enter the IP address of the management interface netmask.

Step 20 In the Gateway field, enter the IP address of the default gateway.

Step 21 In the Port Number field, enter the number of the port assigned to the management interface. Each interface is mapped to at least one primary port.

Step 22 In the Backup Port field, enter the number of the backup port assigned to the management interface. If the primary port for the management interface fails, the interface automatically moves to the backup port.

Step 23 In the Primary DHCP Server field, enter the IP address of the default DHCP server that will supply IP addresses to clients, the controller's management interface, and optionally the service port interface.

Step 24 In the Secondary DHCP Server field, enter the IP address of an optional secondary DHCP server that will supply IP addresses to clients, the controller's management interface, and optionally the service port interface.

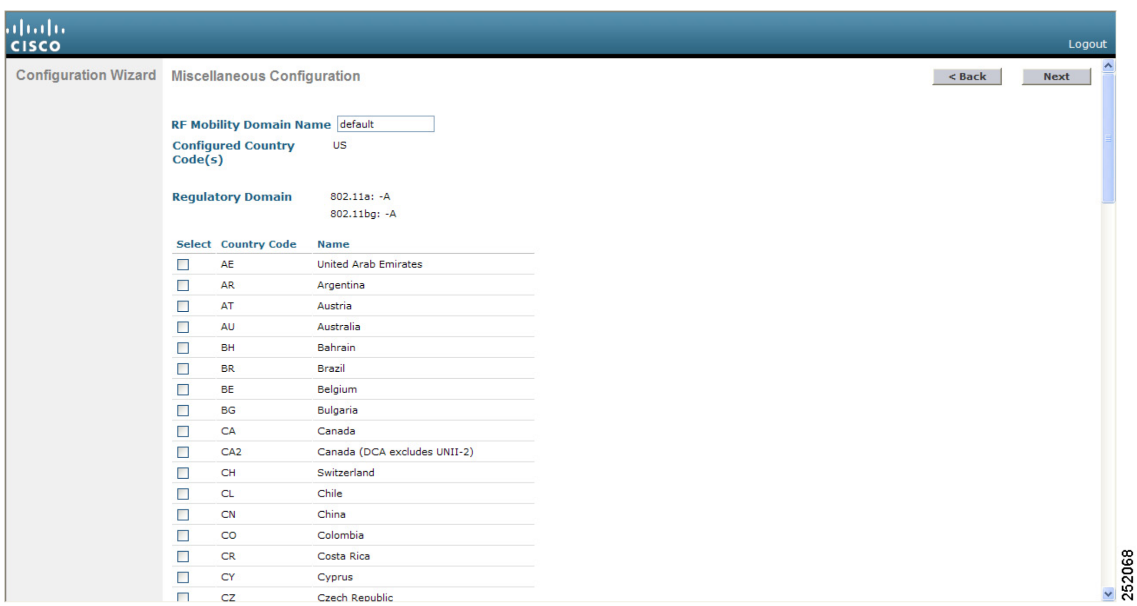
Step 25 Click **Next**. The AP-Manager Interface Configuration page appears.

> **Note** This page does not appear for 5500 series controllers because you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default.

Step 26 In the IP Address field, enter the IP address of the AP-manager interface.

Step 27 Click **Next**. The Miscellaneous Configuration page appears (see Figure 6).

Figure 6 Configuration Wizard — Miscellaneous Configuration Page



Step 28 In the RF Mobility Domain Name field, enter the name of the mobility group/RF group to which you want the controller to belong.

> **Note** Although the name that you enter here is assigned to both the mobility group and the RF group, these groups are not identical. Both groups define clusters of controllers, but they have different purposes. All of the controllers in an RF group are usually also in the same mobility group and vice versa. However, a mobility group facilitates scalable, system-wide mobility and controller redundancy while an RF group facilitates scalable, system-wide dynamic RF management. See the *Configuring Radio Resource Management* and *Configuring Mobility Groups* chapters for more information.

Step 29 The Configured Country Code(s) field shows the code for the country in which the controller will be used. If you want to change the country of operation, check the check box for the desired country.

> **Note** You can choose more than one country code if you want to manage access points in multiple countries from a single controller. After the configuration wizard runs, you need to assign each access point joined to the controller to a specific country. See the "Configuring Country Codes" section on page 75 for instructions.

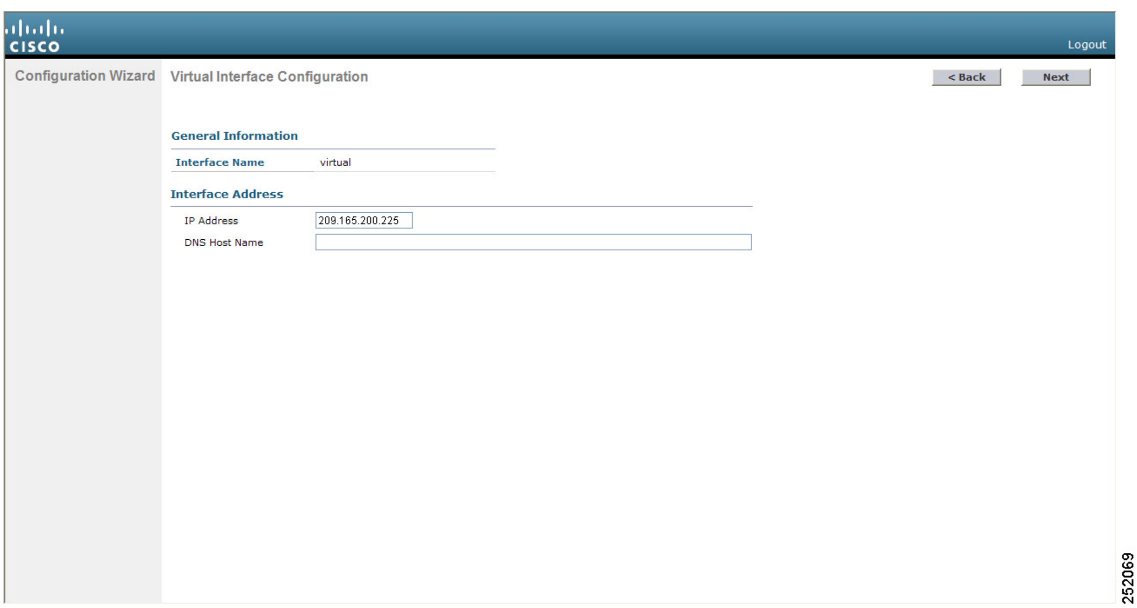
Step 30 Click **Next**.

Step 31 When the following message appears, click **OK**:

```
Warning! To maintain regulatory compliance functionality, the country code setting may
only be modified by a network administrator or qualified IT professional. Ensure that
proper country codes are selected before proceeding.
```

The Virtual Interface Configuration page appears (see Figure 7).

Figure 7 Configuration Wizard — Virtual Interface Configuration Page



Step 32 In the IP Address field, enter the IP address of the controller's virtual interface. You should enter a fictitious, unassigned IP address.

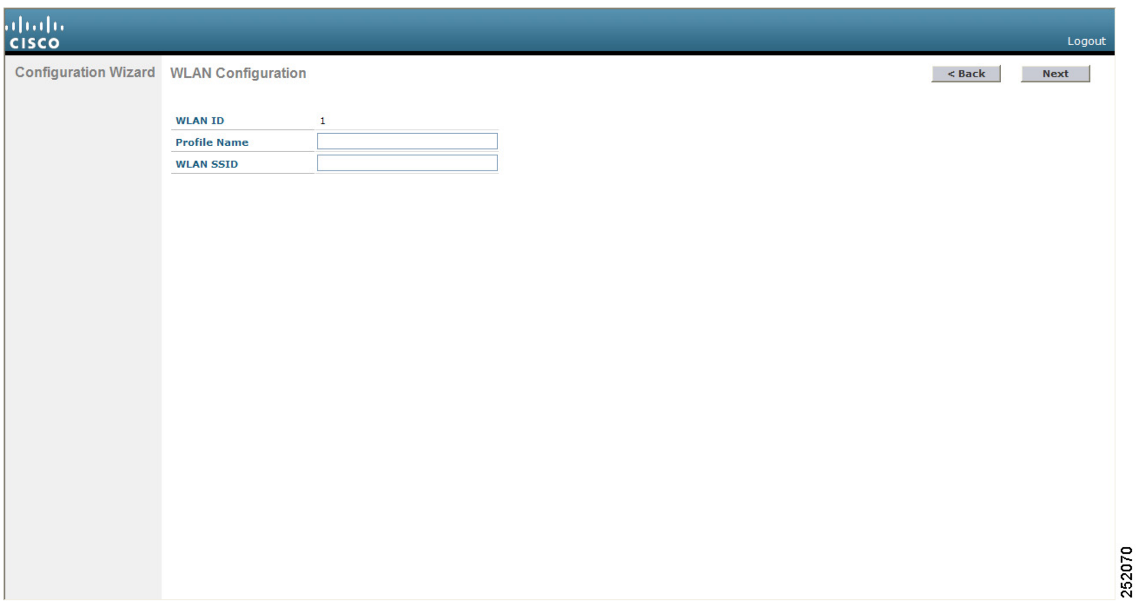
Note The virtual interface is used to support mobility management, DHCP relay, and embedded Layer 3 security such as guest web authentication and VPN termination. All controllers within a mobility group must be configured with the same virtual interface IP address.

Step 33 In the DNS Host Name field, enter the name of the Domain Name System (DNS) gateway used to verify the source of certificates when Layer 3 web authorization is enabled.

Note To ensure connectivity and web authentication, the DNS server should always point to the virtual interface. If a DNS host name is configured for the virtual interface, then the same DNS host name must be configured on the DNS servers used by the client.

Step 34 Click **Next**. The WLAN Configuration page appears (see Figure 8).

Figure 8 Configuration Wizard — WLAN Configuration Page



Step 35 In the Profile Name field, enter up to 32 alphanumeric characters for the profile name to be assigned to this WLAN.

Step 36 In the WLAN SSID field, enter up to 32 alphanumeric characters for the network name, or service set identifier (SSID). The SSID enables basic functionality of the controller and allows access points that have joined the controller to enable their radios.

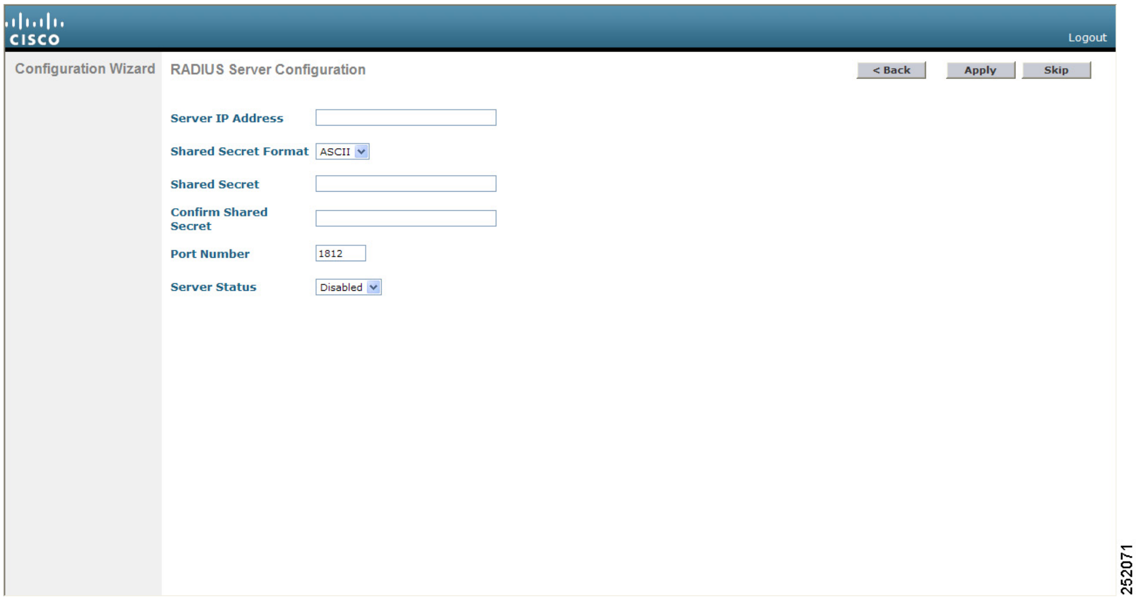
Step 37 Click **Next**.

Step 38 When the following message appears, click **OK**:

```
Default Security applied to WLAN is: [WPA2(AES)][Auth(802.1x)]. You can change this after
the wizard is complete and the system is rebooted.
```

The RADIUS Server Configuration page appears (see Figure 9).

Figure 9 Configuration Wizard — RADIUS Server Configuration Page



Step 39 In the Server IP Address field, enter the IP address of the RADIUS server.

Step 40 From the Shared Secret Format drop-down box, choose ASCII or Hex to specify the format of the shared secret.

Note Due to security reasons, the RADIUS shared secret key reverts to ASCII mode even if you have selected HEX as the shared secret format from the Shared Secret Format drop-down list.

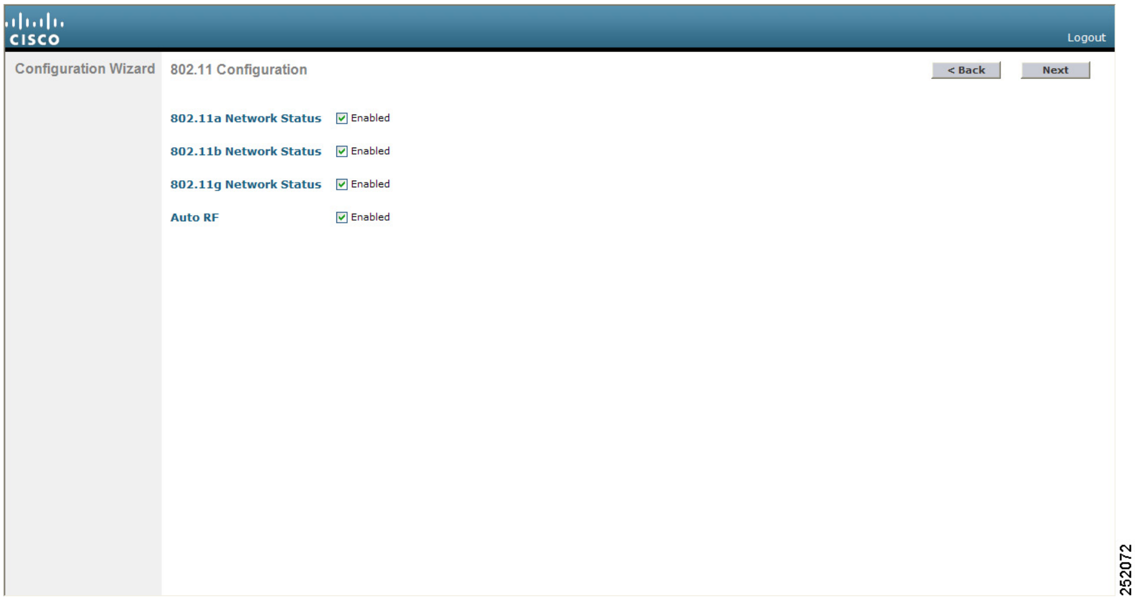
Step 41 In the Shared Secret and Confirm Shared Secret fields, enter the secret key used by the RADIUS server.

Step 42 In the Port Number field, enter the communication port of the RADIUS server. The default value is 1812.

Step 43 To enable the RADIUS server, choose **Enabled** from the Server Status drop-down box. To disable the RADIUS server, leave this field set to **Disabled**.

Step 44 Click **Apply**. The 802.11 Configuration page appears (see Figure 10).

Figure 10 Configuration Wizard — 802.11 Configuration Page



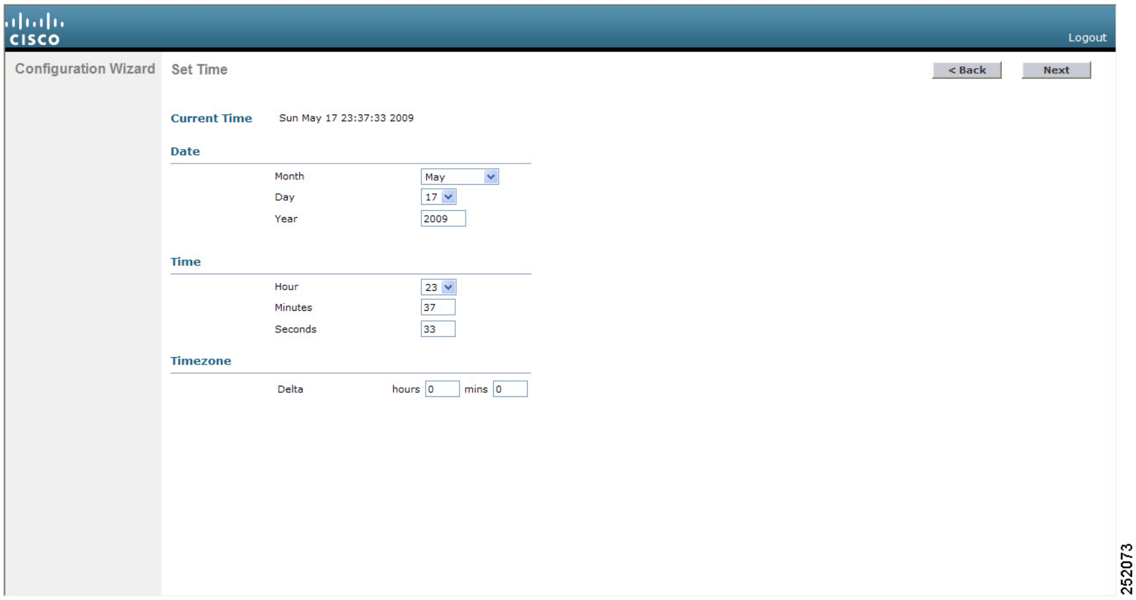
Step 45 To enable the 802.11a, 802.11b, and 802.11g lightweight access point networks, leave the **802.11a Network Status**, **802.11b Network Status**, and **802.11g Network Status** check boxes checked. To disable support for any of these networks, uncheck the check boxes.

Step 46 To enable the controller's radio resource management (RRM) auto-RF feature, leave the **Auto RF** check box checked. To disable support for the auto-RF feature, uncheck this check box. Refer to the *Configuring Radio Resource Management* chapter for more information on RRM.

Note The auto-RF feature enables the controller to automatically form an RF group with other controllers. The group dynamically elects a leader to optimize RRM parameter settings, such as channel and transmit power assignment, for the group.

Step 47 Click **Next**. The Set Time page appears (see Figure 11).

Figure 11 Configuration Wizard — Set Time Page



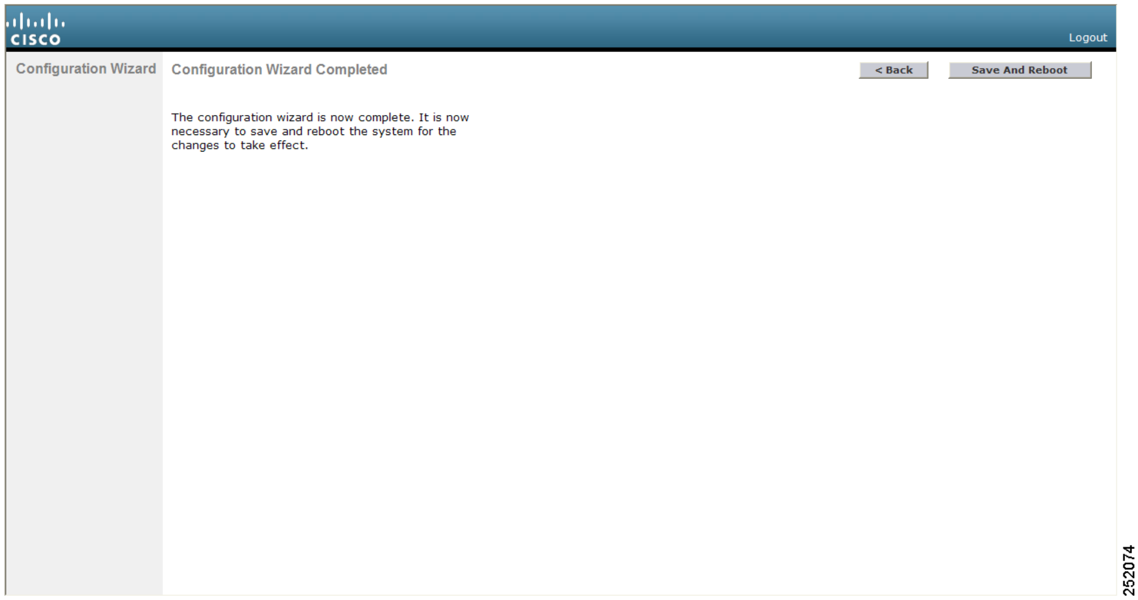
Step 48 To manually configure the system time on your controller, enter the current date in Month/DD/YYYY format and the current time in HH:MM:SS format.

Step 49 To manually set the time zone so that Daylight Saving Time (DST) is not set automatically, enter the local hour difference from Greenwich Mean Time (GMT) in the Delta Hours field and the local minute difference from GMT in the Delta Mins field.

Note When manually setting the time zone, enter the time difference of the local current time zone with respect to GMT (+/–). For example, Pacific time in the United States is 8 hours behind GMT. Therefore, it is entered as –8.

Step 50 Click **Next**. The Configuration Wizard Completed page appears (see Figure 12).

Figure 12 Configuration Wizard — Configuration Wizard Completed Page



Step 51 Click **Save and Reboot** to save your configuration and reboot the controller.

Step 52 When the following message appears, click **OK**:

```
Configuration will be saved and the controller will be rebooted. Click ok to confirm.
```

Step 53 The controller saves your configuration, reboots, and prompts you to log in. Follow the instructions in the "Using the GUI" section on page 16 to log into the controller.

Using the CLI Configuration Wizard

Note The available options appear in brackets after each configuration parameter. The default value appears in all uppercase letters.

Note If you enter an incorrect response, the controller provides you with an appropriate error message, such as "Invalid Response," and returns you to the wizard prompt.

Note Press the hyphen key if you ever need to return to the previous command line.

Follow these steps to configure the controller using the CLI configuration wizard.

Step 1 When prompted to terminate the AutoInstall process, enter **yes**. If you do not enter **yes**, the AutoInstall process begins after 30 seconds.

> **Note** The AutoInstall feature downloads a configuration file from a TFTP server and then loads the configuration onto the controller automatically. Refer to the "Using the AutoInstall Feature for Controllers Without a Configuration" section on page 26 for more information.

> **Note** The Cisco WiSM controllers do not support the AutoInstall feature.

Step 2 Enter the system name, which is the name you want to assign to the controller. You can enter up to 31 ASCII characters.

Step 3 Enter the administrative username and password to be assigned to this controller. You can enter up to 24 ASCII characters for each. The default administrative username and password are *admin* and *admin*, respectively.

Step 4 If you want the controller's service-port interface to obtain an IP address from a DHCP server, enter **DHCP**. If you do not want to use the service port or if you want to assign a static IP address to the service port, enter **none**.

> **Note** The service-port interface controls communications through the service port. Its IP address must be on a different subnet from the management interface. This configuration enables you to manage the controller directly or through a dedicated management network to ensure service access during network downtime.

Step 5 If you entered **none** in Step 4, enter the IP address and netmask for the service-port interface on the next two lines.

Step 6 Enable or disable link aggregation (LAG) by choosing **yes** or **NO**. Refer to the *Configuring Ports and Interfaces* chapter for more information on LAG.

Step 7 Enter the IP address of the management interface.

> **Note** The management interface is the default interface for in-band management of the controller and connectivity to enterprise services such as AAA servers.

Step 8 Enter the IP address of the management interface netmask.

Step 9 Enter the IP address of the default router.

Step 10 Enter the VLAN identifier of the management interface (either a valid VLAN identifier or **0** for an untagged VLAN). The VLAN identifier should be set to match the switch interface configuration.

Step 11 Enter the IP address of the default DHCP server that will supply IP addresses to clients, the controller's management interface, and optionally the service port interface.

Step 12 Enter the IP address of the AP-manager interface.

> **Note** This prompt does not appear for 5500 series controllers because you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default.

Step 13 Enter the IP address of the controller's virtual interface. You should enter a fictitious, unassigned IP address.

> **Note** The virtual interface is used to support mobility management, DHCP relay, and embedded Layer 3 security such as guest web authentication and VPN termination. All controllers within a mobility group must be configured with the same virtual interface IP address.

Step 14 If desired, enter the name of the mobility group/RF group to which you want the controller to belong.

> **Note** Although the name that you enter here is assigned to both the mobility group and the RF group, these groups are not identical. Both groups define clusters of controllers, but they have different purposes. All of the controllers in an RF group are usually also in the same mobility group and vice versa. However, a mobility group facilitates scalable, system-wide mobility and controller redundancy while an RF group facilitates scalable, system-wide dynamic RF management. See the *Configuring Radio Resource Management* and *Configuring Mobility Groups* chapters for more information.

Step 15 Enter the network name, or service set identifier (SSID). The SSID enables basic functionality of the controller and allows access points that have joined the controller to enable their radios.

Step 16 Enter **YES** to allow clients to assign their own IP address or **no** to require clients to request an IP address from a DHCP server.

Step 17 To configure a RADIUS server now, enter **YES** and then enter the IP address, communication port, and secret key of the RADIUS server. Otherwise, enter **no**. If you enter no, the following message appears: "Warning! The default WLAN security policy requires a RADIUS server. Please see documentation for more details."

Step 18 Enter the code for the country in which the controller will be used.

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

> **Note** You can enter more than one country code if you want to manage access points in multiple countries from a single controller. To do so, separate the country codes with a comma (for example, US,CA,MX). After the configuration wizard runs, you need to assign each access point joined to the controller to a specific country. See the "Configuring Country Codes" section on page 75 for instructions.

Step 19 Enable or disable the 802.11b, 802.11a, and 802.11g lightweight access point networks by entering **YES** or **no**.

Step 20 Enable or disable the controller's radio resource management (RRM) auto-RF feature by entering **YES** or **no**. Refer to the *Configuring Radio Resource Management* chapter for more information on RRM.

Note The auto-RF feature enables the controller to automatically form an RF group with other controllers. The group dynamically elects a leader to optimize RRM parameter settings, such as channel and transmit power assignment, for the group.

Step 21 If you want the controller to receive its time setting from an external Network Time Protocol (NTP) server when it powers up, enter **YES** to configure an NTP server. Otherwise, enter **no**.

Note The controller network module installed in a Cisco Integrated Services Router does not have a battery and cannot save a time setting. Therefore, it must receive a time setting from an external NTP server when it powers up.

Step 22 If you entered **no** in Step 21 and want to manually configure the system time on your controller now, enter **YES**. If you do not want to configure the system time now, enter **no**.

Step 23 If you entered **YES** in Step 22, enter the current date in MM/DD/YY format and the current time in HH:MM:SS format.

Step 24 When prompted to verify that the configuration is correct, enter **yes** or **NO**.

The controller saves your configuration, reboots, and prompts you to log in. Follow the instructions in the "Using the CLI" section on page 23 to log into the controller.

Using the GUI

A web-browser, or graphical user interface (GUI), is built into each controller. It allows up to five users to simultaneously browse into the controller HTTP or HTTPS (HTTP + SSL) management pages to configure parameters and monitor operational status for the controller and its associated access points.

Note Cisco recommends that you enable the HTTPS interface and disable the HTTP interface to ensure more robust security for your Cisco UWN Solution.

Guidelines for Using the GUI

Keep these guidelines in mind when using the GUI:

- The GUI must be used on a PC running Windows XP SP1 (or later) or Windows 2000 SP4 (or later).
- The GUI is fully compatible with Microsoft Internet Explorer version 6.0 SP1 (or later) or Mozilla Firefox 2.0.0.11 (or later).

  Note Opera and Netscape are not supported.

Note Internet Explorer 6.0 SP1 (or later) and Mozilla Firefox 2.0.0.11 (or later) are the only browsers supported for accessing the controller GUI and for using web authentication.

- You can use either the service port interface or the management interface to access the GUI. Cisco recommends that you use the service-port interface. Refer to the *Configuring Ports and Interfaces* chapter for instructions on configuring the service port interface.
- Click **Help** at the top of any page in the GUI to display online help. You might need to disable your browser's pop-up blocker to view the online help.

Logging into the GUI

Follow these steps to log into the controller GUI.

Step 1 Enter the controller IP address in your browser's address line. For a secure connection, enter **https://*ip-address***. For a less secure connection, enter **http://*ip-address***.

Note See the "Using the GUI to Enable Web and Secure Web Modes" section on page 18 for instructions on setting up HTTPS.

Step 2 When prompted, enter a valid username and password and click **OK**. The controller Summary page appears.

Note The administrative username and password that you created in the configuration wizard are case sensitive. The default username is *admin*, and the default password is *admin*.

Logging Out of the GUI

To logout out of the controller GUI, follow these steps:

Step 1 Click **Logout** in the top right corner of the screen.

Step 2 Click **Close** to complete the logoff process and prevent unauthorized users from accessing the controller GUI.

Step 3 When prompted to confirm your decision, click **Yes**.

Enabling Web and Secure Web Modes

This section provides instructions for enabling the distribution system port as a web port (using HTTP) or as a secure web port (using HTTPS). You can protect communication with the GUI by enabling HTTPS. HTTPS protects HTTP browser sessions by using the Secure Socket Layer (SSL) protocol. When you enable HTTPS, the controller generates its own local web administration SSL certificate and automatically applies it to the GUI. You also have the option of downloading an externally generated certificate.

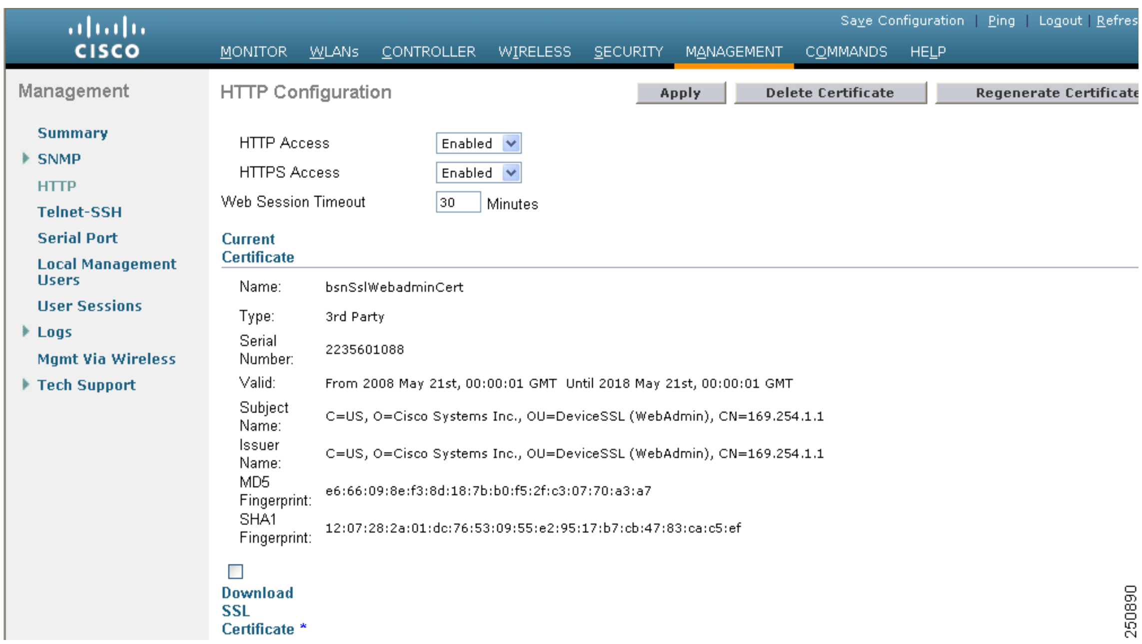
You can configure web and secure web mode using the controller GUI or CLI.

Using the GUI to Enable Web and Secure Web Modes

Follow these steps to enable web mode, secure web mode, or both using the controller GUI.

Step 1 Choose **Management** > **HTTP** to open the HTTP Configuration page (see Figure 13).

Figure 13 HTTP Configuration Page



Step 2 To enable web mode, which allows users to access the controller GUI using "http://*ip-address*," choose **Enabled** from the HTTP Access drop-down box. Otherwise, choose **Disabled**. The default value is Disabled. Web mode is not a secure connection.

Step 3 To enable secure web mode, which allows users to access the controller GUI using "https://*ip-address*," choose **Enabled** from the HTTPS Access drop-down box. Otherwise, choose **Disabled**. The default value is Enabled. Secure web mode is a secure connection.

Step 4 In the Web Session Timeout field, enter the amount of time (in minutes) before the web session times out due to inactivity. You can enter a value between 30 and 160 minutes (inclusive), and the default value is 30 minutes.

Step 5 Click **Apply** to commit your changes.

Step 6 If you enabled secure web mode in Step 3, the controller generates a local web administration SSL certificate and automatically applies it to the GUI. The details of the current certificate appear in the middle of the HTTP Configuration page (see Figure 13).

> **Note** If you want to download your own SSL certificate to the controller, follow the instructions in the "Loading an Externally Generated SSL Certificate" section on page 20.

> **Note** If desired, you can delete the current certificate by clicking **Delete Certificate** and have the controller generate a new certificate by clicking **Regenerate Certificate**.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Enable Web and Secure Web Modes

Follow these steps to enable web mode, secure web mode, or both using the controller CLI.

Step 1 To enable or disable web mode, enter this command:

config network webmode {**enable** | **disable**}

This command allows users to access the controller GUI using "http://*ip-address*." The default value is disabled. Web mode is not a secure connection.

Step 2 To enable or disable secure web mode, enter this command:

config network secureweb {**enable** | **disable**}

This command allows users to access the controller GUI using "https://*ip-address*." The default value is enabled. Secure web mode is a secure connection.

Step 3 To enable or disable secure web mode with increased security, enter this command:

config network secureweb cipher-option high {**enable** | **disable**}

This command allows users to access the controller GUI using "https://*ip-address*" but only from browsers that support 128-bit (or larger) ciphers. The default value is disabled.

Step 4 To enable or disable SSLv2 for web administration, enter this command:

config network secureweb cipher-option sslv2 {**enable** | **disable**}

If you disable SSLv2, users cannot connect using a browser configured with SSLv2 only. They must use a browser that is configured to use a more secure protocol such as SSLv3 or later. The default value is enabled.

Step 5 To verify that the controller has generated a certificate, enter this command:

show certificate summary

Information similar to the following appears:

```
Web Administration Certificate................. Locally Generated
Web Authentication Certificate................. Locally Generated
Certificate compatibility mode:................ off
```

Note If you want to download your own SSL certificate to the controller, follow the instructions in the "Loading an Externally Generated SSL Certificate" section on page 20.

Step 6 (Optional) If you need to generate a new certificate, enter this command:

config certificate generate webadmin

After a few seconds, the controller verifies that the certificate has been generated.

Step 7 To save the SSL certificate, key, and secure web password to non-volatile RAM (NVRAM) so that your changes are retained across reboots, enter this command:

save config

Step 8 To reboot the controller, enter this command:

reset system

Loading an Externally Generated SSL Certificate

You can use a TFTP server to download an externally generated SSL certificate to the controller. Follow these guidelines for using TFTP:

- If you load the certificate through the service port, the TFTP server must be on the same subnet as the controller because the service port is not routable, or you must create static routes on the controller. Also, if you load the certificate through the distribution system network port, the TFTP server can be on any subnet.
- A third-party TFTP server cannot run on the same PC as the Cisco WCS because the WCS built-in TFTP server and the third-party TFTP server require the same communication port.

Note Chained certificates are supported for web authentication only and not for the management certificate.

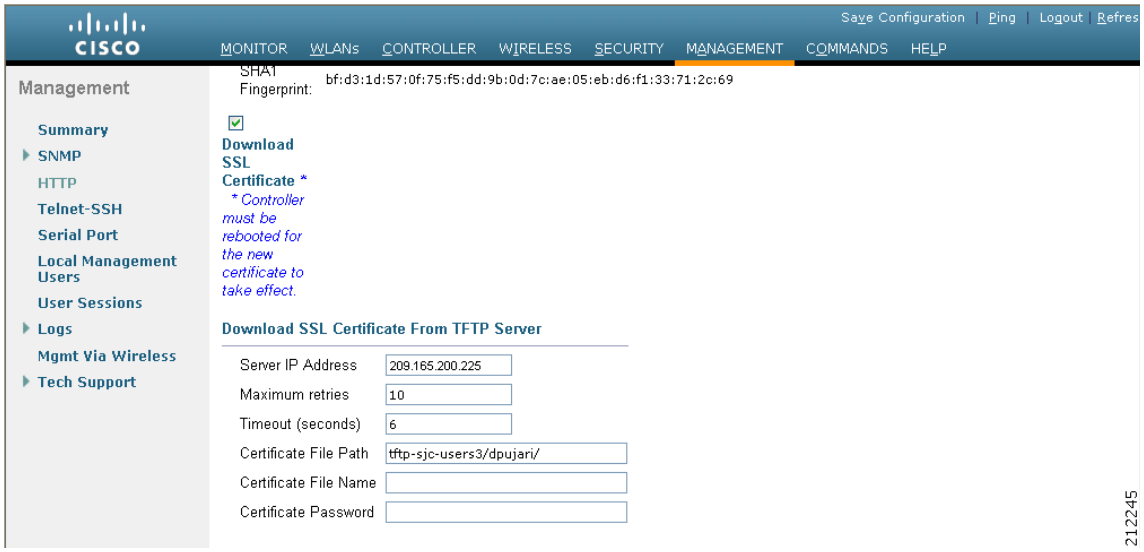
Note Every HTTPS certificate contains an embedded RSA key. The length of the key can vary from 512 bits, which is relatively insecure, to thousands of bits, which is very secure. When you obtain a new certificate from a Certificate Authority, make sure that the RSA key embedded in the certificate is at least 768 bits long.

Using the GUI to Load an SSL Certificate

Follow these steps to load an externally generated SSL certificate using the controller GUI.

Step 1 On the HTTP Configuration page, check the **Download SSL Certificate** check box (see Figure 14).

Figure 14 HTTP Configuration Page



Step 2 In the Server IP Address field, enter the IP address of the TFTP server.

Step 3 In the Maximum Retries field, enter the maximum number of times that the TFTP server attempts to download the certificate.

Step 4 In the Timeout field, enter the amount of time (in seconds) that the TFTP server attempts to download the certificate.

Step 5 In the Certificate File Path field, enter the directory path of the certificate.

Step 6 In the Certificate File Name field, enter the name of the certificate (*webadmincert_name*.pem).

Step 7 (Optional) In the Certificate Password field, enter a password to encrypt the certificate.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Step 10 To reboot the controller for your changes to take effect, choose **Commands** > **Reboot** > **Reboot** > **Save and Reboot**.

Using the CLI to Load an SSL Certificate

Follow these steps to load an externally generated SSL certificate using the controller CLI.

Step 1 Use a password to encrypt the HTTPS certificate in a .PEM-encoded file. The PEM-encoded file is called a web administration certificate file (*webadmincert_name*.pem).

Step 2 Move the *webadmincert_name*.pem file to the default directory on your TFTP server.

Step 3 To view the current download settings, enter this command and answer **n** to the prompt:

transfer download start

Information similar to the following appears:

```
Mode........................................... TFTP
Data Type...................................... Admin Cert
TFTP Server IP................................. xxx.xxx.xxx.xxx
TFTP Path...................................... <directory path>
TFTP Filename..................................
Are you sure you want to start? (y/n) n
Transfer Canceled
```

Step 4 Use these commands to change the download settings:

transfer download mode tftp

transfer download datatype webauthcert

transfer download serverip *TFTP_server IP_address*

transfer download path *absolute_TFTP_server_path_to_the_update_file*

transfer download filename *webadmincert_name.pem*

Step 5 To set the password for the .PEM file so that the operating system can decrypt the web administration SSL key and certificate, enter this command:

transfer download certpassword *private_key_password*

Step 6 To confirm the current download settings and start the certificate and key download, enter this command and answer **y** to the prompt:

transfer download start

Information similar to the following appears:

```
Mode........................................... TFTP
Data Type...................................... Site Cert
TFTP Server IP................................. xxx.xxx.xxx.xxx
TFTP Path...................................... directory path
TFTP Filename.................................. webadmincert_name
Are you sure you want to start? (y/n) y
TFTP Webadmin cert transfer starting.
Certificate installed.
Please restart the switch (reset system) to use the new certificate.
```

Step 7 To save the SSL certificate, key, and secure web password to NVRAM so that your changes are retained across reboots, enter this command:

save config

Step 8 To reboot the controller, enter this command:

reset system

Using the CLI

A Cisco UWN Solution command line interface (CLI) is built into each controller. The CLI allows you to use a VT-100 terminal emulation program to locally or remotely configure, monitor, and control individual controllers and its associated lightweight access points. The CLI is a simple text-based, tree-structured interface that allows up to five users with Telnet-capable terminal emulation programs to access the controller.

Note Refer to the C*isco Wireless LAN Controller Command Reference* for information on specific commands.

Note If you want to input any strings from the XML configuration into CLI commands, you must enclose the strings in quotation marks.

Logging into the CLI

You access the controller CLI using one of two methods:

- A direct serial connection to the controller console port
- A remote console session over Ethernet through the pre-configured service port or the distribution system ports

Before you log into the CLI, configure your connectivity and environment variables based on the type of connection you use.

Using a Local Serial Connection

You need these items to connect to the serial port:

- A PC that is running a VT-100 terminal emulation program (such as HyperTerminal, ProComm, Minicom, or Tip)
- A null-modem serial cable

Follow these steps to log into the controller CLI through the serial port.

Step 1 Connect one end of a null-modem serial cable to the controller's console port and the other end to your PC's serial port.

Note On 5500 series controllers, you can use either the RJ-45 console port or the USB console port. If you use the USB console port, plug the 5-pin mini Type B connector into the controller's USB console port and the other end of the cable into the PC's USB Type A port. The first time that you connect a Windows PC to the USB console port, you are prompted to install the USB console driver. Follow the installation prompts to install the driver. The USB console driver maps to a COM port on your PC; you then need to map the terminal emulator application to the COM port.

Step 2 Start the PC's VT-100 terminal emulation program.

Step 3 Configure the terminal emulation program for these parameters:

- 9600 baud
- 8 data bits
- 1 stop bit
- No parity
- No hardware flow control

Note The controller serial port is set for a 9600 baud rate and a short timeout. If you would like to change either of these values, enter **config serial baudrate** *baudrate* and **config serial timeout** *timeout* to make your changes. If you enter **config serial timeout 0**, serial sessions never time out.

Step 4 When prompted, enter a valid username and password to log into the controller. The administrative username and password that you created in the configuration wizard are case sensitive.

Note The default username is *admin*, and the default password is *admin*.

The CLI displays the root level system prompt:

```
#(system prompt)>
```

Note The system prompt can be any alphanumeric string up to 31 characters. You can change it by entering the **config prompt** command.

Using a Remote Ethernet Connection

You need these items to connect to a controller remotely:

- A PC with access to the controller over the Ethernet network
- The IP address of the controller
- A VT-100 terminal emulation program or a DOS shell for the Telnet session

Note By default, controllers block Telnet sessions. You must use a local connection to the serial port to enable Telnet sessions. See the "Configuring Telnet and SSH Sessions" section on page 34 for information on enabling Telnet sessions.

Follow these steps to log into the controller CLI through a remote Ethernet connection.

Step 1 Verify that your VT-100 terminal emulation program or DOS shell interface is configured with these parameters:

- Ethernet address
- Port 23

Step 2 Use the controller IP address to Telnet to the CLI.

Step 3 When prompted, enter a valid username and password to log into the controller. The administrative username and password that you created in the configuration wizard are case sensitive.

Note The default username is *admin*, and the default password is *admin*.

The CLI displays the root level system prompt:

```
#(system prompt)>
```

Note The system prompt can be any alphanumeric string up to 31 characters. You can change it by entering the **config prompt** command.

Logging Out of the CLI

When you finish using the CLI, navigate to the root level and enter **logout**. The system prompts you to save any changes you made to the volatile RAM.

Note The CLI automatically logs you out without saving any changes after 5 minutes of inactivity. You can set the automatic logout from 0 (never log out) to 160 minutes using the **config serial timeout** command.

Navigating the CLI

The CLI is organized around five levels:

Root Level

Level 2

Level 3

Level 4

Level 5

When you log into the CLI, you are at the root level. From the root level, you can enter any full command without first navigating to the correct command level. Table 1 lists commands you use to navigate the CLI and to perform common tasks.

Table 1 Commands for CLI Navigation and Common Tasks

Command	Action
help	At the root level, view systemwide navigation commands
?	View commands available at the current level
command **?**	View parameters for a specific command
exit	Move down one level
Ctrl-Z	Return from any level to the root level
save config	At the root level, save configuration changes from active working RAM to non-volatile RAM (NVRAM) so they are retained after reboot
reset system	At the root level, reset the controller without logging out

Using the AutoInstall Feature for Controllers Without a Configuration

When you boot up a controller that does not have a configuration, the AutoInstall feature can download a configuration file from a TFTP server and then load the configuration onto the controller automatically.

Note The Cisco WiSM controllers do not support the AutoInstall feature.

Overview of AutoInstall

If you create a configuration file on a controller that is already on the network (or through a WCS filter), place that configuration file on a TFTP server, and configure a DHCP server so that a new controller can get an IP address and TFTP server information, the AutoInstall feature can obtain the configuration file for the new controller automatically.

When the controller boots, the AutoInstall process starts. The controller does not take any action until AutoInstall is notified that the configuration wizard has started. If the wizard has not started, the controller has a valid configuration.

If AutoInstall is notified that the configuration wizard has started (which means that the controller does not have a configuration), AutoInstall waits for an additional 30 seconds. This time period gives you an opportunity to respond to the first prompt from the configuration wizard:

```
Would you like to terminate autoinstall? [yes]:
```

When the 30-second abort timeout expires, AutoInstall starts the DHCP client. You can abort the AutoInstall task even after this 30-second timeout if you enter **Yes** at the prompt. However, AutoInstall cannot be aborted if the TFTP task has locked the flash and is in the process of downloading and installing a valid configuration file.

Obtaining an IP Address Through DHCP and Downloading a Configuration File from a TFTP Server

AutoInstall uses the following interfaces:

- 5500 and 4400 series controllers
  - eth0—Service port (untagged)
  - dtl0—Gigabit port 1 through the NPU (untagged)
- 2100 series controllers
  - dtl0—FastEthernet port 1 (untagged)

AutoInstall attempts to obtain an IP address from the DHCP server until the DHCP process is successful or until you abort the AutoInstall process. The first interface to successfully obtain an IP address from the DHCP server registers with the AutoInstall task. The registration of this interface causes AutoInstall to begin the process of obtaining TFTP server information and downloading the configuration file.

Following the acquisition of the DHCP IP address for an interface, AutoInstall begins a short sequence of events to determine the host name of the controller and the IP address of the TFTP server. Each phase of this sequence gives preference to explicitly configured information over default or implied information and to explicit host names over explicit IP addresses.

The process is as follows:

- If at least one Domain Name System (DNS) server IP address is learned through DHCP, AutoInstall creates a /etc/resolv.conf file. This file includes the domain name and the list of DNS servers that have been received. The Domain Name Server option provides the list of DNS servers, and the Domain Name option provides the domain name.
- If the domain servers are not on the same subnet as the controller, static route entries are installed for each domain server. These static routes point to the gateway that is learned through the DHCP Router option.
- The host name of the controller is determined in this order by one of the following:
  - If the DHCP Host Name option was received, this information (truncated at the first period [.]) is used as the host name for the controller.
  - A reverse DNS lookup is performed on the controller IP address. If DNS returns a host name, this name (truncated at the first period [.]) is used as the host name for the controller.
- The IP address of the TFTP server is determined in this order by one of the following:
  - If AutoInstall received the DHCP TFTP Server Name option, AutoInstall performs a DNS lookup on this server name. If the DNS lookup is successful, the returned IP address is used as the IP address of the TFTP server.
  - If the DHCP Server Host Name (sname) field is valid, AutoInstall performs a DNS lookup on this name. If the DNS lookup is successful, the IP address that is returned is used as the IP address of the TFTP server.
  - If AutoInstall received the DHCP TFTP Server Address option, this address is used as the IP address of the TFTP server.
  - AutoInstall performs a DNS lookup on the default TFTP server name (cisco-wlc-tftp). If the DNS lookup is successful, the IP address that is received is used as the IP address of the TFTP server.

- If the DHCP server IP address (siaddr) field is non-zero, this address is used as the IP address of the TFTP server.
- The limited broadcast address (255.255.255.255) is used as the IP address of the TFTP server.

- If the TFTP server is not on the same subnet as the controller, a static route (/32) is installed for the IP address of the TFTP server. This static route points to the gateway that is learned through the DHCP Router option.

Note For more information on configuring DHCP on a controller, see the "Configuring DHCP" section on page 9.

Note For more information on configuring a TFTP server on a controller, see the *Managing Controller Software and Configurations* chapter.

Note For more information on configuring DHCP and TFTP servers through WCS, see Chapter 10 of the *Cisco Wireless Control System Configuration Guide, Release 6.0.*

Selecting a Configuration File

After the host name and TFTP server have been determined, AutoInstall attempts to download a configuration file. AutoInstall performs three full download iterations on each interface that obtains a DHCP IP address. For example, if a 4400 series controller obtains DHCP IP addresses on both eth0 and dtl0, each interface tries to download a configuration. If the interface cannot download a configuration file successfully after three attempts, the interface does not attempt further.

The first configuration file that is downloaded and installed successfully triggers a reboot of the controller. After the reboot, the controller runs the newly downloaded configuration.

AutoInstall searches for configuration files in the order in which the names are listed:

- The filename that is provided by the DHCP Boot File Name option
- The filename that is provided by the DHCP File field
- *host name*-confg
- *host name*.cfg
- *base MAC address*-confg (for example, 0011.2233.4455-confg)
- *serial number*-confg
- ciscowlc-confg
- ciscowlc.cfg

AutoInstall runs through this list until it finds a configuration file. It stops running if it does not find a configuration file after it cycles through this list three times on each registered interface.

Note The downloaded configuration file can be a complete configuration, or it can be a minimal configuration that provides enough information for the controller to be managed by WCS. Full configuration can then be deployed directly from WCS.

Note For information about creating and uploading a configuration file that AutoInstall can obtain from a TFTP server, see the *Managing Controller Software and Configurations* chapter.

Note WCS release 5.0 or later provides AutoInstall capabilities for controllers. A WCS administrator can create a filter that includes the host name, the MAC address, or the serial number of the controller and associate a group of templates (a configuration group) to this filter rule. WCS pushes the initial configuration to the controller when the controller boots up initially. After the controller is discovered, WCS pushes the templates that are defined in the configuration group. For more information about the AutoInstall feature and WCS, see Chapter 15 of the *Cisco Wireless Control System Configuration Guide, Release 6.0*.

Example of AutoInstall Operation

The following is an example of an AutoInstall process from start to finish:

```
Welcome to the Cisco Wizard Configuration Tool
Use the '-' character to backup
Would you like to terminate autoinstall? [yes]:
AUTO-INSTALL: starting now...
AUTO-INSTALL: interface 'service-port' - setting DHCP TFTP Filename ==> 'abcd-confg'
AUTO-INSTALL: interface 'service-port' - setting DHCP TFTP Server IP ==> 1.100.108.2
AUTO-INSTALL: interface 'service-port' - setting DHCP siaddr ==> 1.100.108.2
AUTO-INSTALL: interface 'service-port' - setting DHCP Domain Server[0] ==> 1.100.108.2
AUTO-INSTALL: interface 'service-port' - setting DHCP Domain Name ==> 'engtest.com'
AUTO-INSTALL: interface 'service-port' - setting DHCP yiaddr ==> 172.19.29.253
AUTO-INSTALL: interface 'service-port' - setting DHCP Netmask ==> 255.255.255.0
AUTO-INSTALL: interface 'service-port' - setting DHCP Gateway ==> 172.19.29.1
AUTO-INSTALL: interface 'service-port' registered
AUTO-INSTALL: interation 1 -- interface 'service-port'
AUTO-INSTALL: DNS reverse lookup 172.19.29.253 ===> 'wlc-1'
AUTO-INSTALL: hostname 'wlc-1'
AUTO-INSTALL: TFTP server 1.100.108.2 (from DHCP Option 150)
AUTO-INSTALL: attempting download of 'abcd-confg'
AUTO-INSTALL: TFTP status - 'TFTP Config transfer starting.' (2)
AUTO-INSTALL: interface 'management' - setting DHCP file ==> 'bootfile1'
AUTO-INSTALL: interface 'management' - setting DHCP TFTP Filename ==> 'bootfile2-confg'
AUTO-INSTALL: interface 'management' - setting DHCP siaddr ==> 1.100.108.2
AUTO-INSTALL: interface 'management' - setting DHCP Domain Server[0] ==> 1.100.108.2
AUTO-INSTALL: interface 'management' - setting DHCP Domain Server[1] ==> 1.100.108.3
AUTO-INSTALL: interface 'management' - setting DHCP Domain Server[2] ==> 1.100.108.4
AUTO-INSTALL: interface 'management' - setting DHCP Domain Name ==> 'engtest.com'
AUTO-INSTALL: interface 'management' - setting DHCP yiaddr ==> 1.100.108.238
AUTO-INSTALL: interface 'management' - setting DHCP Netmask ==> 255.255.254.0
AUTO-INSTALL: interface 'management' - setting DHCP Gateway ==> 1.100.108.1
AUTO-INSTALL: interface 'management' registered
AUTO-INSTALL: TFTP status - 'Config file transfer failed - Error from server: File not
found' (3)
AUTO-INSTALL: attempting download of 'wlc-1-confg'
AUTO-INSTALL: TFTP status - 'TFTP Config transfer starting.' (2)
AUTO-INSTALL: TFTP status - 'TFTP receive complete... updating configuration.' (2)
AUTO-INSTALL: TFTP status - 'TFTP receive complete... storing in flash.' (2)
AUTO-INSTALL: TFTP status - 'System being reset.' (2)
Resetting system
```

Managing the System Date and Time

If you did not configure the system date and time through the configuration wizard or if you want to change your configuration, you can follow the instructions in this section to configure the controller to obtain the date and time from a Network Time Protocol (NTP) server or to configure the date and time manually. Greenwich Mean Time (GMT) is used as the standard for setting the time zone on the controller.

Note Cisco Aironet lightweight access points might not connect to the controller if the date and time are not set properly. Set the current date and time on the controller before allowing the access points to connect to it.

Configuring an NTP Server to Obtain the Date and Time

Each NTP server IP address is added to the controller database. Each controller searches for an NTP server and obtains the current time upon reboot and at each user-defined polling interval (daily to weekly).

Use these commands to configure an NTP server to obtain the date and time:

1. To specify the NTP server for the controller, enter this command:

   config time ntp server *index ip_address*

2. To specify the polling interval (in seconds), enter this command:

   config time ntp *interval*

Configuring the Date and Time Manually

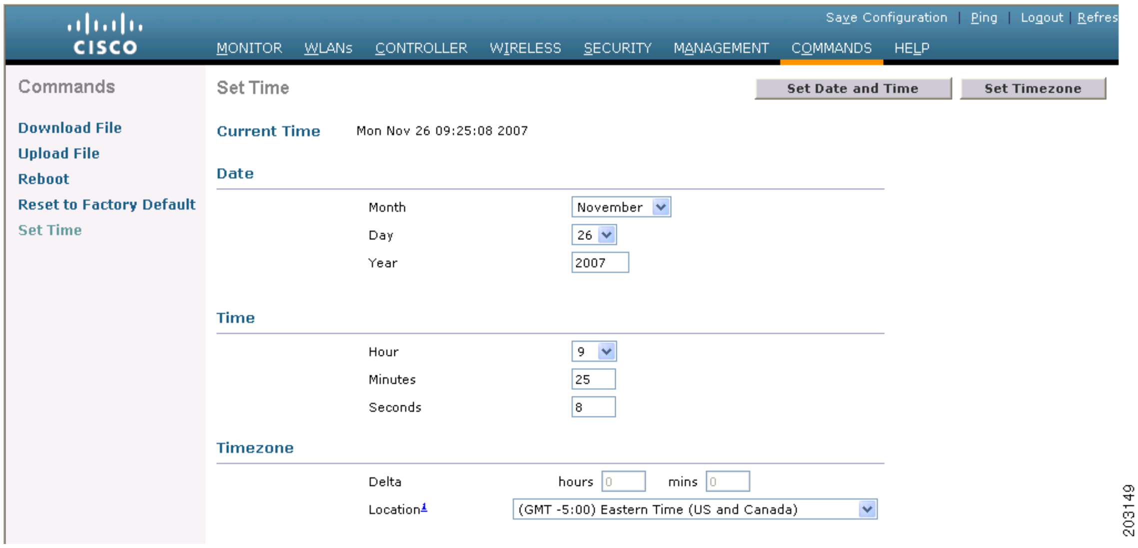
Follow the instructions in this section to configure the date and time manually using the controller GUI or CLI.

Using the GUI to Configure the Date and Time

Using the controller GUI, follow these steps to configure the local date and time.

Step 1 Choose **Commands** > **Set Time** to open the Set Time page (see Figure 15).

Figure 15 Set Time Page



The current date and time appear at the top of the page.

Step 2 In the Timezone section, choose your local time zone from the Location drop-down box.

Note When you choose a time zone that uses Daylight Saving Time (DST), the controller automatically sets its system clock to reflect the time change when DST occurs. In the United States, DST starts on the second Sunday in March and ends on the first Sunday in November.

Note You cannot set the time zone delta on the controller GUI. However, if you do so on the controller CLI, the change is reflected in the Delta Hours and Mins fields on the controller GUI.

Step 3 Click **Set Timezone** to apply your changes.

Step 4 In the Date section, choose the current local month and day from the Month and Day drop-down boxes, and enter the year in the Year field.

Step 5 In the Time section, choose the current local hour from the Hour drop-down box, and enter the minutes and seconds in the Minutes and Seconds fields.

Note If you change the time zone location after setting the date and time, the values in the Time section are updated to reflect the time in the new time zone location. For example, if the controller is currently configured for noon Eastern time and you change the time zone to Pacific time, the time automatically changes to 9:00 a.m.

Step 6 Click **Set Date and Time** to apply your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure the Date and Time

Using the controller CLI, follow these steps to configure the local date and time.

Step 1 To configure the current local date and time in GMT on the controller, enter this command:

config time manual *mm/dd/yy hh:mm:ss*

Note When setting the time, the current local time is entered in terms of GMT and as a value between 00:00 and 24:00. For example, if it is 8:00 a.m. Pacific time in the United States, you would enter 16:00 because the Pacific time zone is 8 hours behind GMT.

Step 2 Perform one of the following to set the time zone for the controller:

- To set the time zone location in order to have Daylight Saving Time (DST) set automatically when it occurs, enter this command:

  config time timezone location *location_index*

  where *location_index* is a number representing one of the following time zone locations:

  - 1. (GMT-12:00) International Date Line West
  - 2. (GMT-11:00) Samoa
  - 3. (GMT-10:00) Hawaii
  - 4. (GMT-9:00) Alaska
  - 5. (GMT-8:00) Pacific Time (US and Canada)
  - 6. (GMT-7:00) Mountain Time (US and Canada)
  - 7. (GMT-6:00) Central Time (US and Canada)
  - 8. (GMT-5:00) Eastern Time (US and Canada)
  - 9. (GMT-4:00) Atlantic Time (Canada)
  - 10. (GMT-3:00) Buenos Aires (Argentina)
  - 11. (GMT-2:00) Mid-Atlantic
  - 12. (GMT-1:00) Azores
  - 13. (GMT) London, Lisbon, Dublin, Edinburgh (default value)
  - 14. (GMT +1:00) Amsterdam, Berlin, Rome, Vienna
  - 15. (GMT +2:00) Jerusalem
  - 16. (GMT +3:00) Baghdad
  - 17. (GMT +4:00) Muscat, Abu Dhabi
  - 18. (GMT +4:30) Kabul
  - 19. (GMT +5:00) Karachi, Islamabad, Tashkent
  - 20. (GMT +5:30) Colombo, Kolkata, Mumbai, New Delhi
  - 21. (GMT +5:45) Katmandu
  - 22. (GMT +6:00) Almaty, Novosibirsk
  - 23. (GMT +6:30) Rangoon
  - 24. (GMT +7:00) Saigon, Hanoi, Bangkok, Jakatar

- 25. (GMT +8:00) Hong Kong, Bejing, Chongquing
- 26. (GMT +9:00) Tokyo, Osaka, Sapporo
- 27. (GMT +9:30) Darwin
- 28. (GMT+10:00) Sydney, Melbourne, Canberra
- 29. (GMT+11:00) Magadan, Solomon Is., New Caledonia
- 30. (GMT+12:00) Kamchatka, Marshall Is., Fiji

Note If you enter this command, the controller automatically sets its system clock to reflect DST when it occurs. In the United States, DST starts on the second Sunday in March and ends on the first Sunday in November.

- To manually set the time zone so that DST is not set automatically, enter this command:

  config time timezone *delta_hours delta_mins*

  where *delta_hours* is the local hour difference from GMT, and *delta_mins* is the local minute difference from GMT.

  When manually setting the time zone, enter the time difference of the local current time zone with respect to GMT (+/–). For example, Pacific time in the United States is 8 hours behind GMT. Therefore, it is entered as –8.

Note You can manually set the time zone and prevent DST from being set only on the controller CLI.

Step 3 To save your changes, enter this command:

save config

Step 4 To verify that the controller shows the current local time with respect to the local time zone, enter this command:

show time

Information similar to the following appears:

```
Time............................................ Mon Nov 26 10:25:33 2007

Timezone delta.................................. 0:0
Timezone location............................... (GMT -5:00) Eastern Time (US and Canada)

NTP Servers
    NTP Polling Interval........................ 86400

     Index              NTP Server
    -------  --------------------------------
       1              19.1.1.1
```

Note If you configured the time zone location, the Timezone Delta value is set to “0:0.” If you manually configured the time zone using the time zone delta, the Timezone Location is blank.

Configuring Telnet and SSH Sessions

Telnet is a network protocol used to provide access to the controller's CLI. Secure Shell (SSH) is a more secure version of Telnet that uses data encryption and a secure channel for data transfer. You can use the controller GUI or CLI to configure Telnet and SSH sessions.

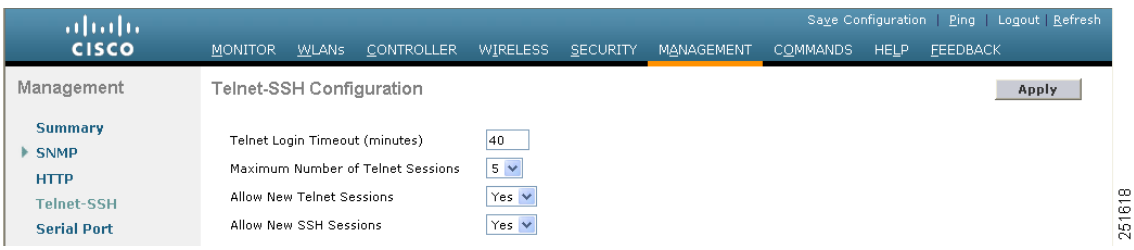
Note Refer to the "Troubleshooting Access Points Using Telnet or SSH" section on page 50 for instructions on using Telnet or SSH to troubleshoot lightweight access points.

Using the GUI to Configure Telnet and SSH Sessions

Using the controller GUI, follow these steps to configure Telnet and SSH sessions.

Step 1 Choose **Management** > **Telnet-SSH** to open the Telnet-SSH Configuration page (see Figure 16).

Figure 16 Telnet-SSH Configuration Page



Step 2 In the Telnet Login Timeout field, enter the number of minutes that a Telnet session is allowed to remain inactive before being terminated. The valid range is 0 to 160 minutes (inclusive), and the default value is 5 minutes. A value of 0 indicates no timeout.

Step 3 From the Maximum Number of Telnet Sessions drop-down box, choose the number of simultaneous Telnet sessions allowed. The valid range is 0 to 5 sessions (inclusive), and the default value is 5 sessions.

Step 4 From the Allow New Telnet Sessions drop-down box, choose **Yes** or **No** to allow or disallow new Telnet sessions on the controller. The default value is No.

Step 5 From the Allow New SSH Sessions drop-down box, choose **Yes** or **No** to allow or disallow new SSH sessions on the controller. The default value is Yes.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Step 8 To see a summary of the Telnet configuration settings, choose **Management** > **Summary**. The Summary page appears (see Figure 17).

Figure 17 Summary Page

This page shows whether additional Telnet and SSH sessions are permitted.

Using the CLI to Configure Telnet and SSH Sessions

Using the controller CLI, follow these steps to configure Telnet and SSH sessions.

Step 1 To allow or disallow new Telnet sessions on the controller, enter this command:

config network telnet {**enable** | **disable**}

The default value is disabled.

Step 2 To allow or disallow new SSH sessions on the controller, enter this command:

config network ssh {**enable** | **disable**}

The default value is enabled.

Step 3 To specify the number of minutes that a Telnet session is allowed to remain inactive before being terminated, enter this command:

config sessions timeout *timeout*

where *timeout* is a value between 0 and 160 minutes (inclusive). The default value is 5 minutes. A value of 0 indicates no timeout.

Step 4 To specify the number of simultaneous Telnet sessions allowed, enter this command:

config sessions maxsessions *session_num*

where *session_num* is a value between 0 and 5 (inclusive). The default value is 5 sessions.

Step 5 To save your changes, enter this command:

save config

Step 6 To see the Telnet and SSH configuration settings, enter this command:

show network summary

Information similar to the following appears:

```
RF-Network Name............................ TestNetwork1
Web Mode................................... Enable
Secure Web Mode............................ Enable
Secure Web Mode Cipher-Option High......... Disable
Secure Web Mode Cipher-Option SSLv2......... Enable
Secure Shell (ssh)......................... Enable
Telnet.................................. Disable
...
```

Step 7 To see the Telnet session configuration settings, enter this command:

show sessions

Information similar to the following appears:

```
CLI Login Timeout (minutes)............ 5
Maximum Number of CLI Sessions....... 5
```

Step 8 To see all active Telnet sessions, enter this command:

show loginsession

Information similar to the following appears:

```
ID    User Name     Connection From   Idle Time    Session Time
-- ---------------  ---------------  ------------  ------------
00     admin           EIA-232     00:00:00      00:19:04
```

Step 9 If you ever want to close all active Telnet sessions or a specific Telnet session, enter this command:

config loginsession close {**all** | *session_id*}

Enabling Wireless Connections to the GUI and CLI

You can monitor and configure controllers using a wireless client. This feature is supported for all management tasks except uploads from and downloads to the controller.

Before you can open the GUI or the CLI from a wireless client device, you must configure the controller to allow the connection. Follow these steps to enable wireless connections to the GUI or CLI.

Step 1 Log into the CLI.

Step 2 Enter **config network mgmt-via-wireless enable**.

Step 3 Use a wireless client to associate to a lightweight access point connected to the controller.

Step 4 On the wireless client, open a Telnet session to the controller, or browse to the controller GUI.

Tip To use the controller GUI to enable wireless connections, choose **Management** > **Mgmt Via Wireless** page and check the **Enable Controller Management to be accessible from Wireless Clients** check box.

Configuring Ports and Interfaces

This chapter describes the controller's physical ports and interfaces and provides instructions for configuring them. It contains these sections:

Overview of Ports and Interfaces

Three concepts are key to understanding how controllers connect to a wireless network: ports, interfaces, and WLANs.

Ports

A port is a physical entity that is used for connections on the controller platform. Controllers have two types of ports: distribution system ports and a service port. The following figures show the ports available on each controller.

Note The controller in a Cisco Integrated Services Router and the controllers on the Cisco WiSM do not have external physical ports. They connect to the network through ports on the router or switch.

Figure 3-1 Ports on the Cisco 2100 Series Wireless LAN Controllers

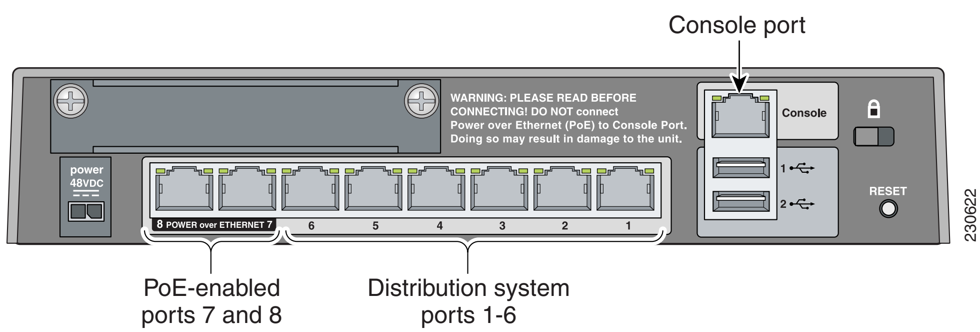
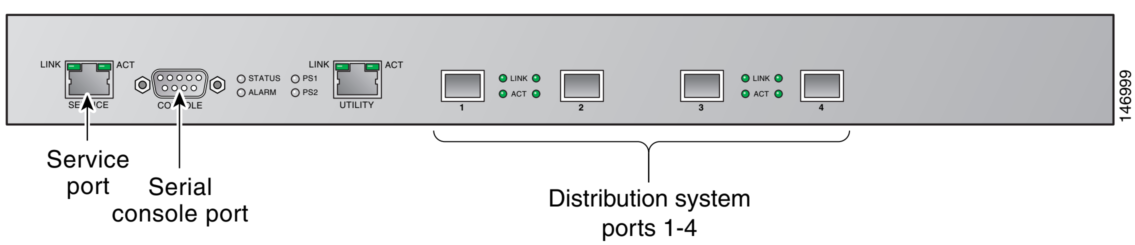
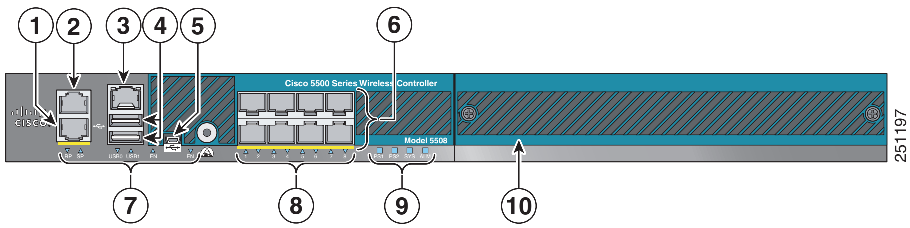


Figure 3-2 Ports on the Cisco 4400 Series Wireless LAN Controllers



Note Figure 3-2 shows a Cisco 4404 controller. The Cisco 4402 controller is similar but has only two distribution system ports. The utility port, which is the unlabeled port in Figure 3-2, is currently not operational.

Figure 3 Ports on the Cisco 5500 Series Wireless LAN Controllers



1	Redundant port for future use (RJ-45)	**6**	SFP distribution system ports 1-8
2	Service port (RJ-45)	**7**	Management port LEDs
3	Console port (RJ-45)[1]	**8**	SFP distribution port Link and Activity LEDs
4	USB ports 0 and 1 (Type A)	**9**	Power supply (PS1 and PS2), System (SYS), and Alarm (ALM) LEDs
5	Console port (Mini USB Type B)[1]	**10**	Expansion module slot

1. You can use only one console port (either RJ-45 or mini USB). When you connect to one console port, the other is disabled.

Figure 3-4 Ports on the Catalyst 3750G Integrated Wireless LAN Controller Switch

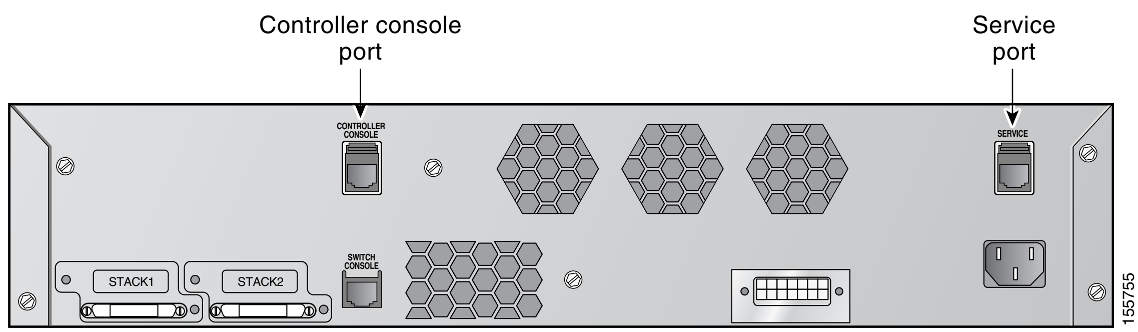


Table 3-1 provides a list of ports per controller.

Table 3-1 Controller Ports

Controller	Service Ports	Distribution System Ethernet Ports	Serial Console Port
2100 series	None	8 (6 + 2 PoE ports)	1
4402	1	2	1
4404	1	4	1
5508	1	8 (ports 1-8)	1
Cisco WiSM	2 (ports 9 and 10)	8 (ports 1-8)	2
Controller Network Module within the Cisco 28/37/38xx Series Integrated Services Routers	None	1	1[1]
Catalyst 3750G Integrated Wireless LAN Controller Switch	1	2 (ports 27 and 28)	1

1. The baud rate for the Gigabit Ethernet version of the controller network module is limited to 9600 bps while the baud rate for the Fast Ethernet version supports up to 57600 bps.

Note *Appendix E, Logical Connectivity Diagrams* provides logical connectivity diagrams and related software commands for the integrated controllers.

Distribution System Ports

A distribution system port connects the controller to a neighbor switch and serves as the data path between these two devices.

- Cisco 2100 series controllers have eight 10/100 copper Ethernet distribution system ports through which the controller can support up to 6, 12, or 25 access points. Two of these ports (7 and 8) are power-over-Ethernet (PoE) enabled and can be used to provide power directly to access points that are connected to these ports.

  Note All client connections to the 2100 series controllers are limited to the 10/100 Ethernet uplink port connection between the switch and the controller, even though their connection speeds might be higher. The exception is for access points running in local hybrid-REAP mode because this traffic is switched at the access point level and not forwarded back to the controller.

- Cisco 4402 controllers have two Gigabit Ethernet distribution system ports, each of which is capable of managing up to 48 access points. However, Cisco recommends no more than 25 access points per port due to bandwidth constraints. The 4402-25 and 4402-50 models allow a total of 25 or 50 access points to join the controller.

- Cisco 4404 controllers have four Gigabit Ethernet distribution system ports, each of which is capable of managing up to 48 access points. However, Cisco recommends no more than 25 access points per port due to bandwidth constraints. The 4404-25, 4404-50, and 4404-100 models allow a total of 25, 50, or 100 access points to join the controller.

Note The Gigabit Ethernet ports on the 4402 and 4404 controllers accept these SX/LC/T small form-factor plug-in (SFP) modules:
- 1000BASE-SX SFP modules, which provide a 1000-Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector
- 1000BASE-LX SFP modules, which provide a 1000-Mbps wired connection to a network through a 1300nM (LX/LH) fiber-optic link using an LC physical connector
- 1000BASE-T SFP modules, which provide a 1000-Mbps wired connection to a network through a copper link using an RJ-45 physical connector

- Cisco 5508 controllers have eight Gigabit Ethernet distribution system ports, through which the controller can manage multiple access points. The 5508-12, 5508-25, 5508-50, 5508-100, and 5508-250 models allow a total of 12, 25, 50, 100, or 250 access points to join the controller. Cisco 5508 controllers have no restrictions on the number of access points per port. However, Cisco recommends using link aggregation (LAG) or configuring dynamic AP-manager interfaces on each Gigabit Ethernet port to automatically balance the load. If more than 100 access points are connected to the 5500 series controller, make sure that more than one gigabit Ethernet interface is connected to the upstream switch.

Note The Gigabit Ethernet ports on the 5508 controllers accept these SX/LC/T small form-factor plug-in (SFP) modules:
- 1000BASE-SX SFP modules, which provide a 1000-Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector
- 1000BASE-LX SFP modules, which provide a 1000-Mbps wired connection to a network through a 1300nM (LX/LH) fiber-optic link using an LC physical connector
- 1000BASE-T SFP modules, which provide a 1000-Mbps wired connection to a network through a copper link using an RJ-45 physical connector

- The Cisco Catalyst 6500 Series Switch Wireless Services Module (WiSM) and the Cisco 7600 Series Router Wireless Services Module (WiSM) have eight internal Gigabit Ethernet distribution system ports (ports 1 through 8) that connect the switch or router and the integrated controller. These internal ports are located on the backplane of the switch or router and are not visible on the front panel. Through these ports, the controller can support up to 300 access points.
- The controller network module within the Cisco 28/37/38xx Series Integrated Services Router can support up to 6, 8, 12, or 25 access points (and up to 256, 256, 350, or 350 clients, respectively), depending on the version of the network module. The network module supports these access points through a Fast Ethernet distribution system port (on the NM-AIR-WLC6-K9 6-access-point version) or a Gigabit Ethernet distribution system port (on the 8-, 12-, and 25-access-point versions and on the NME-AIR-WLC6-K9 6-access-point version) that connects the router and the integrated controller. This port is located on the router backplane and is not visible on the front panel. The Fast Ethernet port operates at speeds up to 100 Mbps, and the Gigabit Ethernet port operates at speeds up to 1 Gbps.
- The Catalyst 3750G Integrated Wireless LAN Controller Switch has two internal Gigabit Ethernet distribution system ports (ports 27 and 28) that connect the switch and the integrated controller. These internal ports are located on the switch backplane and are not visible on the front panel. Each

port is capable of managing up to 48 access points. However, Cisco recommends no more than 25 access points per port due to bandwidth constraints. The -S25 and -S50 models allow a total of 25 or 50 access points to join the controller.

Note Refer to the "Choosing Between Link Aggregation and Multiple AP-Manager Interfaces" section on page 3-34 if you want to configure your Cisco 4400 series controller to support more than 48 access points.

Each distribution system port is, by default, an 802.1Q VLAN trunk port. The VLAN trunking characteristics of the port are not configurable.

Note Some controllers support link aggregation (LAG), which bundles all of the controller's distribution system ports into a single 802.3ad port channel. Cisco 4400 series controllers support LAG in software release 3.2 or later, Cisco 5500 series controllers support LAG in software release 6.0 or later, and LAG is enabled automatically on the controllers within the Cisco WiSM and the Catalyst 3750G Integrated Wireless LAN Controller Switch. Refer to the "Enabling Link Aggregation" section on page 3-35 for more information.

Service Port

Cisco 4400 and 5500 series controllers also have a 10/100 copper Ethernet service port. The service port is controlled by the service-port interface and is reserved for out-of-band management of the controller and system recovery and maintenance in the event of a network failure. It is also the only port that is active when the controller is in boot mode. The service port is not capable of carrying 802.1Q tags, so it must be connected to an access port on the neighbor switch. Use of the service port is optional.

Note The Cisco WiSM's controllers use the service port for internal protocol communication between the controllers and the Supervisor 720.

Note The Cisco 2100 series controllers and the controller in the Cisco Integrated Services Router do not have a service port.

Note The service port is not auto-sensing. You must use the correct straight-through or crossover Ethernet cable to communicate with the service port.

Caution Do not configure wired clients in the same VLAN or subnet of the service port on the network.

Interfaces

An interface is a logical entity on the controller. An interface has multiple parameters associated with it, including an IP address, default-gateway (for the IP subnet), primary physical port, secondary physical port, VLAN identifier, and DHCP server.

These five types of interfaces are available on the controller. Four of these are static and are configured at setup time:

- Management interface (Static and configured at setup time; mandatory)
- AP-manager interface (Static and configured at setup time; mandatory)

Note You are not required to configure an AP-manager interface on 5500 series controllers.

- Virtual interface (Static and configured at setup time; mandatory)
- Service-port interface (Static and configured at setup time; optional)
- Dynamic interface (User-defined)

Each interface is mapped to at least one primary port, and some interfaces (management and dynamic) can be mapped to an optional secondary (or backup) port. If the primary port for an interface fails, the interface automatically moves to the backup port. In addition, multiple interfaces can be mapped to a single controller port.

Note For 5500 series controllers in a non-link-aggregation (non-LAG) configuration, the management interface must be on a different VLAN than any dynamic AP-manager interface. Otherwise, the management interface cannot fail over to the port that the AP-manager is on.

Note Cisco 5500 series controllers do not support fragmented pings on any interface. Similarly, Cisco 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Integrated Wireless LAN Controller Switch do not support fragmented pings on the AP-manager interface.

Note Refer to the "Enabling Link Aggregation" section on page 3-35 if you want to configure the controller to dynamically map the interfaces to a single port channel rather than having to configure primary and secondary ports for each interface.

Management Interface

The management interface is the default interface for in-band management of the controller and connectivity to enterprise services such as AAA servers. It is also used for communications between the controller and access points. The management interface has the only consistently "pingable" in-band interface IP address on the controller. You can access the controller's GUI by entering the controller's management interface IP address in Internet Explorer's or Mozilla Firefox's Address field.

For CAPWAP, the controller requires one management interface to control all inter-controller communications and one AP-manager interface to control all controller-to-access point communications, regardless of the number of ports.

Note If the service port is in use, the management interface must be on a different supernet from the service-port interface.

Note Do not map a guest WLAN to the management interface. This is because if the EoIP tunnel breaks, the client could obtain an IP and be placed on the management subnet.

Caution Do not configure wired clients in the same VLAN or subnet of the service port on the network. If you configure wired clients on the same subnet or VLAN as the service port, you will not be able to access the management interface.

AP-Manager Interface

A controller has one or more AP-manager interfaces, which are used for all Layer 3 communications between the controller and lightweight access points after the access points have joined the controller. The AP-manager IP address is used as the tunnel source for CAPWAP packets from the controller to the access point and as the destination for CAPWAP packets from the access point to the controller.

Note For 5500 series controllers, you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default, and the access points can join on this interface.

The AP-manager interface communicates through any distribution system port by listening across the Layer 3 network for access point CAPWAP or LWAPP join messages to associate and communicate with as many lightweight access points as possible.

For 4404 and WiSM controllers, configure the AP-manager interface on all distribution system ports (1, 2, 3, and 4). For 4402 controllers, configure the AP-manager interface on distribution system ports 1 and 2. In both cases, the static (or permanent) AP-manager interface is always assigned to distribution system port 1 and given a unique IP address. Configuring the AP-manager interface on the same VLAN or IP subnet as the management interface results in optimum access point association, but this is not a requirement.

Note If only one distribution system port can be used, you should use distribution system port 1.

If link aggregation (LAG) is enabled, there can be only one AP-manager interface. But when LAG is disabled, one or more AP-manager interfaces can be created, generally one per physical port.

Note The 2100 series controllers do not support LAG.

Note Port redundancy for the AP-manager interface is not supported. You cannot map the AP-manager interface to a backup port.

Note Refer to the "Configuring Multiple AP-Manager Interfaces" section on page 3-39 for information on creating and using multiple AP-manager interfaces.

Virtual Interface

The virtual interface is used to support mobility management, Dynamic Host Configuration Protocol (DHCP) relay, and embedded Layer 3 security such as guest web authentication and VPN termination. It also maintains the DNS gateway host name used by Layer 3 security and mobility managers to verify the source of certificates when Layer 3 web authorization is enabled.

Specifically, the virtual interface plays these two primary roles:

- Acts as the DHCP server placeholder for wireless clients that obtain their IP address from a DHCP server.
- Serves as the redirect address for the web authentication login page.

Note See the *Configuring Security Solutions* chapter for additional information on web authentication.

The virtual interface IP address is used only in communications between the controller and wireless clients. It never appears as the source or destination address of a packet that goes out a distribution system port and onto the switched network. For the system to operate correctly, the virtual interface IP address must be set (it cannot be 0.0.0.0), and no other device on the network can have the same address as the virtual interface. Therefore, the virtual interface must be configured with an unassigned and unused gateway IP address. The virtual interface IP address is not pingable and should not exist in any routing table in your network. In addition, the virtual interface cannot be mapped to a backup port.

Note All controllers within a mobility group must be configured with the same virtual interface IP address. Otherwise, inter-controller roaming may appear to work, but the hand-off does not complete, and the client loses connectivity for a period of time.

Service-Port Interface

The service-port interface controls communications through and is statically mapped by the system to the service port. The service port can obtain an IP address using DHCP, or it can be assigned a static IP address, but a default gateway cannot be assigned to the service-port interface. Static routes can be defined through the controller for remote network access to the service port.

Note Only Cisco 4400 and 5500 series controllers have a service-port interface.

Note You must configure an IP address on the service-port interface of both Cisco WiSM controllers. Otherwise, the neighbor switch is unable to check the status of each controller.

Dynamic Interface

Dynamic interfaces, also known as VLAN interfaces, are created by users and designed to be analogous to VLANs for wireless LAN clients. A controller can support up to 512 dynamic interfaces (VLANs). Each dynamic interface is individually configured and allows separate communication streams to exist on any or all of a controller's distribution system ports. Each dynamic interface controls VLAN and other communications between controllers and all other network devices, and each acts as a DHCP relay for wireless clients associated to WLANs mapped to the interface. You can assign dynamic interfaces to distribution system ports, WLANs, the Layer 2 management interface, and the Layer 3 AP-manager interface, and you can map the dynamic interface to a backup port.

You can configure zero, one, or multiple dynamic interfaces on a distribution system port. However, all dynamic interfaces must be on a different VLAN or IP subnet from all other interfaces configured on the port. If the port is untagged, all dynamic interfaces must be on a different IP subnet from any other interface configured on the port.

Note A controller's WLAN dynamic interface and all wireless clients in the WLAN that are local to the controller must have IP addresses in the same subnet.

Note Cisco recommends using tagged VLANs for dynamic interfaces.

Dynamic AP Management

A dynamic interface is created as a WLAN interface by default. However, any dynamic interface can be configured as an AP-manager interface, with one AP-manager interface allowed per physical port. A dynamic interface with the Dynamic AP Management option enabled is used as the tunnel source for packets from the controller to the access point and as the destination for CAPWAP packets from the access point to the controller. The dynamic interfaces for AP management must have a unique IP address and are usually configured on the same subnet as the management interface.

Note If link aggregation (LAG) is enabled, there can be only one AP-manager interface.

Cisco recommends having a separate dynamic AP-manager interface per controller port. Refer to the "Configuring Multiple AP-Manager Interfaces" section on page 3-39 for instructions on configuring multiple dynamic AP-manager interfaces.

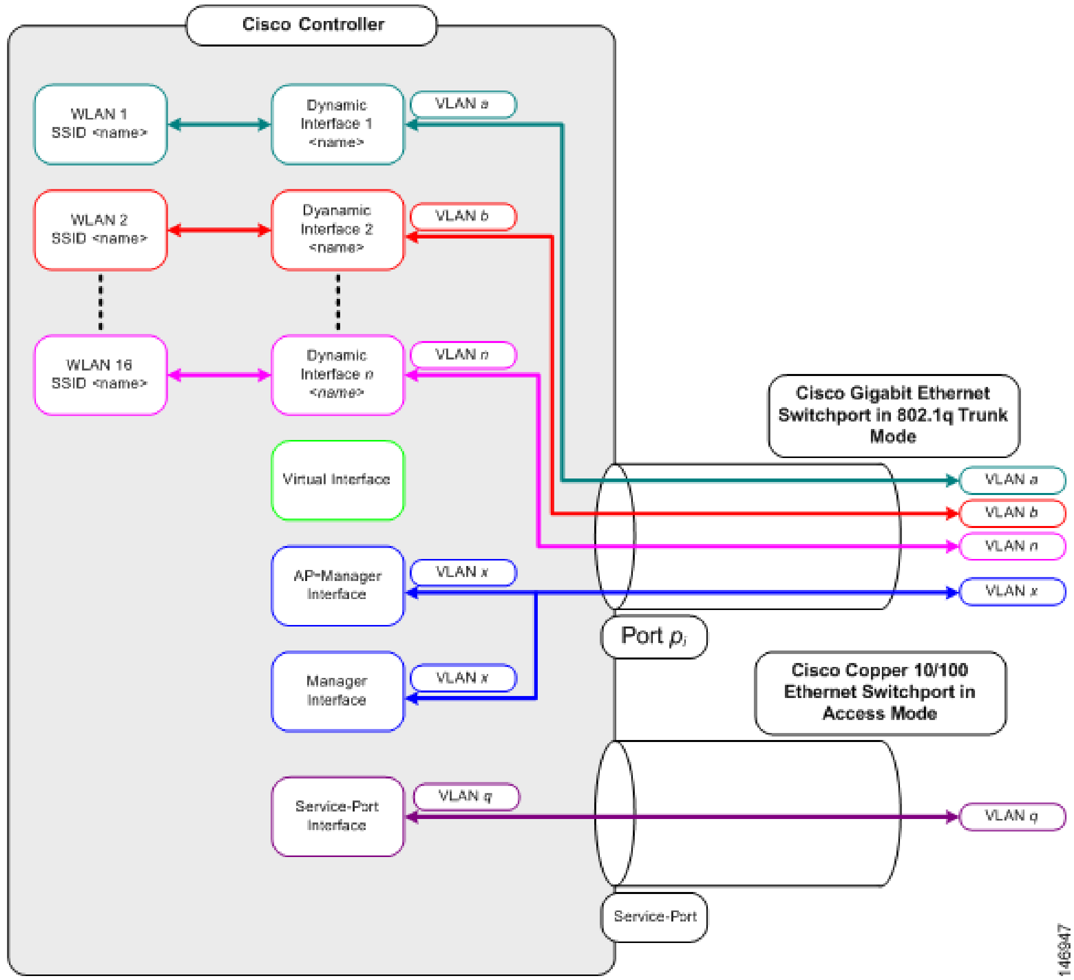
WLANs

A WLAN associates a service set identifier (SSID) to an interface. It is configured with security, quality of service (QoS), radio policies, and other wireless network parameters. Up to 512 access point WLANs can be configured per controller.

Note The *Configuring WLANs* chapter provides instructions for configuring WLANs.

Figure 3-5 illustrates the relationship between ports, interfaces, and WLANs.

Figure 3-5 Ports, Interfaces, and WLANs



As shown in Figure 3-5, each controller port connection is an 802.1Q trunk and should be configured as such on the neighbor switch. On Cisco switches, the native VLAN of an 802.1Q trunk is an untagged VLAN. Therefore, if you configure an interface to use the native VLAN on a neighboring Cisco switch, make sure you configure the interface on the controller to be untagged.

Note A zero value for the VLAN identifier (on the Controller > Interfaces page) means that the interface is untagged.

The default (untagged) native VLAN on Cisco switches is VLAN 1. When controller interfaces are configured as tagged (meaning that the VLAN identifier is set to a non-zero value), the VLAN must be allowed on the 802.1Q trunk configuration on the neighbor switch and not be the native untagged VLAN.

Cisco recommends that tagged VLANs be used on the controller. You should also allow only relevant VLANs on the neighbor switch's 802.1Q trunk connections to controller ports. All other VLANs should be disallowed or pruned in the switch port trunk configuration. This practice is extremely important for optimal performance of the controller.

Note Cisco recommends that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that controllers properly route VLAN traffic.

Follow the instructions on the pages indicated to configure your controller's interfaces and ports:

- Configuring the Management, AP-Manager, Virtual, and Service-Port Interfaces, page 3-12
- Configuring Dynamic Interfaces, page 3-18
- Configuring Ports, page 3-22
- Configuring the Management, AP-Manager, Virtual, and Service-Port Interfaces, page 3-12
- Choosing Between Link Aggregation and Multiple AP-Manager Interfaces, page 3-34
- Enabling Link Aggregation, page 3-35
- Configuring Multiple AP-Manager Interfaces, page 3-39

Configuring the Management, AP-Manager, Virtual, and Service-Port Interfaces

Typically, you define the management, AP-manager, virtual, and service-port interface parameters using the Startup Wizard. However, you can display and configure interface parameters through either the GUI or CLI after the controller is running.

Note When assigning a WLAN to a DHCP server, both should be on the same subnet. Otherwise, you need to use a router to route traffic between the WLAN and the DHCP server.

Using the GUI to Configure the Management, AP-Manager, Virtual, and Service-Port Interfaces

Follow these steps to display and configure the management, AP-manager, virtual, and service-port interface parameters using the GUI.

Step 1 Choose **Controller** > **Interfaces** to open the Interfaces page (see Figure 3-6).

Figure 3-6 Interfaces Page

This page shows the current controller interface settings.

Step 2 If you want to modify the settings of a particular interface, click the name of the interface. The Interfaces > Edit page for that interface appears.

Step 3 Configure the following parameters for each interface type:

Management Interface

Note The management interface uses the controller's factory-set distribution system MAC address.

- Quarantine and quarantine VLAN ID, if applicable

  Note Check the **Quarantine** check box if you want to configure this VLAN as unhealthy or you want to configure network access control (NAC) out-of-band integration. Doing so causes the data traffic of any client that is assigned to this VLAN to pass through the controller. See the *Configuring WLANs* chapter for more information about NAC out-of-band integration.

- NAT address (only for 5500 series controllers configured for dynamic AP management)

  Note Check the **Enable NAT Address** check box and enter the external NAT IP address if you want to be able to deploy your 5500 series controller behind a router or other gateway device that is using one-to-one mapping network address translation (NAT). NAT allows a device, such as a router, to act as an agent between the Internet (public) and a local network (private). In this case, it maps the controller's intranet IP addresses to a corresponding external address. The controller's dynamic AP-manager interface must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

  Note The NAT parameters are supported for use only with one-to-one-mapping NAT, whereby each private client has a direct and fixed mapping to a global address. They do not support one-to-many NAT, which uses source port mapping to enable a group of clients to be represented by a single IP address.

- VLAN identifier

  Note Enter **0** for an untagged VLAN or a non-zero value for a tagged VLAN. Cisco recommends using tagged VLANs for the management interface.

- Fixed IP address, IP netmask, and default gateway
- Dynamic AP management (for 5500 series controllers only)

  Note For 5500 series controllers, the management interface acts like an AP-manager interface by default. If desired, you can disable the management interface as an AP-manager interface and create another dynamic interface as an AP manager.

- Physical port assignment (for all controllers except the 5500 series)
- Primary and secondary DHCP servers

- Access control list (ACL) setting, if required

> **Note** To create ACLs, follow the instructions in the *Configuring Security Solutions* chapter.

AP-Manager Interface

> **Note** For 5500 series controllers, you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default.

- Physical port assignment
- VLAN identifier

> **Note** Enter **0** for an untagged VLAN or a non-zero value for a tagged VLAN. Cisco recommends using tagged VLANs for the AP-manager interface.

- Fixed IP address, IP netmask, and default gateway

> **Note** The AP-manager interface's IP address must be different from the management interface's IP address and may or may not be on the same subnet as the management interface. However, Cisco recommends that both interfaces be on the same subnet for optimum access point association.

- Primary and secondary DHCP servers
- Access control list (ACL) name, if required

> **Note** To create ACLs, follow the instructions in the *Configuring Security Solutions* chapter.

Virtual Interface

- Any fictitious, unassigned, and unused gateway IP address.
- DNS gateway host name

> **Note** To ensure connectivity and web authentication, the DNS server should always point to the virtual interface. If a DNS host name is configured for the virtual interface, then the same DNS host name must be configured on the DNS server(s) used by the client.

Service-Port Interface

> **Note** The service-port interface uses the controller's factory-set service-port MAC address.

- DHCP protocol (enabled) or
- DHCP protocol (disabled) and IP address and IP netmask

Step 4 Click **Save Configuration** to save your changes.

Step 5 If you made any changes to the management or virtual interface, reboot the controller so that your changes take effect.

Using the CLI to Configure the Management, AP-Manager, Virtual, and Service-Port Interfaces

This section provides instructions for displaying and configuring the management, AP-manager, virtual, and service-port interfaces using the CLI.

Using the CLI to Configure the Management Interface

Follow these steps to display and configure the management interface parameters using the CLI.

Step 1 Enter **show interface detailed management** to view the current management interface settings.

> **Note** The management interface uses the controller's factory-set distribution system MAC address.

Step 2 Enter **config wlan disable** *wlan-number* to disable each WLAN that uses the management interface for distribution system communication.

Step 3 Enter these commands to define the management interface:

- **config interface address management** *ip-addr ip-netmask gateway*
- **config interface quarantine vlan management** *vlan_id*

> **Note** Use this command to configure a quarantine VLAN on the management interface.

- **config interface vlan management** {*vlan-id* | **0**}

> **Note** Enter **0** for an untagged VLAN or a non-zero value for a tagged VLAN. Cisco recommends using tagged VLANs for the management interface.

- **config interface ap-manager management** {**enable** | **disable**} (for 5500 series controllers only)

> **Note** Use this command to enable or disable dynamic AP management for the management interface. For 5500 series controllers, the management interface acts like an AP-manager interface by default. If desired, you can disable the management interface as an AP-manager interface and create another dynamic interface as an AP manager.

- **config interface port management** *physical-ds-port-number* (for all controllers except the 5500 series)
- **config interface dhcp management** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]

- **config interface acl management** *access-control-list-name*

> **Note** See the *Configuring Security Solutions* chapter for more information on ACLs.

Step 4 Enter these commands if you want to be able to deploy your 5500 series controller behind a router or other gateway device that is using one-to-one mapping network address translation (NAT):

- **config interface nat-address management** {**enable** | **disable**}
- **config interface nat-address management set** *public_IP_address*

NAT allows a device, such as a router, to act as an agent between the Internet (public) and a local network (private). In this case, it maps the controller's intranet IP addresses to a corresponding external address. The controller's dynamic AP-manager interface must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

> **Note** These NAT commands can be used only on 5500 series controllers and only if the management interface is configured for dynamic AP management.

> **Note** These commands are supported for use only with one-to-one-mapping NAT, whereby each private client has a direct and fixed mapping to a global address. They do not support one-to-many NAT, which uses source port mapping to enable a group of clients to be represented by a single IP address.

Step 5 Enter **save config** to save your changes.

Step 6 Enter **show interface detailed management** to verify that your changes have been saved.

Step 7 If you made any changes to the management interface, enter **reset system** to reboot the controller in order for the changes to take effect.

Using the CLI to Configure the AP-Manager Interface

Follow these steps to display and configure the AP-manager interface parameters using the CLI.

> **Note** For 5500 series controllers, you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default.

Step 1 Enter **show interface summary** to view the current interfaces.

> **Note** If the system is operating in Layer 2 mode, the AP-manager interface is not listed.

Step 2 Enter **show interface detailed ap-manager** to view the current AP-manager interface settings.

Step 3 Enter **config wlan disable** *wlan-number* to disable each WLAN that uses the AP-manager interface for distribution system communication.

Step 4 Enter these commands to define the AP-manager interface:

- **config interface address ap-manager** *ip-addr ip-netmask gateway*
- **config interface vlan ap-manager** {*vlan-id* | **0**}

Note Enter **0** for an untagged VLAN or a non-zero value for a tagged VLAN. Cisco recommends using tagged VLANs for the AP-manager interface.

- **config interface port ap-manager** *physical-ds-port-number*
- **config interface dhcp ap-manager** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- **config interface acl ap-manager** *access-control-list-name*

Note See the *Configuring Security Solutions* chapter for more information on ACLs.

Step 5 Enter **save config** to save your changes.

Step 6 Enter **show interface detailed ap-manager** to verify that your changes have been saved.

Using the CLI to Configure the Virtual Interface

Follow these steps to display and configure the virtual interface parameters using the CLI.

Step 1 Enter **show interface detailed virtual** to view the current virtual interface settings.

Step 2 Enter **config wlan disable** *wlan-number* to disable each WLAN that uses the virtual interface for distribution system communication.

Step 3 Enter these commands to define the virtual interface:

- **config interface address virtual** *ip-address*

Note For *ip-address*, enter any fictitious, unassigned, and unused gateway IP address.

- **config interface hostname virtual** *dns-host-name*

Step 4 Enter **reset system**. At the confirmation prompt, enter **Y** to save your configuration changes to NVRAM. The controller reboots.

Step 5 Enter **show interface detailed virtual** to verify that your changes have been saved.

Using the CLI to Configure the Service-Port Interface

Follow these steps to display and configure the service-port interface parameters using the CLI.

Step 1 Enter **show interface detailed service-port** to view the current service-port interface settings.

> **Note** The service-port interface uses the controller's factory-set service-port MAC address.

Step 2 Enter these commands to define the service-port interface:

- To configure the DHCP server: **config interface dhcp service-port** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- To disable the DHCP server: **config interface dhcp service-port none**
- To configure the IP address: **config interface address service-port** *ip-addr ip-netmask*

Step 3 The service port is used for out-of-band management of the controller. If the management workstation is in a remote subnet, you may need to add a route on the controller in order to manage the controller from that remote workstation. To do so, enter this command:

config route add *network-ip-addr ip-netmask gateway*

Step 4 Enter **save config** to save your changes.

Step 5 Enter **show interface detailed service-port** to verify that your changes have been saved.

Configuring Dynamic Interfaces

This section provides instructions for configuring dynamic interfaces using either the GUI or CLI.

Using the GUI to Configure Dynamic Interfaces

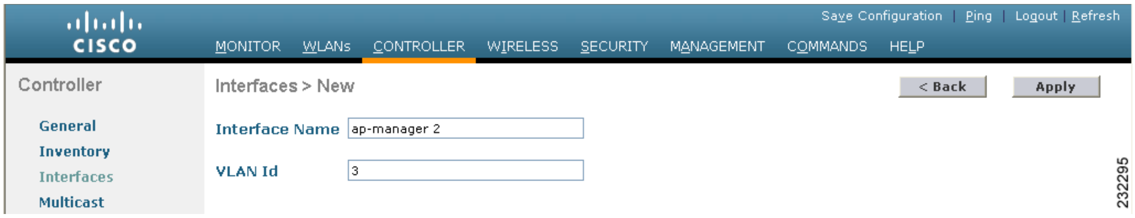
Follow these steps to create new or edit existing dynamic interfaces using the GUI.

Step 1 Choose **Controller** > **Interfaces** to open the Interfaces page (see Figure 3-6).

Step 2 Perform one of the following:

- To create a new dynamic interface, click **New**. The Interfaces > New page appears (see Figure 3-7). Go to Step 3.
- To modify the settings of an existing dynamic interface, click the name of the interface. The Interfaces > Edit page for that interface appears (see Figure 3-8). Go to Step 5.
- To delete an existing dynamic interface, hover your cursor over the blue drop-down arrow for the desired interface and choose **Remove**.

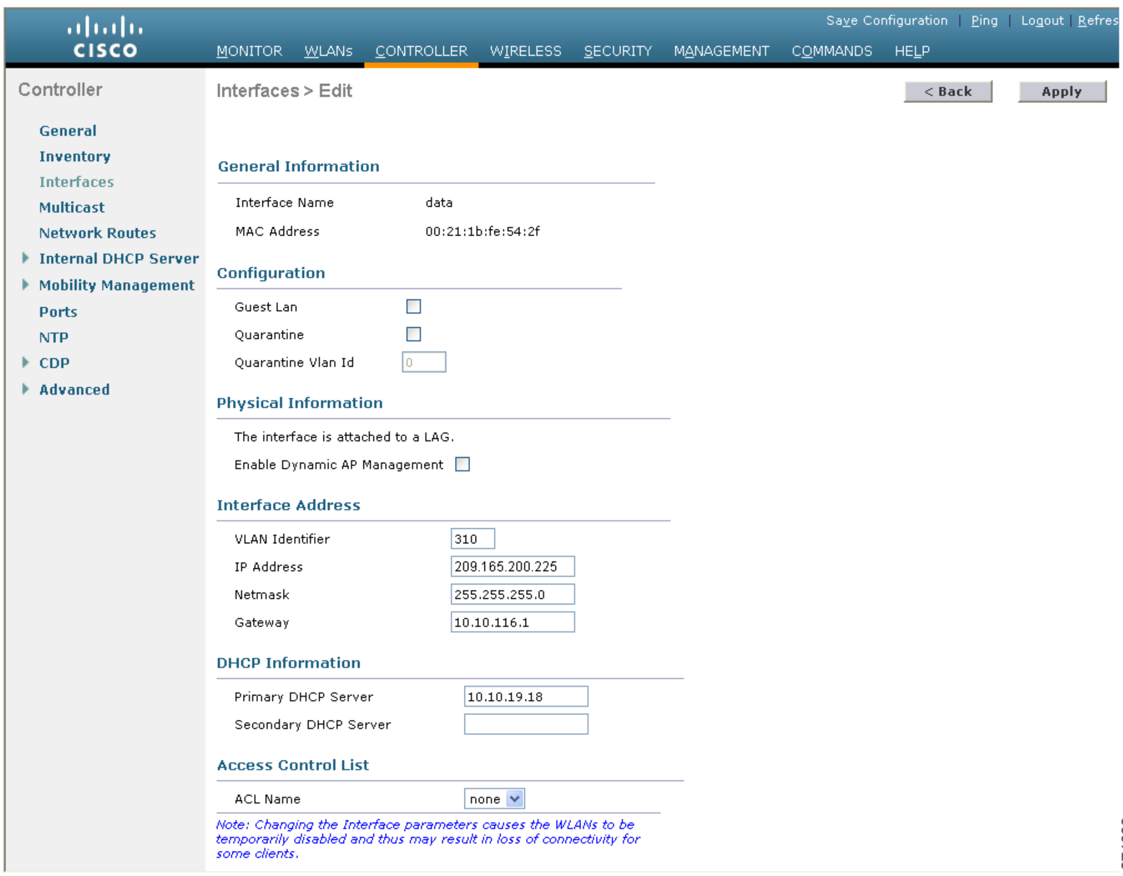
Figure 3-7 Interfaces > New Page



Step 3 Enter an interface name and a VLAN identifier, as shown in Figure 3-7.

Step 4 Click **Apply** to commit your changes. The Interfaces > Edit page appears (see Figure 3-8).

Figure 3-8 Interfaces > Edit Page



Step 5 Configure the following parameters:

- Guest LAN, if applicable
- Quarantine and quarantine VLAN ID, if applicable

Note Check the **Quarantine** check box if you want to configure this VLAN as unhealthy or you want to configure network access control (NAC) out-of-band integration. Doing so causes the data traffic of any client that is assigned to this VLAN to pass through the controller. See the *Configuring WLANs* chapter for more information about NAC out-of-band integration.

- Physical port assignment (for all controllers except the 5500 series)
- NAT address (only for 5500 series controllers configured for dynamic AP management)

Note Check the **Enable NAT Address** check box and enter the external NAT IP address if you want to be able to deploy your 5500 series controller behind a router or other gateway device that is using one-to-one mapping network address translation (NAT). NAT allows a device, such as a router, to act as an agent between the Internet (public) and a local network (private). In this case, it maps the controller's intranet IP addresses to a corresponding external address. The controller's dynamic AP-manager interface must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

Note The NAT parameters are supported for use only with one-to-one-mapping NAT, whereby each private client has a direct and fixed mapping to a global address. They do not support one-to-many NAT, which uses source port mapping to enable a group of clients to be represented by a single IP address.

- Dynamic AP management

Note When you enable this feature, this dynamic interface is configured as an AP-manager interface (only one AP-manager interface is allowed per physical port). A dynamic interface that is marked as an AP-manager interface cannot be used as a WLAN interface.

Note Set the APs in a VLAN that is different from the dynamic interface configured on the Controller. If the APs are in the same VLAN as the dynamic interface, the APs are not registered on the Controller and the 'LWAPP discovery rejected' and 'Layer 3 discovery request not received on management VLAN' errors are logged on the Controller.

- VLAN identifier
- Fixed IP address, IP netmask, and default gateway
- Primary and secondary DHCP servers
- Access control list (ACL) name, if required

Note See the *Configuring Security Solutions* chapter for more information on ACLs.

Note To ensure proper operation, you must set the Port Number and Primary DHCP Server parameters.

Step 6 Click **Save Configuration** to save your changes.

Step 7 Repeat this procedure for each dynamic interface that you want to create or edit.

Using the CLI to Configure Dynamic Interfaces

Follow these steps to configure dynamic interfaces using the CLI.

Step 1 Enter **show interface summary** to view the current dynamic interfaces.

Step 2 To view the details of a specific dynamic interface, enter **show interface detailed** *operator_defined_interface_name*.

Step 3 Enter **config wlan disable** *wlan_id* to disable each WLAN that uses the dynamic interface for distribution system communication.

Step 4 Enter these commands to configure dynamic interfaces:

- **config interface create** *operator_defined_interface_name* {*vlan_id* | ***x***}
- **config interface address** *operator_defined_interface_name ip_addr ip_netmask* [*gateway*]
- **config interface vlan** *operator_defined_interface_name* {*vlan_id* | **0**}
- **config interface port** *operator_defined_interface_name physical_ds_port_number*
- **config interface ap-manager** *operator_defined_interface_name* {**enable** | **disable**}

Note Use this command to enable or disable dynamic AP management. When you enable this feature, this dynamic interface is configured as an AP-manager interface (only one AP-manager interface is allowed per physical port). A dynamic interface that is marked as an AP-manager interface cannot be used as a WLAN interface.

- **config interface dhcp** *operator_defined_interface_name ip_address_of_primary_dhcp_server* [*ip_address_of_secondary_dhcp_server*]
- **config interface quarantine vlan** *interface_name vlan_id*

Note Use this command to configure a quarantine VLAN on any interface.

- **config interface acl** *operator_defined_interface_name access_control_list_name*

Note See the *Configuring Security Solutions* chapter for more information on ACLs.

Step 5 Enter these commands if you want to be able to deploy your 5500 series controller behind a router or other gateway device that is using one-to-one mapping network address translation (NAT):

- **config interface nat-address dynamic-interface** *operator_defined_interface_name* {**enable** | **disable**}
- **config interface nat-address dynamic-interface** *operator_defined_interface_name* **set** *public_IP_address*

NAT allows a device, such as a router, to act as an agent between the Internet (public) and a local network (private). In this case, it maps the controller's intranet IP addresses to a corresponding external address. The controller's dynamic AP-manager interface must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

Note These NAT commands can be used only on 5500 series controllers and only if the dynamic interface is configured for dynamic AP management.

Note These commands are supported for use only with one-to-one-mapping NAT, whereby each private client has a direct and fixed mapping to a global address. They do not support one-to-many NAT, which uses source port mapping to enable a group of clients to be represented by a single IP address.

Step 6 Enter **config wlan enable** *wlan_id* to re-enable each WLAN that uses the dynamic interface for distribution system communication.

Step 7 Enter **save config** to save your changes.

Step 8 Enter **show interface detailed** *operator_defined_interface_name* and **show interface summary** to verify that your changes have been saved.

Note If desired, you can enter **config interface delete** *operator_defined_interface_name* to delete a dynamic interface.

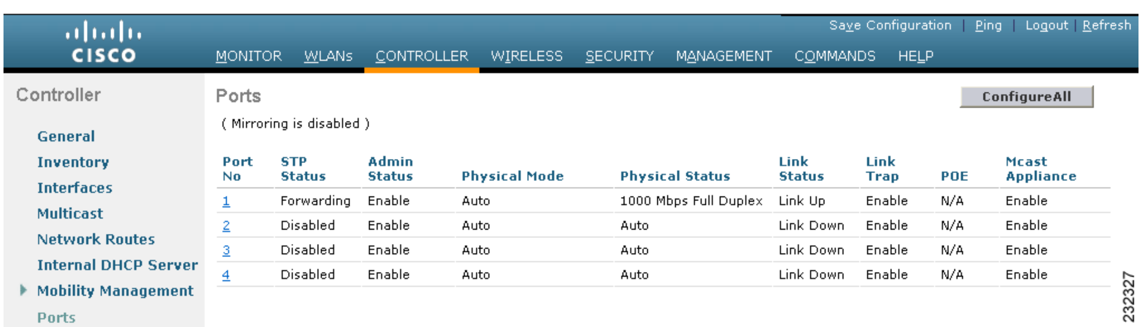
Configuring Ports

The controller's ports are preconfigured with factory default settings designed to make the controllers' ports operational without additional configuration. However, you can view the status of the controller's ports and edit their configuration parameters at any time.

Follow these steps to use the GUI to view the status of the controller's ports and make any configuration changes if necessary.

Step 1 Choose **Controller** > **Ports** to open the Ports page (see Figure 3-9).

Figure 3-9 Ports Page



This page shows the current configuration for each of the controller's ports.

Step 2 If you want to change the settings of any port, click the number for that specific port. The Port > Configure page appears (see Figure 3-10).

Note If the management and AP-manager interfaces are mapped to the same port and are members of the same VLAN, you must disable the WLAN before making a port-mapping change to either interface. If the management and AP-manager interfaces are assigned to different VLANs, you do not need to disable the WLAN.

Note The number of parameters available on the Port > Configure page depends on your controller type. For instance, 2100 series controllers and the controller in a Cisco Integrated Services Router have fewer configurable parameters than a 4400 series controller, which is shown in Figure 3-10.

Figure 3-10 Port > Configure Page

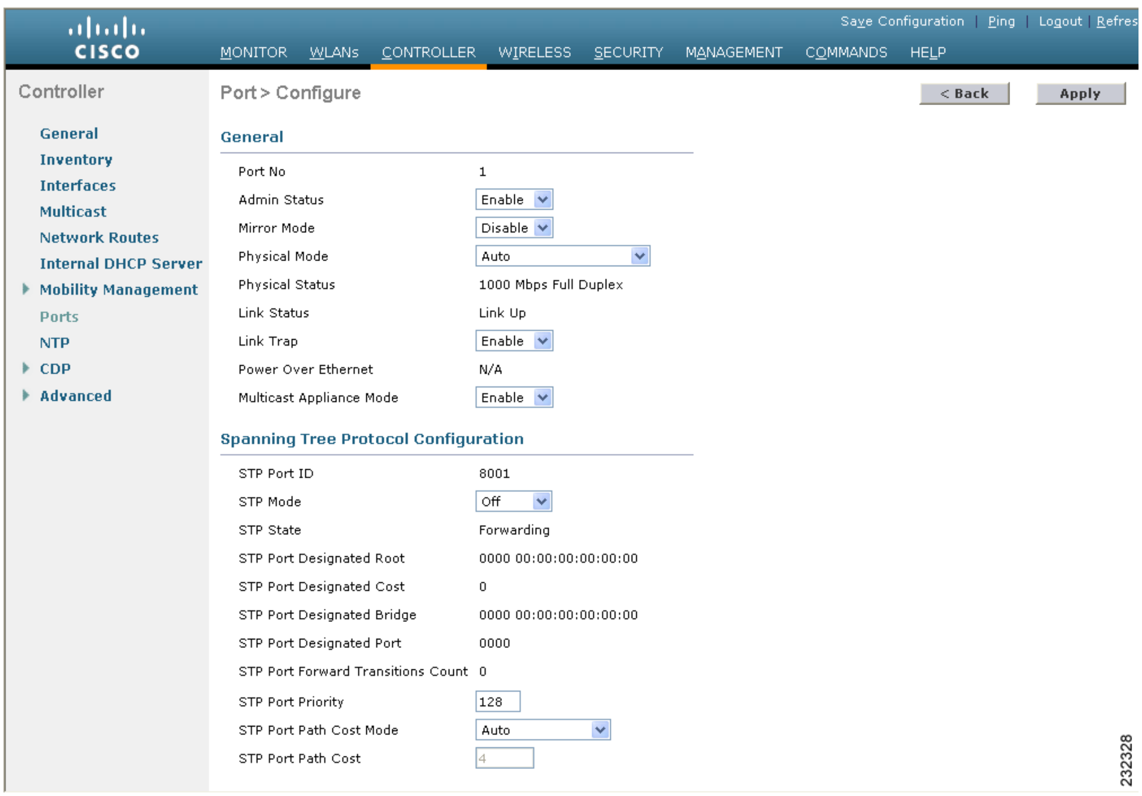


Table 3-2 interprets the current status of the port.

Table 3-2 Port Status

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td>Port Number</td><td colspan="2">The number of the current port.</td></tr>
<tr><td>Admin Status</td><td colspan="2">The current state of the port.
Values: Enable or Disable</td></tr>
<tr><td>Physical Mode</td><td colspan="2">The configuration of the port physical interface. Varies by controller.
Values: Auto, 100 Mbps Full Duplex, 100 Mbps Half Duplex, 10 Mbps Full Duplex, or 10 Mbps Half Duplex</td></tr>
<tr><td rowspan="8">Physical Status</td><td colspan="2">The data rate being used by the port. The available data rates vary based on controller type.
Note As of Controller Release 5.2 the 4400 series controllers can only run with the speed and duplex set to Auto.</td></tr>
<tr><td>Controller</td><td>Available Data Rates</td></tr>
<tr><td>5500 series</td><td>1000 Mbps full duplex</td></tr>
<tr><td>4400 series</td><td>1000 Mbps full duplex</td></tr>
<tr><td>2100 series</td><td>10 or 100 Mbps, half or full duplex</td></tr>
<tr><td>WiSM</td><td>1000 Mbps full duplex</td></tr>
<tr><td>Controller network module</td><td>100 Mbps full duplex</td></tr>
<tr><td>Catalyst 3750G Integrated Wireless LAN Controller Switch</td><td>1000 Mbps full duplex</td></tr>
<tr><td>Link Status</td><td colspan="2">The port’s link status.
Values: Link Up or Link Down</td></tr>
<tr><td>Link Trap</td><td colspan="2">Indicates whether the port is set to send a trap when the link status changes.
Values: Enable or Disable</td></tr>
<tr><td>Power over Ethernet (PoE)</td><td colspan="2">Determines if the connecting device is equipped to receive power through the Ethernet cable and if so provides -48 VDC.
Values: Enable or Disable
Note Some older Cisco access points do not draw PoE even if it is enabled on the controller port. In such cases, contact the Cisco Technical Assistance Center (TAC).
Note The controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch supports PoE on all ports.</td></tr>
</table>

Step 3 Table 3-3 lists and describes the port's configurable parameters. Follow the instructions in the table to make any desired changes.

Table 3-3 Port Parameters

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Admin Status</td><td>Enables or disables the flow of traffic through the port.
Options: Enable or Disable
Default: Enable
Note Administratively disabling the port on a controller does not affect the port's link status. The link can be brought down only by other Cisco devices. On other Cisco products, however, administratively disabling a port brings the link down.</td></tr>
<tr><td>Physical Mode</td><td>Determines whether the port's data rate is set automatically or specified by the user. The supported data rates vary based on controller type.
Default: Auto
Note As of Controller Release 5.2 the 4400 series controllers can only run with the speed and duplex set to Auto.
<table>
<tr><th>Controller</th><th>Supported Data Rates</th></tr>
<tr><td>5500 series</td><td>Auto or 1000 Mbps full duplex</td></tr>
<tr><td>4400 series</td><td>Auto or 1000 Mbps full duplex</td></tr>
<tr><td>2100 series</td><td>Auto or 10 or 100 Mbps, half or full duplex</td></tr>
<tr><td>WiSM</td><td>Auto or 1000 Mbps full duplex</td></tr>
<tr><td>Controller network module</td><td>Auto or 100 Mbps full duplex</td></tr>
<tr><td>Catalyst 3750G Integrated Wireless LAN Controller Switch</td><td>Auto or 1000 Mbps full duplex</td></tr>
</table>
Note Make sure that a duplex mismatch does not exist between a 2100 series controller and the Catalyst switch. A duplex mismatch is a situation where the switch operates at full duplex and the connected device operates at half duplex or vice versa. The results of a duplex mismatch are extremely slow performance, intermittent connectivity, and loss of connection. Other possible causes of data link errors at full duplex are bad cables, faulty switch ports, or client software or hardware issues.</td></tr>
<tr><td>Link Trap</td><td>Causes the port to send a trap when the port's link status changes.
Options: Enable or Disable
Default: Enable</td></tr>
<tr><td>Multicast Appliance Mode</td><td>Enables or disables the multicast appliance service for this port.
Options: Enable or Disable
Default: Enable</td></tr>
</table>

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Step 6 Click **Back** to return to the Ports page and review your changes.

Step 7 Repeat this procedure for each additional port that you want to configure.

Step 8 Go to the following sections if you want to configure the controller's ports for these advanced features:

- Port mirroring, see below
- Spanning Tree Protocol (STP), page 3-27

Configuring Port Mirroring

Mirror mode enables you to duplicate to another port all of the traffic originating from or terminating at a single client device or access point. It is useful in diagnosing specific network problems. Mirror mode should be enabled only on an unused port as any connections to this port become unresponsive.

Note The 5500 series controllers, 2100 series controllers, controller network modules, and Cisco WiSM controllers do not support mirror mode. Also, a controller's service port cannot be used as a mirrored port.

Note Port mirroring is not supported when link aggregation (LAG) is enabled on the controller.

Note Cisco recommends that you do not mirror traffic from one controller port to another as this setup could cause network problems.

Follow these steps to enable port mirroring.

Step 1 Choose **Controller** > **Ports** to open the Ports page (see Figure 3-9).

Step 2 Click the number of the unused port for which you want to enable mirror mode. The Port > Configure page appears (see Figure 3-10).

Step 3 Set the Mirror Mode parameter to **Enable**.

Step 4 Click **Apply** to commit your changes.

Step 5 Perform one of the following:

- Follow these steps if you want to choose a specific client device that will mirror its traffic to the port you selected on the controller:
  - **a.** Choose **Wireless** > **Clients** to open the Clients page.
  - **b.** Click the MAC address of the client for which you want to enable mirror mode. The Clients > Detail page appears.
  - **c.** Under Client Details, set the Mirror Mode parameter to **Enable**.

- Follow these steps if you want to choose an access point that will mirror its traffic to the port you selected on the controller:
  a. Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.
  b. Click the name of the access point for which you want to enable mirror mode. The All APs > Details page appears.
  c. Choose the **Advanced** tab.
  d. Set the Mirror Mode parameter to **Enable**.

Step 6 Click **Save Configuration** to save your changes.

Configuring Spanning Tree Protocol

Spanning Tree Protocol (STP) is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two network devices. STP allows only one active path at a time between network devices but establishes redundant links as a backup if the initial link should fail.

The spanning-tree algorithm calculates the best loop-free path throughout a Layer 2 network. Infrastructure devices such as controllers and switches send and receive spanning-tree frames, called bridge protocol data units (BPDUs), at regular intervals. The devices do not forward these frames but use them to construct a loop-free path.

Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Infrastructure devices might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network.

STP defines a tree with a root bridge and a loop-free path from the root to all infrastructure devices in the Layer 2 network.

Note STP discussions use the term *root* to describe two concepts: the controller on the network that serves as a central point in the spanning tree is called the *root bridge*, and the port on each controller that provides the most efficient path to the root bridge is called the *root port*. The root bridge in the spanning tree is called the *spanning-tree root*.

STP forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path.

When two ports on a controller are part of a loop, the spanning-tree port priority and path cost settings determine which port is put in the forwarding state and which is put in the blocking state. The port priority value represents the location of a port in the network topology and how well it is located to pass traffic. The path cost value represents media speed.

The controller maintains a separate spanning-tree instance for each active VLAN configured on it. A bridge ID, consisting of the bridge priority and the controller's MAC address, is associated with each instance. For each VLAN, the controller with the lowest controller ID becomes the spanning-tree root for that VLAN.

STP is disabled for the controller's distribution system ports by default. The following sections provide instructions for configuring STP for your controller using either the GUI or CLI.

Note STP cannot be configured for 2100 series controllers, 5500 series controllers, and the controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch.

Using the GUI to Configure Spanning Tree Protocol

Follow these steps to configure STP using the GUI.

Step 1 Choose **Controller** > **Ports** to open the Ports page (see Figure 3-9).

Step 2 Click the number of the port for which you want to configure STP. The Port > Configure page appears (see Figure 3-10). This page shows the STP status of the port and enables you to configure STP parameters.

Table 3-4 interprets the current STP status of the port.

Table 3-4 Port Spanning Tree Status

Parameter	Description
STP Port ID	The number of the port for which STP is enabled or disabled.
STP State	The port's current STP state. It controls the action that a port takes upon receiving a frame. **Values:** Disabled, Blocking, Listening, Learning, Forwarding, and Broken **STP State** – **Description** Disabled – The port is not participating in spanning tree because the port is shut down, the link is down, or STP is not enabled for this port. Blocking – The port does not participate in frame forwarding. Listening – The first transitional state after the blocking state when STP determines that the port should participate in frame forwarding. Learning – The port prepares to participate in frame forwarding. Forwarding – The port forwards frames. Broken – The port is malfunctioning.
STP Port Designated Root	The unique identifier of the root bridge in the configuration BPDUs.
STP Port Designated Cost	The path cost of the designated port.
STP Port Designated Bridge	The identifier of the bridge that the port considers to be the designated bridge for this port.
STP Port Designated Port	The port identifier on the designated bridge for this port.
STP Port Forward Transitions Count	The number of times that the port has transitioned from the learning state to the forwarding state.

Step 3 Table 3-5 lists and describes the port's configurable STP parameters. Follow the instructions in the table to make any desired changes.

Table 3-5 Port Spanning Tree Parameters

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td rowspan="5">STP Mode</td><td colspan="2">The STP administrative mode associated with this port.
Options: Off, 802.1D, or Fast
Default: Off</td></tr>
<tr><td>STP Mode</td><td>Description</td></tr>
<tr><td>Off</td><td>Disables STP for this port.</td></tr>
<tr><td>802.1D</td><td>Enables this port to participate in the spanning tree and go through all of the spanning tree states when the link state transitions from down to up.</td></tr>
<tr><td>Fast</td><td>Enables this port to participate in the spanning tree and puts it in the forwarding state when the link state transitions from down to up more quickly than when the STP mode is set to 802.1D.
Note In this state, the forwarding delay timer is ignored on link up.</td></tr>
<tr><td>STP Port Priority</td><td colspan="2">The location of the port in the network topology and how well the port is located to pass traffic.
Range: 0 to 255
Default: 128</td></tr>
<tr><td>STP Port Path Cost Mode</td><td colspan="2">Determines whether the STP port path cost is set automatically or specified by the user. If you choose User Configured, you also need to set a value for the STP Port Path Cost parameter.
Range: Auto or User Configured
Default: Auto</td></tr>
<tr><td>STP Port Path Cost</td><td colspan="2">The speed at which traffic is passed through the port. This parameter must be set if the STP Port Path Cost Mode parameter is set to User Configured.
Options: 0 to 65535
Default: 0, which causes the cost to be adjusted for the speed of the port when the link comes up.
Note Typically, a value of 100 is used for 10-Mbps ports and 19 for 100-Mbps ports.</td></tr>
</table>

Step 4 Click **Apply** to commit your changes.

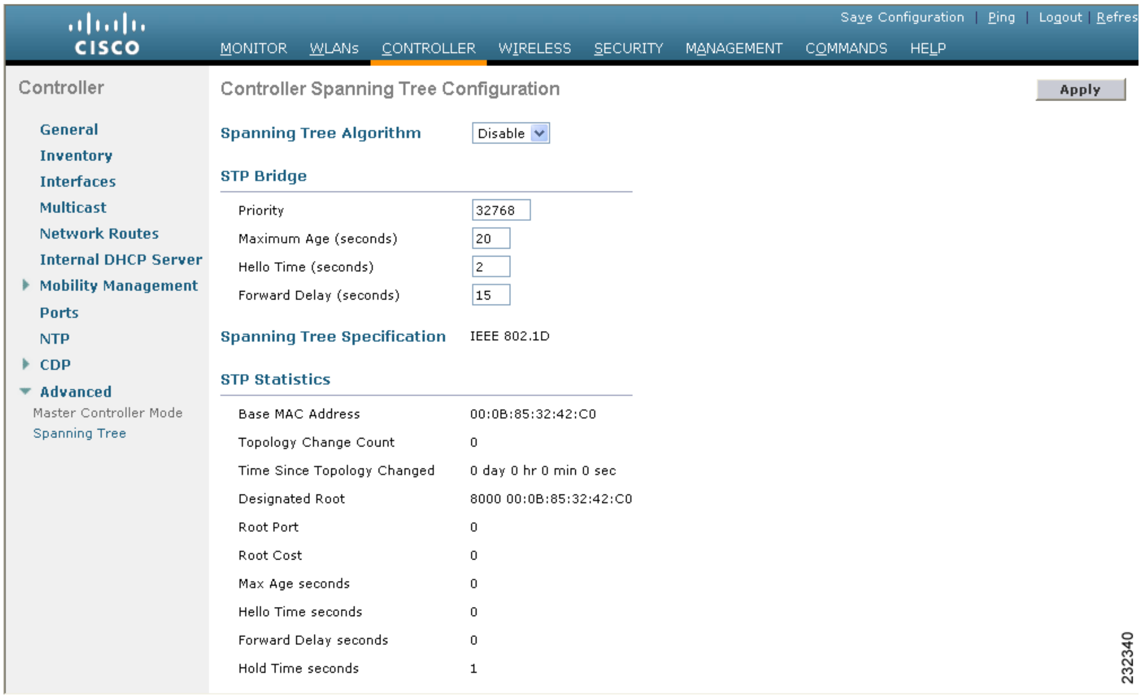
Step 5 Click **Save Configuration** to save your changes.

Step 6 Click **Back** to return to the Ports page.

Step 7 Repeat Step 2 through Step 6 for each port for which you want to enable STP.

Step 8 Choose **Controller** > **Advanced** > **Spanning Tree** to open the Controller Spanning Tree Configuration page (see Figure 3-11).

Figure 3-11 Controller Spanning Tree Configuration Page



This page allows you to enable or disable the spanning tree algorithm for the controller, modify its characteristics, and view the STP status. Table 3-6 interprets the current STP status for the controller.

Table 3-6 Controller Spanning Tree Status

Parameter	Description
Spanning Tree Specification	The STP version being used by the controller. Currently, only an IEEE 802.1D implementation is available.
Base MAC Address	The MAC address used by this bridge when it must be referred to in a unique fashion. When it is concatenated with dot1dStpPriority, a unique bridge identifier is formed that is used in STP.
Topology Change Count	The total number of topology changes detected by this bridge since the management entity was last reset or initialized.
Time Since Topology Changed	The time (in days, hours, minutes, and seconds) since a topology change was detected by the bridge.
Designated Root	The bridge identifier of the spanning tree root. This value is used as the Root Identifier parameter in all configuration BPDUs originated by this node.
Root Port	The number of the port that offers the lowest cost path from this bridge to the root bridge.
Root Cost	The cost of the path to the root as seen from this bridge.
Max Age (seconds)	The maximum age of STP information learned from the network on any port before it is discarded.

Table 3-6 Controller Spanning Tree Status (continued)

Parameter	Description
Hello Time (seconds)	The amount of time between the transmission of configuration BPDUs by this node on any port when it is the root of the spanning tree or trying to become so. This is the actual value that this bridge is currently using.
Forward Delay (seconds)	This value controls how fast a port changes its spanning tree state when moving toward the forwarding state. It determines how long the port stays in each of the listening and learning states that precede the forwarding state. This value is also used, when a topology change has been detected and is underway, to age all dynamic entries in the forwarding database. **Note** This is the actual value that this bridge is currently using, in contrast to *Stp Bridge Forward Delay*, which is the value that this bridge and all others would start using if this bridge were to become the root.
Hold Time (seconds)	The minimum time period to elapse between the transmission of configuration BPDUs through a given LAN port. **Note** At most, one configuration BPDU can be transmitted in any hold time period.

Step 9 Table 3-7 lists and describes the controller's configurable STP parameters. Follow the instructions in the table to make any desired changes.

Table 3-7 Controller Spanning Tree Parameters

Parameter	Description
Spanning Tree Algorithm	Enables or disables STP for the controller. **Options:** Enable or Disable **Default:** Disable
Priority	The location of the controller in the network topology and how well the controller is located to pass traffic. **Range:** 0 to 65535 **Default:** 32768
Maximum Age (seconds)	The length of time that the controller stores protocol information received on a port. **Range:** 6 to 40 seconds **Default:** 20 seconds
Hello Time (seconds)	The length of time that the controller broadcasts hello messages to other controllers. **Options:** 1 to 10 seconds **Default:** 2 seconds

Table 3-7 Controller Spanning Tree Parameters (continued)

Parameter	Description
Forward Delay (seconds)	The length of time that each of the listening and learning states lasts before the port begins forwarding. **Options:** 4 to 30 seconds **Default:** 15 seconds

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Configure Spanning Tree Protocol

Follow these steps to configure STP using the CLI.

Step 1 Enter **show spanningtree port** and **show spanningtree switch** to view the current STP status.

Step 2 If STP is enabled, you must disable it before you can change STP settings. Enter **config spanningtree switch mode disable** to disable STP on all ports.

Step 3 Enter one of these commands to configure the STP port administrative mode:

- **config spanningtree port mode 802.1d** {*port-number* | **all**}
- **config spanningtree port mode fast** {*port-number* | **all**}
- **config spanningtree port mode off** {*port-number* | **all**}

Step 4 Enter one of these commands to configure the STP port path cost on the STP ports:

- **config spanningtree port pathcost** *1-65535* {*port-number* | **all**}—Specifies a path cost from 1 to 65535 to the port.
- **config spanningtree port mode pathcost auto** {*port-number* | **all**}—Enables the STP algorithm to automatically assign the path cost. This is the default setting.

Step 5 Enter **config spanningtree port priority** *0-255 port-number* to configure the port priority on STP ports. The default priority is 128.

Step 6 If necessary, enter **config spanningtree switch bridgepriority** *0-65535* to configure the controller's STP bridge priority. The default bridge priority is 32768.

Step 7 If necessary, enter **config spanningtree switch forwarddelay** *4-30* to configure the controller's STP forward delay in seconds. The default forward delay is 15 seconds.

Step 8 If necessary, enter **config spanningtree switch hellotime** *1-10* to configure the controller's STP hello time in seconds. The default hello time is 2 seconds.

Step 9 If necessary, enter **config spanningtree switch maxage** *6-40* to configure the controller's STP maximum age. The default maximum age is 20 seconds.

Step 10 After you configure STP settings for the ports, enter **config spanningtree switch mode enable** to enable STP for the controller. The controller automatically detects logical network loops, places redundant ports on standby, and builds a network with the most efficient pathways.

Step 11 Enter **save config** to save your settings.

Step 12 Enter **show spanningtree port** and **show spanningtree switch** to verify that your changes have been saved.

Using the Cisco 5500 Series Controller USB Console Port

The USB console port on the 5500 series controllers connects directly to the USB connector of a PC using a USB Type A-to-5-pin mini Type B cable.

Note The 4-pin mini Type B connector is easily confused with the 5-pin mini Type B connector. They are not compatible. Only the 5-pin mini Type B connector can be used.

For operation with Microsoft Windows, the Cisco Windows USB console driver must be installed on any PC connected to the console port. With this driver, you can plug and unplug the USB cable into and from the console port without affecting Windows HyperTerminal operations.

Note Only one console port can be active at a time. When a cable is plugged into the USB console port, the RJ-45 port becomes inactive. Conversely, when the USB cable is removed from the USB port, the RJ-45 port becomes active.

USB Console OS Compatibility

- Microsoft Windows 2000, XP, Vista (Cisco Windows USB console driver required)
- Apple Mac OS X 10.5.2 (no driver required)
- Linux (no driver required)

To install the Cisco Windows USB console driver, follow these steps:

Step 1 Follow these steps to download the USB_Console.inf driver file:

a. Click this URL to go to the Software Center:

   http://tools.cisco.com/support/downloads/go/Redirect.x?mdfid=278875243

b. Click **Wireless LAN Controllers**.

c. Click **Standalone Controllers**.

d. Click **Cisco 5500 Series Wireless LAN Controllers**.

e. Click **Cisco 5508 Wireless LAN Controller**.

f. Choose the USB driver file.

g. Save the file to your hard drive.

Step 2 Connect the Type A connector to a USB port on your PC.

Step 3 Connect the mini Type B connector to the USB console port on the controller.

Step 4 When prompted for a driver, browse to the USB_Console.inf file on your PC. Follow the prompts to install the USB driver.

Note Some systems might also require an additional system file. You can download the Usbser.sys file from Microsoft's website.

The USB driver is mapped to COM port 6. Some terminal emulation programs do not recognize a port higher than COM 4. If necessary, change the Cisco USB systems management console COM port to an unused port of COM 4 or lower. To do so, follow these steps:

Step 1 From your Windows desktop, right-click **My Computer** and choose **Manage**.

Step 2 From the list on the left side, choose **Device Manager**.

Step 3 From the device list on the right side, double-click **Ports (COM & LPT)**.

Step 4 Right-click **Cisco USB System Management Console 0108** and choose **Properties**.

Step 5 Click the **Port Settings** tab and click the **Advanced** button.

Step 6 From the COM Port Number drop-down box, choose an unused COM port of 4 or lower.

Step 7 Click **OK** to save; then close the Advanced Settings dialog box.

Step 8 Click **OK** to save; then close the Communications Port Properties dialog box.

Choosing Between Link Aggregation and Multiple AP-Manager Interfaces

As noted earlier, 4400 series controllers can support up to 48 access points per port. However, you can configure your 4400 series controller to support more access points by using link aggregation (LAG) or configuring dynamic AP-managers on each Gigabit Ethernet port. Cisco 5500 series controllers have no restrictions on the number of access points per port, but Cisco recommends using LAG or multiple AP-manager interfaces on each Gigabit Ethernet port to automatically balance the load.

The following factors should help you decide which method to use if your controller is set for Layer 3 operation:

- With LAG, all of the controller ports need to connect to the same neighbor switch. If the neighbor switch goes down, the controller loses connectivity.
- With multiple AP-manager interfaces, you can connect your ports to different neighbor devices. If one of the neighbor switches goes down, the controller still has connectivity. However, using multiple AP-manager interfaces presents certain challenges (as discussed in the "Configuring Multiple AP-Manager Interfaces" section below) when port redundancy is a concern.

Follow the instructions on the page indicated for the method you want to use:

- Link aggregation, page 3-35
- Multiple AP-manager interfaces, page 3-39

Enabling Link Aggregation

Link aggregation (LAG) is a partial implementation of the 802.3ad port aggregation standard. It bundles all of the controller's distribution system ports into a single 802.3ad port channel, thereby reducing the number of IP addresses needed to configure the ports on your controller. When LAG is enabled, the system dynamically manages port redundancy and load balances access points transparently to the user.

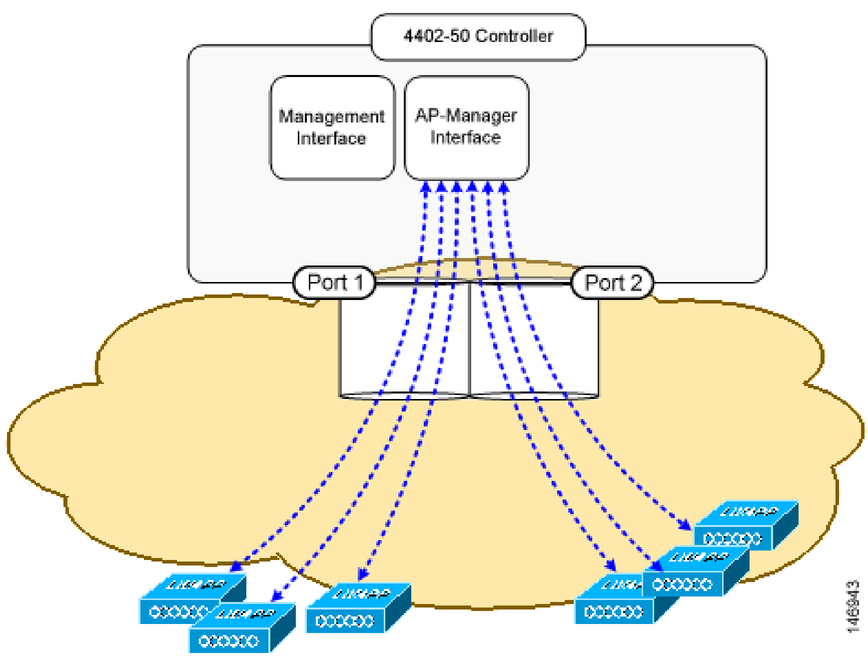
Note The 2100 series controllers do not support LAG.

Note You can bundle all four ports on a 4404 controller (or two on a 4402 controller) or all eight ports on a 5508 controller into a single link.

Cisco 5500 series controllers support LAG in software release 6.0 or later, Cisco 4400 series controllers support LAG in software release 3.2 or later, and LAG is enabled automatically on the controllers within the Cisco WiSM and the Catalyst 3750G Integrated Wireless LAN Controller Switch. Without LAG, each distribution system port on a 4400 series controller supports up to 48 access points. With LAG enabled, a 4402 controller's logical port supports up to 50 access points, a 4404 controller's logical port supports up to 100 access points, and the logical port on the Catalyst 3750G Integrated Wireless LAN Controller Switch and on each Cisco WiSM controller supports up to 150 access points.

Figure 3-12 illustrates LAG.

Figure 3-12 Link Aggregation



LAG simplifies controller configuration because you no longer need to configure primary and secondary ports for each interface. If any of the controller ports fail, traffic is automatically migrated to one of the other ports. As long as at least one controller port is functioning, the system continues to operate, access points remain connected to the network, and wireless clients continue to send and receive data.

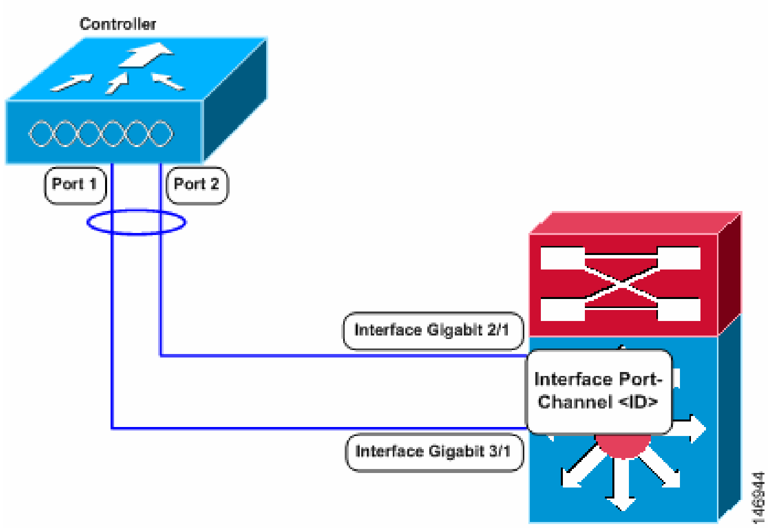
When configuring bundled ports on the controller, you may want to consider terminating on two different modules within a modular switch such as the Catalyst 6500; however, Cisco does not recommend connecting the LAG ports of a 5500 or 4400 series controller to multiple Catalyst 6500 or 3750G switches.

Terminating on two different modules within a single Catalyst 6500 switch provides redundancy and ensures that connectivity between the switch and the controller is maintained when one module fails. Figure 3-13 illustrates this use of redundant modules. A 4402-50 controller is connected to two different Gigabit modules (slots 2 and 3) within the Catalyst 6500. The controller's port 1 is connected to Gigabit interface 3/1, and the controller's port 2 is connected to Gigabit interface 2/1 on the Catalyst 6500. Both switch ports are assigned to the same channel group.

When a 5500 series controller, 4404 controller, or WiSM controller module LAG port is connected to a Catalyst 3750G or a 6500 or 7600 channel group employing load balancing, note the following:

- LAG requires the Etherchannel to be configured for the "on" mode on both the controller and the Catalyst switch.
- Once the Etherchannel is configured as "on" at both ends of the link, it does not matter if the Catalyst switch is configured for either Link Aggregation Control Protocol (LACP) or Cisco proprietary Port Aggregation Protocol (PAgP) because no channel negotiation is done between the controller and the switch. Additionally, LACP and PAgP are not supported on the controller.
- The load-balancing method configured on the Catalyst switch must be a load-balancing method that terminates all IP datagram fragments on a single controller port. Not following this recommendation may result in problems with access point association.
- The recommended load-balancing method for Catalyst switches is src-dest-ip (CLI command: **port-channel load-balance** *src_dest_ip*).
- If the recommended load-balancing method cannot be configured on the Catalyst switch, then configure the LAG connection as a single member link or disable LAG on the controller.

Figure 3-13 Link Aggregation with Catalyst 6500 Neighbor Switch



Link Aggregation Guidelines

Keep these guidelines in mind when using LAG:

- You cannot configure the controller's ports into separate LAG groups. Only one LAG group is supported per controller. Therefore, you can connect a controller in LAG mode to only one neighbor device.

  Note The two internal Gigabit ports on the controller within the Catalyst 3750G Integrated Wireless LAN Controller Switch are always assigned to the same LAG group.

- When you enable LAG or make any changes to the LAG configuration, you must immediately reboot the controller.
- When you enable LAG, you can configure only one AP-manager interface because only one logical port is needed. LAG removes the requirement for supporting multiple AP-manager interfaces.
- When you enable LAG, all dynamic AP-manager interfaces and untagged interfaces are deleted, and all WLANs are disabled and mapped to the management interface. Also, the management, static AP-manager, and VLAN-tagged dynamic interfaces are moved to the LAG port.
- Multiple untagged interfaces to the same port are not allowed.
- When you enable LAG, you cannot create interfaces with a primary port other than 29.
- When you enable LAG, all ports participate in LAG by default. Therefore, you must configure LAG for all of the connected ports in the neighbor switch.
- When you enable LAG on the Cisco WiSM, you must enable port-channeling/Ether-channeling for all of the controller's ports on the switch.
- When you enable LAG, port mirroring is not supported.
- When you enable LAG, if any single link goes down, traffic migrates to the other links.
- When you enable LAG, only one functional physical port is needed for the controller to pass client traffic.
- When you enable LAG, access points remain connected to the switch, and data service for users continues uninterrupted.
- When you enable LAG, you eliminate the need to configure primary and secondary ports for each interface.
- When you enable LAG, the controller sends packets out on the same port on which it received them. If a CAPWAP packet from an access point enters the controller on physical port 1, the controller removes the CAPWAP wrapper, processes the packet, and forwards it to the network on physical port 1. This may not be the case if you disable LAG.
- When you disable LAG, the management, static AP-manager, and dynamic interfaces are moved to port 1.
- When you disable LAG, you must configure primary and secondary ports for all interfaces.
- When you disable LAG, you must assign an AP-manager interface to each port on the controller. Otherwise, access points are unable to join.
- Cisco 5500 and 4400 series controllers support a single static link aggregation bundle.
- LAG is typically configured using the Startup Wizard, but you can enable or disable it at any time through either the GUI or CLI.

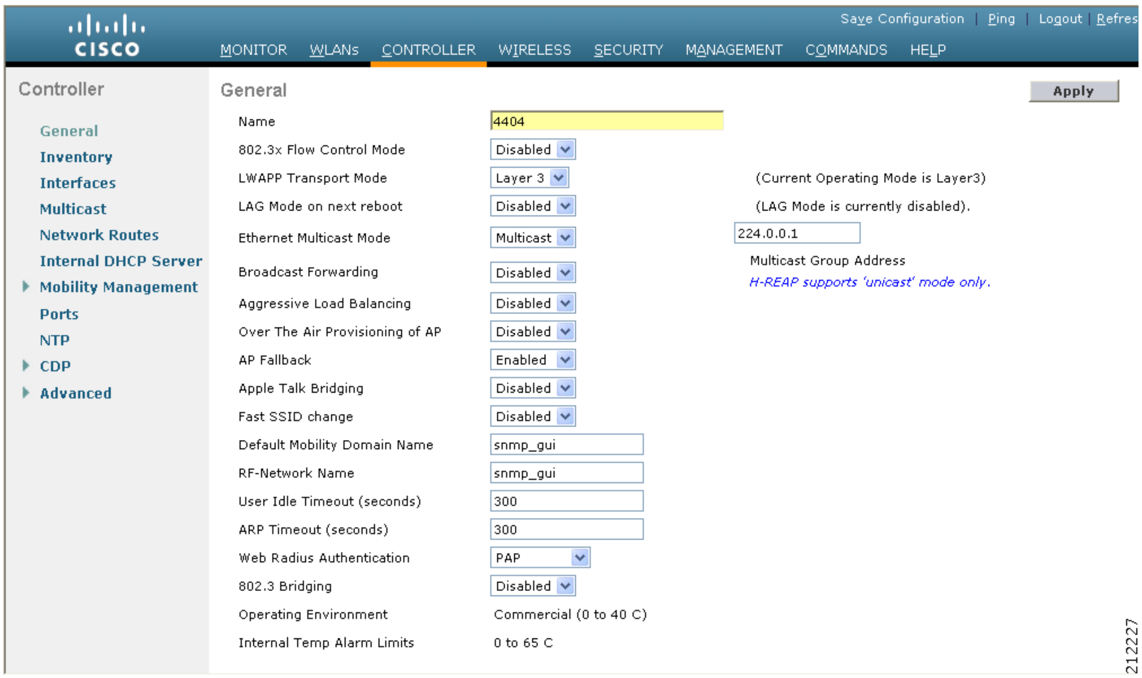
Note LAG is enabled by default and is the only option on the WiSM controller and the controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch.

Using the GUI to Enable Link Aggregation

Follow these steps to enable LAG on your controller using the GUI.

Step 1 Choose **Controller** > **General** to open the General page (see Figure 3-14).

Figure 3-14 General Page



Step 2 Set the LAG Mode on Next Reboot parameter to **Enabled**.

Note Choose **Disabled** if you want to disable LAG. LAG is disabled by default on the Cisco 5500 and 4400 series controllers but enabled by default on the Cisco WiSM and the controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 Reboot the controller.

Step 6 Assign the WLAN to the appropriate VLAN.

Using the CLI to Enable Link Aggregation

Follow these steps to enable LAG on your controller using the CLI.

Step 1 Enter **config lag enable** to enable LAG.

> **Note** Enter **config lag disable** if you want to disable LAG.

Step 2 Enter **save config** to save your settings.

Step 3 Reboot the controller.

Using the CLI to Verify Link Aggregation Settings

To verify your LAG settings, enter this command:

show lag summary

Information similar to the following appears:

```
LAG Enabled
```

Configuring Neighbor Devices to Support Link Aggregation

The controller's neighbor devices must also be properly configured to support LAG.

- Each neighbor port to which the controller is connected should be configured as follows:

```
interface GigabitEthernet <interface id>
    switchport
    channel-group <id> mode on
    no shutdown
```

- The port channel on the neighbor switch should be configured as follows:

```
interface port-channel <id>
    switchport
    switchport trunk encapsulation dot1q
    switchport trunk native vlan <native vlan id>
    switchport trunk allowed vlan <allowed vlans>
    switchport mode trunk
    no shutdown
```

Configuring Multiple AP-Manager Interfaces

> **Note** Only Cisco 5500 series and 4400 series standalone controllers support the use of multiple AP-manager interfaces.

When you create two or more AP-manager interfaces, each one is mapped to a different port (see Figure 3-15). The ports should be configured in sequential order such that AP-manager interface 2 is on port 2, AP-manager interface 3 is on port 3, and AP-manager interface 4 is on port 4.

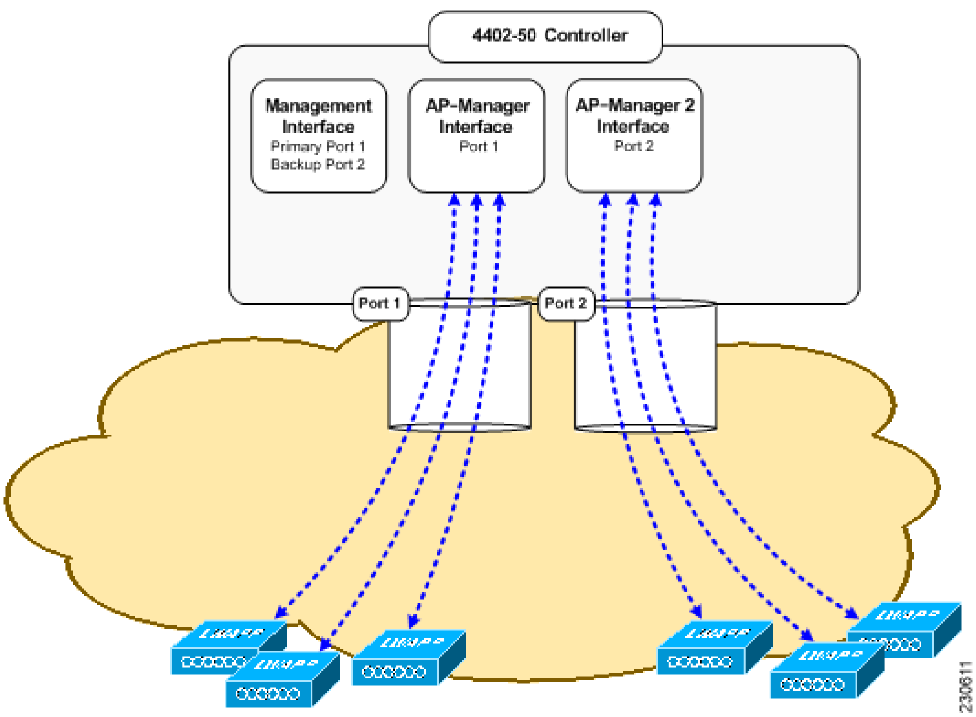
Note AP-manager interfaces need not be on the same VLAN or IP subnet, and they may or may not be on the same VLAN or IP subnet as the management interface. However, Cisco recommends that you configure all AP-manager interfaces on the same VLAN or IP subnet.

Note You must assign an AP-manager interface to each port on the controller.

Before an access point joins a controller, it sends out a discovery request. From the discovery response that it receives, the access point can tell the number of AP-manager interfaces on the controller and the number of access points on each AP-manager interface. The access point generally joins the AP-manager with the least number of access points. In this way, the access point load is dynamically distributed across the multiple AP-manager interfaces.

Note Access points may not be distributed completely evenly across all of the AP-manager interfaces, but a certain level of load balancing occurs.

Figure 3-15 Two AP-Manager Interfaces



Before implementing multiple AP-manager interfaces, you should consider how they would impact your controller's port redundancy.

Examples:

1. The 4402-50 controller supports a maximum of 50 access points and has two ports. To support the maximum number of access points, you would need to create two AP-manager interfaces (see Figure 3-15) because a 4400 series controller can support only 48 access points on one port.
2. The 4404-100 controller supports up to 100 access points and has four ports. To support the maximum number of access points, you would need to create three (or more) AP-manager interfaces (see Figure 3-16). If the port of one of the AP-manager interfaces fails, the controller clears the access points' state, and the access points must reboot to reestablish communication with the controller using the normal controller join process. The controller no longer includes the failed AP-manager interface in the CAPWAP or LWAPP discovery responses. The access points then rejoin the controller and are load-balanced among the available AP-manager interfaces.

Figure 3-16 Three AP-Manager Interfaces

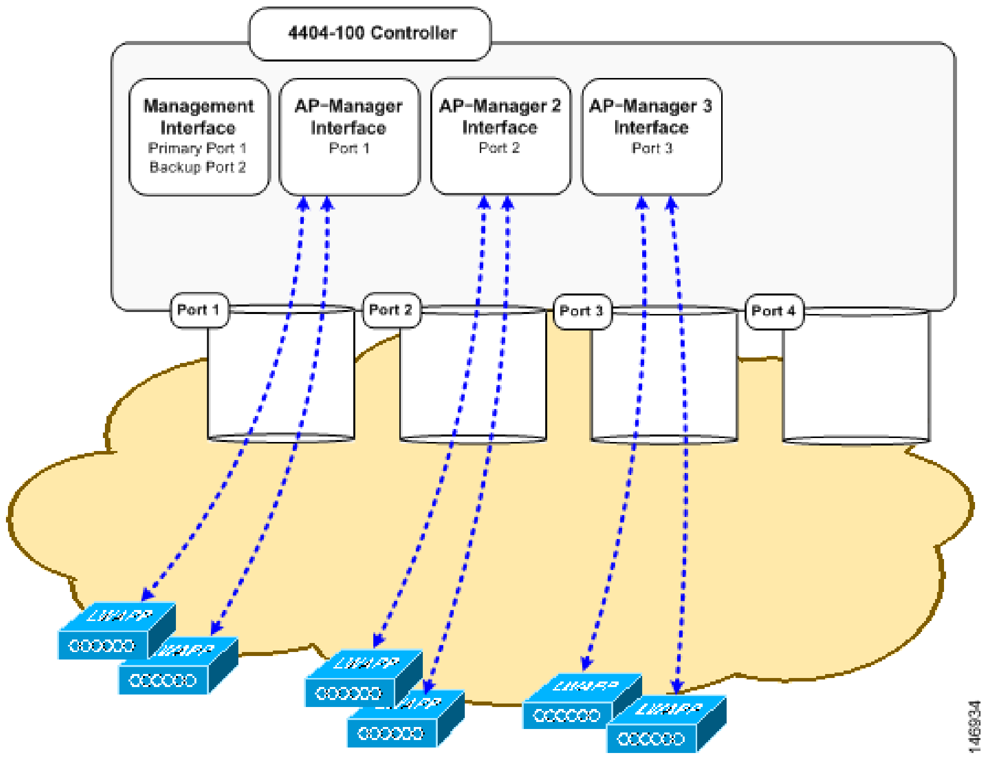
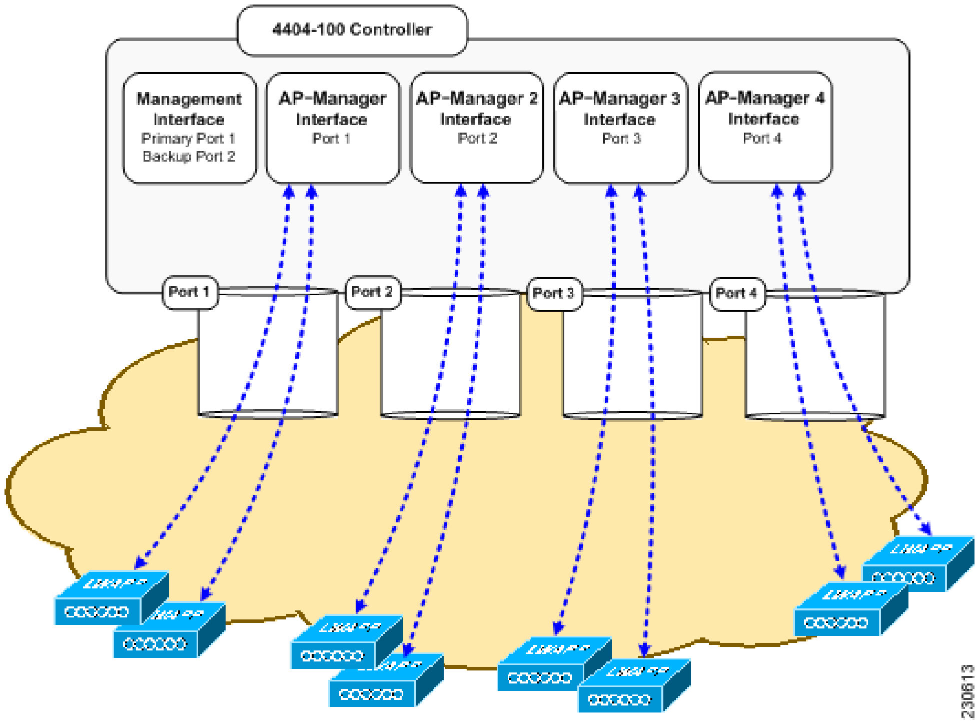


Figure 3-17 illustrates the use of four AP-manager interfaces to support 100 access points on a 4400 series controller.

Figure 3-17 Four AP-Manager Interfaces



This configuration has the advantage of load-balancing all 100 access points evenly across all four AP-manager interfaces. If one of the AP-manager interfaces fails, all of the access points connected to the controller would be evenly distributed among the three available AP-manager interfaces. For example, if AP-manager interface 2 fails, the remaining AP-manager interfaces (1, 3, and 4) would each manage approximately 33 access points.

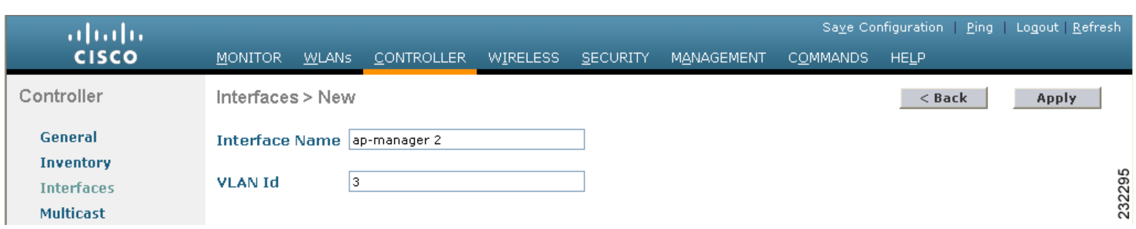
Using the GUI to Create Multiple AP-Manager Interfaces

Using the controller GUI, follow these steps to create multiple AP-manager interfaces.

Step 1 Choose **Controller** > **Interfaces** to open the Interfaces page.

Step 2 Click **New**. The Interfaces > New page appears (see Figure 3-19).

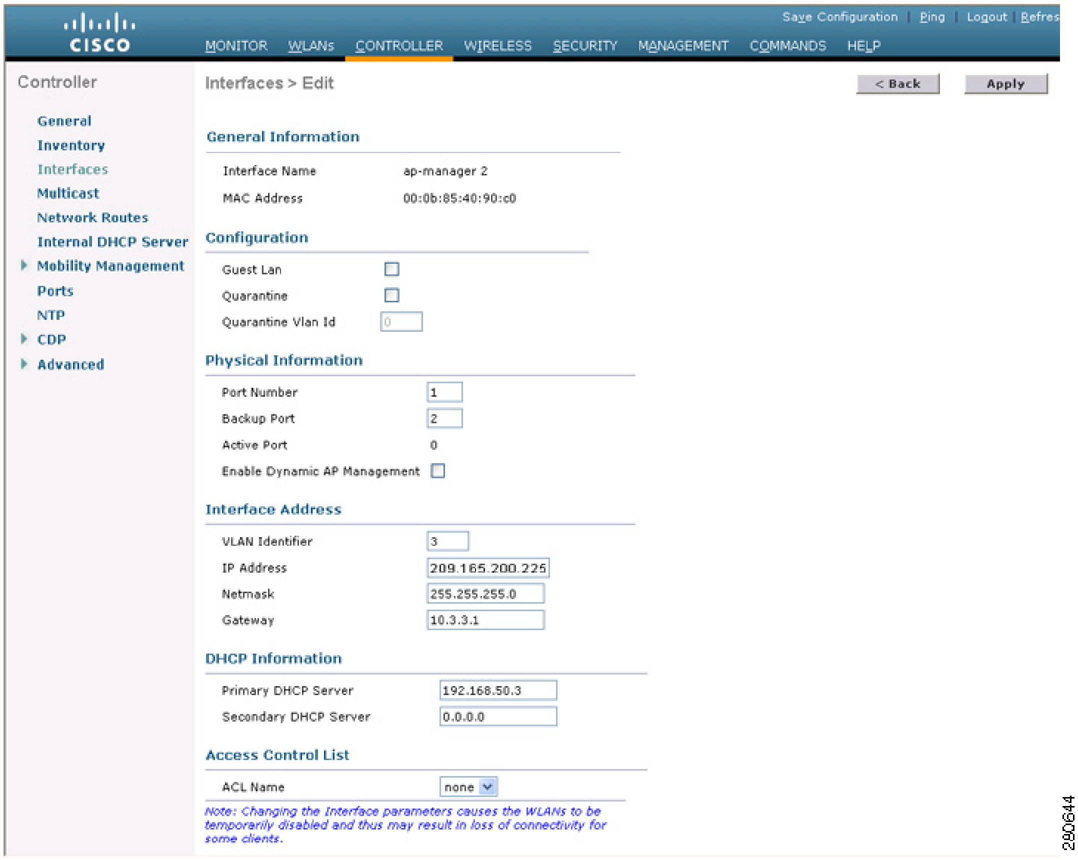
Figure 3-18 Interfaces > New Page



Step 3 Enter an AP-manager interface name and a VLAN identifier, as shown above.

Step 4 Click **Apply** to commit your changes. The Interfaces > Edit page appears (see Figure 3-19).

Figure 3-19 Interfaces > Edit Page



Step 5 Enter the appropriate interface parameters.

> **Note** Do not define a backup port for an AP-manager interface. Port redundancy is not supported for AP-manager interfaces. If the AP-manager interface fails, all of the access points connected to the controller through that interface are evenly distributed among the other configured AP-manager interfaces.

Step 6 To make this interface an AP-manager interface, check the **Enable Dynamic AP Management** check box.

> **Note** Only one AP-manager interface is allowed per physical port. A dynamic interface that is marked as an AP-manager interface cannot be used as a WLAN interface.

Step 7 Click **Save Configuration** to save your settings.

Step 8 Repeat this procedure for each additional AP-manager interface that you want to create.

Using the CLI to Create Multiple AP-Manager Interfaces

Using the controller CLI, follow these steps to create multiple AP-manager interfaces.

Step 1 Enter these commands to create a new interface:

- **config interface create** *operator_defined_interface_name* {*vlan_id* | ***x***}
- **config interface address** *operator_defined_interface_name ip_addr ip_netmask* [*gateway*]
- **config interface vlan** *operator_defined_interface_name* {*vlan_id* | **0**}
- **config interface port** *operator_defined_interface_name physical_ds_port_number*
- **config interface dhcp** *operator_defined_interface_name ip_address_of_primary_dhcp_server* [*ip_address_of_secondary_dhcp_server*]
- **config interface quarantine vlan** *interface_name vlan_id*

  Note Use this command to configure a quarantine VLAN on any interface.

- **config interface acl** *operator_defined_interface_name access_control_list_name*

  Note See the *Configuring Security Solutions* chapter for more information on ACLs.

Step 2 To make this interface an AP-manager interface, enter this command:

config interface ap-manager *operator_defined_interface_name* {**enable** | **disable**}

Note Only one AP-manager interface is allowed per physical port. A dynamic interface that is marked as an AP-manager interface cannot be used as a WLAN interface.

Step 3 To save your changes, enter this command:

save config

Step 4 Repeat this procedure for each additional AP-manager interface that you want to create.

5500 Series Controller Example

For a 5500 series controller, Cisco recommends having eight dynamic AP-manager interfaces and associating them to the controller's eight Gigabit ports. If you are using the management interface, which acts like an AP-manager interface by default, you need to create only 7 more dynamic AP-manager interfaces and associate them to the remaining seven Gigabit ports. For example, Figure 3-20 shows a dynamic interface that is enabled as a dynamic AP-manager interface and associated to port number 2, and Figure 3-20 shows a 5500 series controller with LAG disabled, the management interface used as one dynamic AP-manager interface, and seven additional dynamic AP-manager interfaces, each mapped to a different Gigabit port.

Figure 3-20 Dynamic Interface Example with Dynamic AP Management

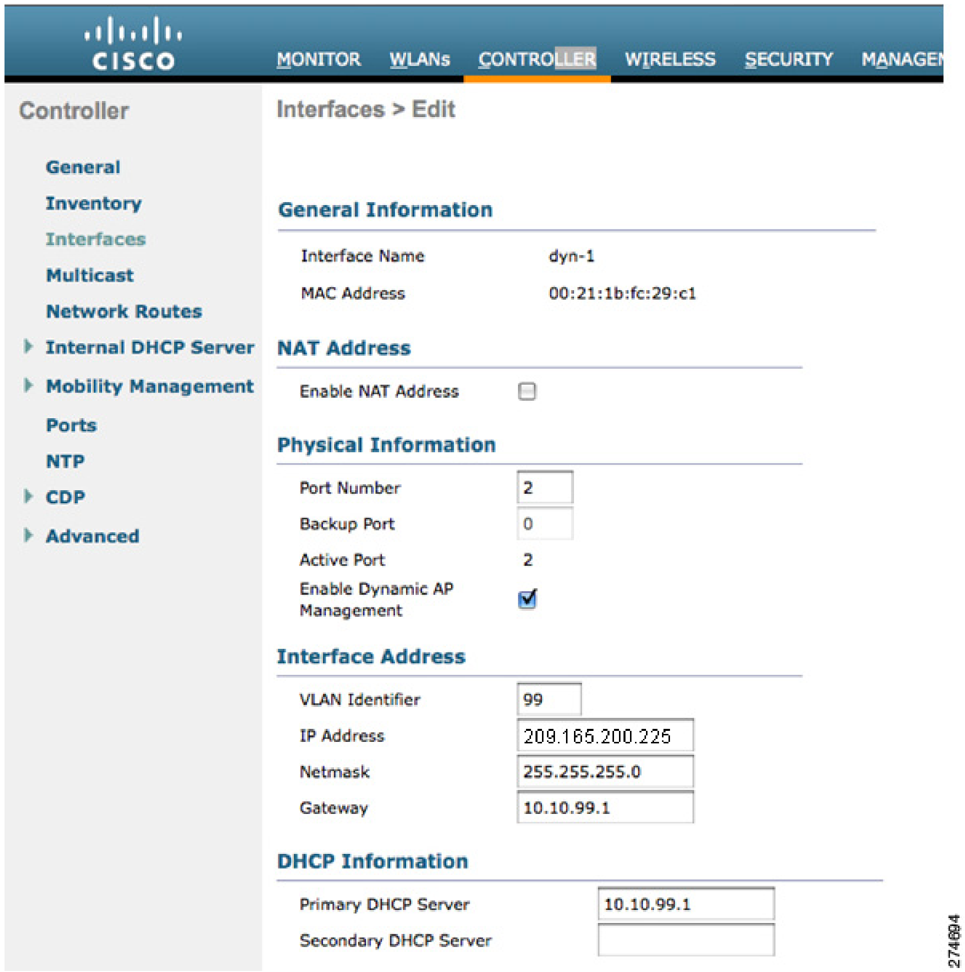
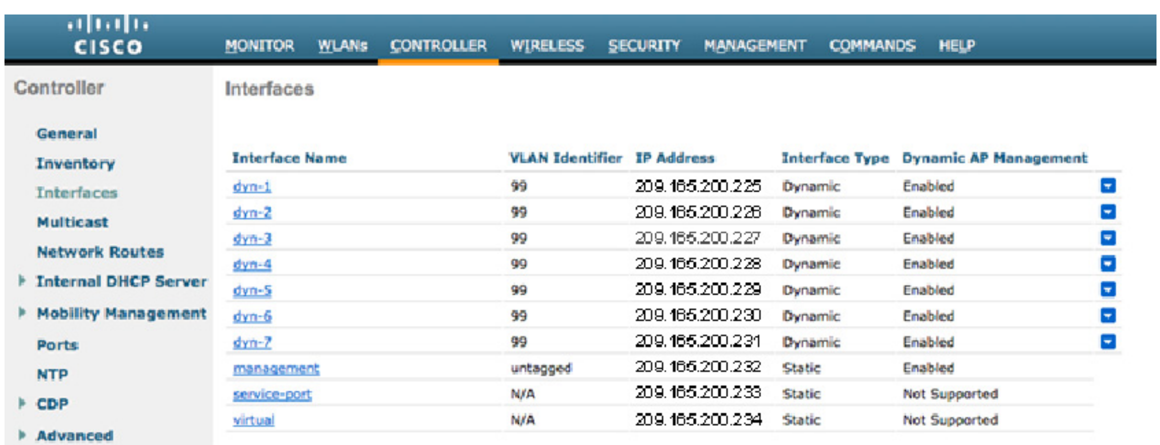
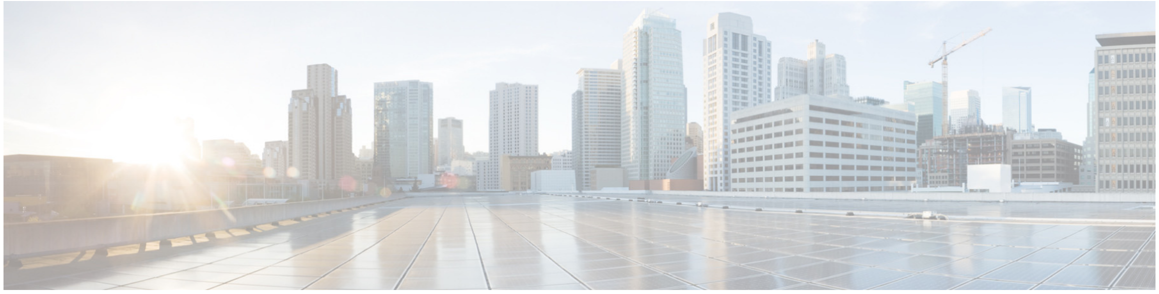


Figure 3-21 5500 Series Controller Interface Configuration Example





4

Configuring Controller Settings

This chapter describes how to configure settings on the controller. It contains these sections:

Installing and Configuring Licenses

Note All features included in a WPlus license are now included in the base license in controller releases 6.0.195.0 and later. These WPlus license features are included in the base license:
- Office Extend AP
- Enterprise Mesh
- CAPWAP Data Encryption
This licensing change can affect features on your wireless LAN when you upgrade or downgrade software releases, so you should be aware of these guidelines:
- If you have a WPlus license and you upgrade from 6.0.18x to 6.0.195.0 or later: Your license file contains both Basic and WPlus license features. You won't see any disruption in feature availability and operation.
- If you have a WPlus license and you downgrade from 6.0.195.0 to 6.0.188 or 6.0.182: The license file in 6.0.195.0 contains both Basic and WPlus license features, so you won't see any disruption in feature availability and operation.
- If you have a base license and you downgrade from 6.0.195.0 to 6.0.188 or 6.0.182: When you downgrade, you lose all WPlus features.

Note Some references to WPlus licenses remain in the controller CLI and GUI in release 6.0.195.0. However, WPlus license features have been included in the Base license, so you can ignore those references.

Two types of licenses are required in order to use the 5500 series controllers in releases 6.0.188.0 and earlier:

- An image-based license (base or wplus), which determines the feature set that the controller uses
- An ap-count license (base-ap-count or wplus-ap-count), which determines the number of access points that the controller supports (12, 25, 50, 100, or 250)

Note These controller platforms do not require licenses: 2100 and 4400 series controllers, Cisco WiSMs, Controller Network Modules, and Catalyst 3750G Integrated Wireless LAN Controller Switches.

The base license supports the standard base software set, and the wplus license supports the premium wireless plus (wplus) software set. The wplus software set provides the standard base feature set as well as this functionality:

- Datagram Transport Layer Security (DTLS) data encryption for added security across remote WAN and LAN links

  Note Refer to the "Configuring Data Encryption" section on page 4 for more information on data encryption.

- Support for OfficeExtend access points, which are used for secure mobile teleworking

  Note Refer to the "OfficeExtend Access Points" section on page 50 for more information on OfficeExtend access points.

- Support for the 1130AG and 1240AG series indoor mesh access points, which dynamically establish wireless connections in locations where it might be difficult to connect to the wired network

> **Note** Cisco Aironet 1520 series outdoor mesh access points can be used with the 5500 series controller without a wplus license.

> **Note** Refer to the *Controlling Mesh Access Points* chapter for more information about mesh access points.

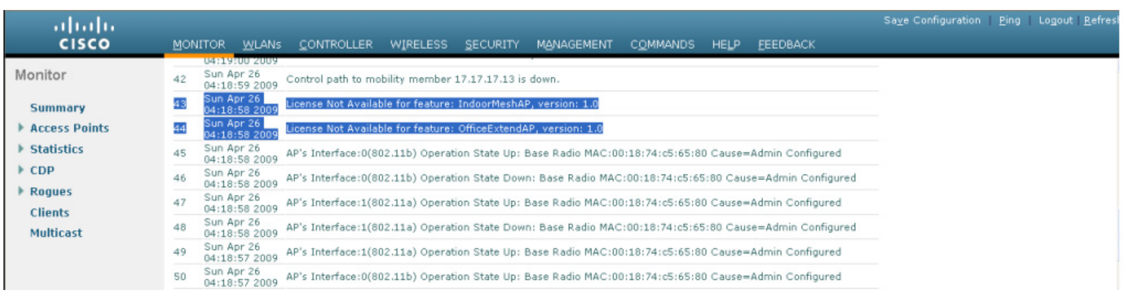
Data-encrypted, OfficeExtend, and indoor mesh access points can join a 5500 series controller only if the wplus license is installed on the controller. If the wplus license is not installed, the access points cannot join the controller, and one of the following messages appears in the controller trap log:

- "Data DTLS: AP Configured for Data DTLS but license not available"
- "License Not Available for feature: IndoorMeshAP"
- "License Not Available for feature: OfficeExtendAP"

To view the controller trap log, choose **Monitor** and click **View All** under "Most Recent Traps" on the controller GUI (see Figure 1).

> **Note** You can also view traps by using SNMP-based management tools.

Figure 1 Trap Logs Page



251614

The ap-count licenses and their corresponding image-based licenses are installed together. For example, the base-ap-count license is installed with the base license, and the wplus-ap-count license is installed with the wplus license. The controller keeps track of the licensed access point count and does not allow more than that number of access points to associate to it.

The 5500 series controller is shipped with both permanent and evaluation base and base-ap-count licenses, evaluation wplus and wplus-ap-count licenses, and if you ordered the wplus software set, permanent wplus and wplus-ap-count licenses. It is configured to use the permanent base or permanent wplus licenses, depending on the feature set ordered. If desired, you can activate the evaluation licenses, which are designed for temporary use and set to expire after 60 days.

> **Note** Refer to the "Choosing the Licensed Feature Set" section on page 15 for instructions on activating an image-based evaluation license and the "Activating an AP-Count Evaluation License" section on page 18 for instructions on activating an ap-count evaluation license.

No licensing steps are required after you receive your 5500 series controller because the licenses you ordered are installed at the factory. In addition, licenses and product authorization keys (PAKs) are pre-registered to serial numbers. However, as your wireless network evolves, you might want to add support for additional access points or upgrade from the standard software set to the wplus software set. To do so, you need to obtain and install an upgrade license.

Obtaining an Upgrade License

A certificate with a product authorization key (PAK) is required before you can obtain an upgrade license for either the standard or wplus software.

You can upgrade your controller's access point count only to one of the approved tiers (25, 50, 100, or 250), and you must upgrade from one tier to the next without skipping any tiers. For example, if you have a base-ap-count or wplus-ap-count license with a 12-access-point count and want to upgrade to 100 access point support, you need to buy a -25U, -50U, and -100U upgrade license. The license with the greatest access point count represents the total number of access points supported by your controller. In the previous example, the -100U upgrade license is the license with the greatest access point count, so the controller would support up to 100 access points.

Note If you skip any tiers when upgrading (for example, if you do not install the -25U and -50U licenses along with the -100U), the license registration fails.

For a single controller, you can order different upgrade licenses in one transaction (for example, -25U, -50U, -100U, and -250U), for which you receive one PAK with one license. Then you have only one license (instead of four) to install on your controller.

If you have multiple controllers and want to upgrade all of them, you can order multiple quantities of each upgrade license in one transaction (for example, you can order 10 each of the -25U, -50U, -100U, and -250 upgrade licenses), for which you receive one PAK with one license. You can continue to register the PAK for multiple controllers until it is exhausted.

Note You cannot install a wplus license that has an access point count greater than the controller's base license. For example, you cannot apply a wplus-ap-count 100 license to a controller with an existing base-ap-count 12 license. If you attempt to register for such a license, an error message appears indicating that the license registration has failed. Before upgrading to a wplus-ap-count 100 license, you would first have to upgrade the controller to a base-ap-count 100 or 250 license.

Follow these steps to obtain and register a PAK certificate.

Step 1 Order the PAK certificate for an upgrade license through your Cisco channel partner or your Cisco sales representative, or order it online at this URL:

http://www.cisco.com/go/ordering

Step 2 If you are ordering online, begin by choosing the primary upgrade SKU **L-LIC-CT5508-UPG**. Then choose any number of the following options to upgrade one or more controllers under one PAK:

- **L-LIC-CT5508-25U**—5500 series controller 12 to 25 access point upgrade license.
- **L-LIC-CT5508-50U**—5500 series controller 25 to 50 access point upgrade license.
- **L-LIC-CT5508-100U**—5500 series controller 50 to 100 access point upgrade license.
- **L-LIC-CT5508-250U**—5500 series controller 100 to 250 access point upgrade license.

- **L-LIC-WPLUS-12**—wplus feature license for up to 12 Cisco access points.
- **L-LIC-WPLUS-25**—wplus feature license for up to 25 Cisco access points.
- **L-LIC-WPLUS-50**—wplus feature license for up to 50 Cisco access points.
- **L-LIC-WPLUS-100**—wplus feature license for up to 100 Cisco access points.
- **L-LIC-WPLUS-250**—wplus feature license for up to 250 Cisco access points.
- **L-LIC-WPLUS-25U**—wplus feature license upgrade for 12 to 25 Cisco access points.
- **L-LIC-WPLUS-50U**—wplus feature license upgrade for 25 to 50 Cisco access points.
- **L-LIC-WPLUS-100U**—wplus feature license upgrade for 50 to 100 Cisco access points.
- **L-LIC-WPLUS-250U**—wplus feature license upgrade for 100 to 250 Cisco access points.

When you use these SKUs, your certificate is delivered to you by email.

Note If you require a paper certificate for Customs, order it without the "L-" in the SKU (for example, LIC-WPLUS-250U) and choose to ship it using US mail.

Step 3 After you receive the certificate, use one of two methods to register the PAK:

- **Cisco License Manager (CLM)**—This method automates the process of obtaining licenses and deploying them on Cisco devices. For deployments with more than five controllers, Cisco recommends using CLM to register PAKs and install licenses. You can also use CLM to rehost or RMA a license.

  Note You cannot use CLM to change the licensed feature set or activate an ap-count evaluation license. To perform these operations, you must follow the instructions in the "Choosing the Licensed Feature Set" section on page 15 and the "Activating an AP-Count Evaluation License" section on page 18. Because you can use CLM to perform all other license operations, you can disregard the remaining licensing information in this chapter except these two sections and the "Configuring the License Agent" section on page 27 if you want your controller to use HTTP to communicate with CLM.

  Note You can download the CLM software and access user documentation at this URL:

  http://www.cisco.com/go/clm

- **Licensing portal**—This alternative method enables you to manually obtain and install licenses on your controller. If you want to use the licensing portal to register the PAK, follow the instructions in Step 4.

Step 4 To use the licensing portal to register the PAK, follow these steps:

a. Go to http://www.cisco.com/go/license

b. On the main Product License Registration page, enter the PAK mailed with the certificate in the Product Authorization Key (PAK) field and click **Submit**.

c. On the Validate Features page, enter the number of licenses that you want to register in the Qty field and click **Update**.

d. To determine the controller's product ID and serial number, choose **Controller** > **Inventory** on the controller GUI or enter the **show license udi** command on the controller CLI.

   Information similar to the following appears on the controller CLI:

```
Device# PID                    SN                     UDI
------- -------------------- ---------------------- --------------------------------
*0      AIR-CT5508-K9         FCW1308L030            AIR-CT5508-K9:FCW1308L030
```

e. On the Designate Licensee page, enter the product ID and serial number of the controller on which you plan to install the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the fields on this page, and click **Submit**.

f. On the Finish and Submit page, verify that all information is correct and click **Submit**.

g. When a message appears indicating that the registration is complete, click **Download License**. The license is emailed within 1 hour to the address you specified.

h. When the email arrives, follow the instructions provided.

i. Copy the license file to your TFTP server.

j. Follow the instructions in the "Installing a License" section below to install the license on your controller.

Installing a License

You can use the controller GUI or CLI to install a license on a 5500 series controller.

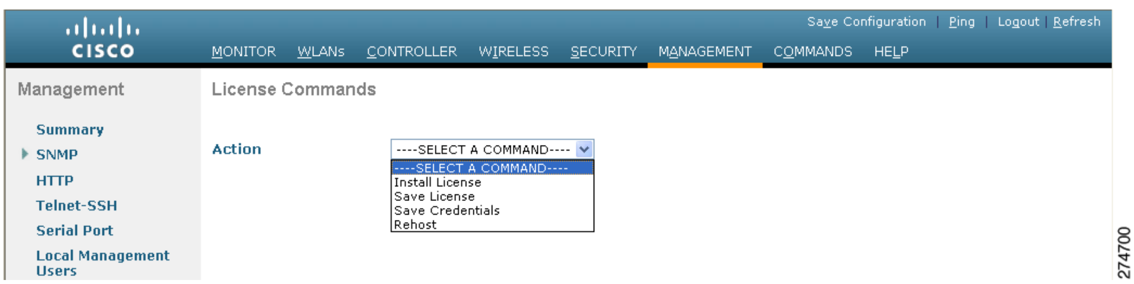
Note Cisco recommends that the access point count be the same for the base-ap-count and wplus-ap-count licenses installed on your controller. If your controller has a base-ap-count license of 100 and you install a wplus-ap-count license of 12, the controller supports up to 100 access points when the base license is in use but only a maximum of 12 access points when the wplus license is in use.

Using the GUI to Install a License

Using the controller GUI, follow these steps to install a license on the controller.

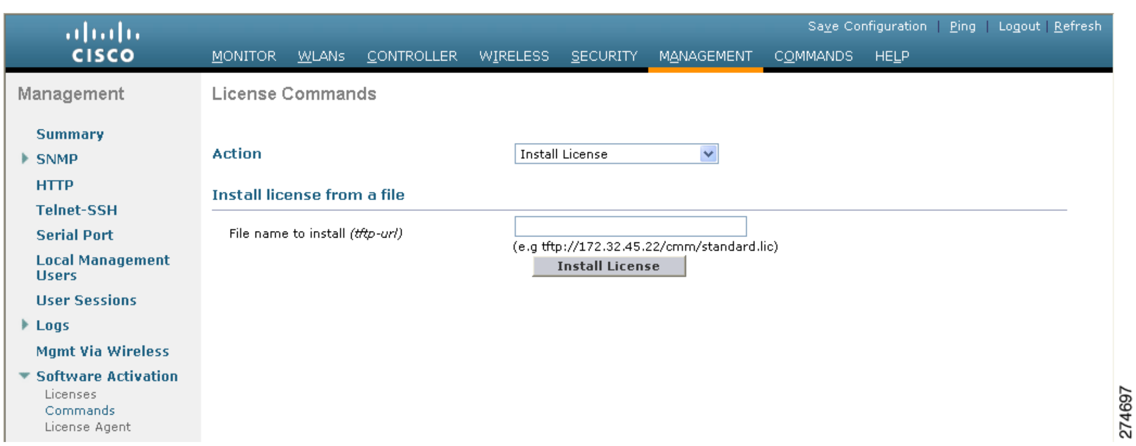
Step 1 Choose **Management** > **Software Activation** > **Commands** to open the License Commands page (see Figure 2).

Figure 2 ***License Commands Page***



Step 2 From the Action drop-down box, choose **Install License**. The Install License from a File section appears (see Figure 3).

Figure 3 ***License Commands (Install License) Page***



Step 3 In the File Name to Install field, enter the path to the license (*.lic) on the TFTP server.

Step 4 Click **Install License**. A message appears to show whether the license was installed successfully. If the installation fails, the message provides the reason for the failure, such as the license is an existing license, the path was not found, the license does not belong to this device, you do not have correct permissions for the license, and so on.

Step 5 If the end-user license agreement (EULA) acceptance window appears, read the agreement and click **Accept** to accept the terms of the agreement.

> **Note** Typically you are prompted to accept the EULA for evaluation, extension, and rehost licenses. The EULA is also required for permanent licenses, but it is accepted during license generation.

Step 6 To save a backup copy of all installed licenses, follow these steps:

a. From the Action drop-down box, choose **Save License**.

b. In the File Name to Save field, enter the path on the TFTP server where you want the licenses to be saved.

> **Note** You cannot save evaluation licenses.

c. Click **Save Licenses**.

Step 7 Reboot the controller.

Step 8 Follow the instructions in the "Viewing Licenses" section on page 10 to see the status of the license that you installed.

Step 9 If the desired license is not being used by the controller, follow the instructions in the "Choosing the Licensed Feature Set" section on page 15 or the "Activating an AP-Count Evaluation License" section on page 18 to change the license that is used by the controller.

Using the CLI to Install a License

Using the controller CLI, follow these steps to install a license on the controller.

Step 1 To install a license on the controller, enter this command:

license install *url*

where *url* is tftp://*server_ip*/*path*/*filename*.

> **Note** To remove a license from the controller, enter this command: **license clear** *license_name*. For example, you might want to delete an expired evaluation license or any unused license. You cannot delete unexpired evaluation licenses, the permanent base image license, or licenses that are in use by the controller.

Step 2 If you are prompted to accept the end-user license agreement (EULA), read and accept the terms of the agreement.

> **Note** Typically you are prompted to accept the EULA for evaluation, extension, and rehost licenses. The EULA is also required for permanent licenses, but it is accepted during license generation.

Step 3 To add comments to a license or delete comments from a license, enter this command:

license comment {**add** | **delete**} *license_name comment_string*

Step 4 To save a backup copy of all installed licenses, enter this command:

license save *url*

where *url* is tftp://*server_ip*/*path*/*filename*.

Step 5 To reboot the controller, enter this command:

reset system

Step 6 Follow the instructions in the "Viewing Licenses" section on page 10 to see the status of the license you installed.

Step 7 If the desired license is not being used by the controller, follow the instructions in the "Choosing the Licensed Feature Set" section on page 15 or the "Activating an AP-Count Evaluation License" section on page 18 to change the license that is used by the controller.

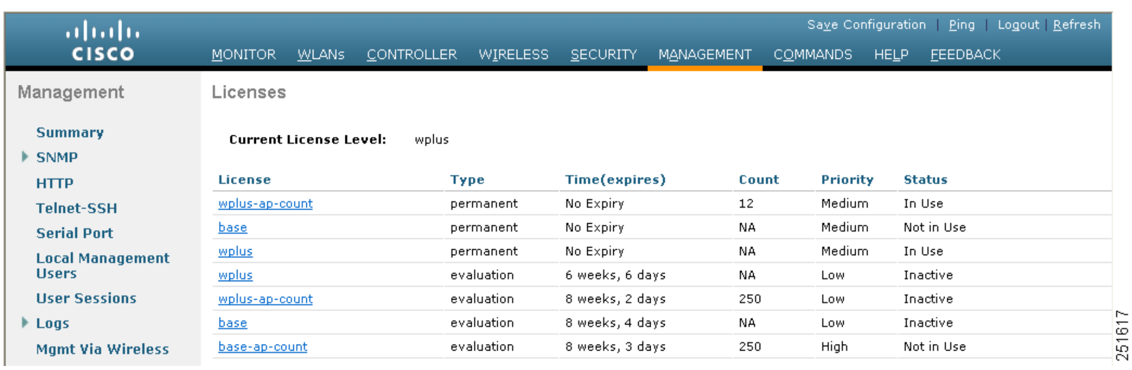
Viewing Licenses

Using the GUI to View Licenses

Using the controller GUI, follow these steps to view licenses on the controller.

Step 1 Choose **Management** > **Software Activation** > **Licenses** to open the Licenses page (see Figure 4).

Figure 4 Licenses Page

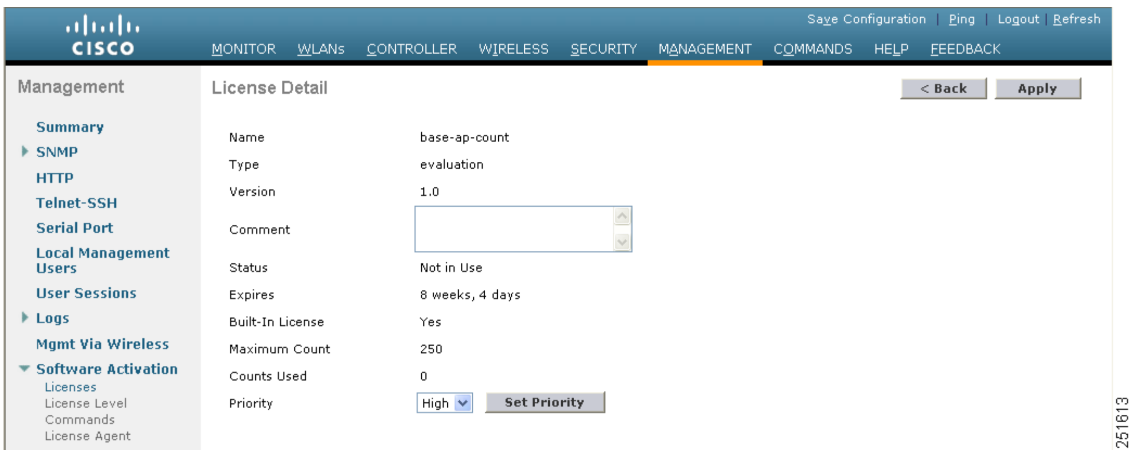


This page lists all of the licenses installed on the controller. For each license, it shows the license type (permanent, evaluation, or extension), expiration, count (the maximum number of access points allowed for this license), priority (low, medium, or high), and status (in use, not in use, inactive, or EULA not accepted).

Note If you ever want to remove a license from the controller, hover your cursor over the blue drop-down arrow for the license and click **Remove**. For example, you might want to delete an expired evaluation license or any unused license. You cannot delete unexpired evaluation licenses, the permanent base image license, or licenses that are in use by the controller.

Step 2 To view more details for a particular license, click the link for the desired license. The License Detail page appears (see Figure 5).

Figure 5 License Detail Page



This page shows the following additional information for the license:

- The license type (permanent, evaluation, or extension)
- The license version
- The status of the license (in use, not in use, inactive, or EULA not accepted)
- The length of time before the license expires

Note Permanent licenses never expire.

- Whether the license is a built-in license
- The maximum number of access points allowed for this license
- The number of access points currently using this license

Step 3 If you want to enter a comment for this license, type it in the Comment field and click **Apply**.

Step 4 Click **Save Configuration**.

Using the CLI to View Licenses

Enter these CLI commands to view licenses on the controller.

- To see the license level, license type, and number of access points licensed on the controller, enter this command:

  show sysinfo

  Information similar to the following appears:

```
Product Name.................................... Cisco Controller
Product Version................................. 6.0.118.0
...
Current Boot License Level...................... wplus
Current Boot License Type....................... Permanent
Next Boot License Level......................... wplus
Next Boot License Type.......................... Permanent
...
Power Supply 1.................................. Not Available
Power Supply 2.................................. Not Available
Maximum number of APs supported............... 250
```

- To see a brief summary of all active licenses installed on the controller, enter this command:

  show license summary

  Information similar to the following appears:

```
Index 1 Feature: wplus
        Period left: Life time
        License Type: Permanent
        License State: Active, In Use
        License Count: Non-Counted
        License Priority: Medium
Index 2 Feature: wplus-ap-count
        Period left: Life time
        License Type: Permanent
        License State: Active, In Use
        License Count: 12/12/0
        License Priority: Medium
Index 3 Feature: base
        Period left: Life time
        License Type: Permanent
        License State: Active, Not in Use
        License Count: Non-Counted
        License Priority: Medium
Index 4 Feature: base-ap-count
        Period left:  8 weeks  3 days
        License Type: Evaluation
        License State: Active, Not in Use, EULA accepted
         License Count: 250/0/0
        License Priority: High
```

- To see all of the licenses installed on the controller, enter this command:

  show license all

  Information similar to the following appears:

```
License Store: Primary License Storage
StoreIndex:  0  Feature: wplus-ap-count   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: 12/12/0
        License Priority: Medium
```

```
StoreIndex:  1  Feature: base   Version: 1.0
        License Type: Permanent
        License State: Active, Not in Use
        License Count: Non-Counted
        License Priority: Medium
StoreIndex:  2  Feature: wplus   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: Non-Counted
        License Priority: Medium
License Store: Evaluation License Storage
StoreIndex:  0  Feature: wplus   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  6 weeks  6 days
         License Count: Non-Counted
        License Priority: Low
StoreIndex:  1  Feature: wplus-ap-count   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  2 days
        License Count: 250/0/0
        License Priority: Low
StoreIndex:  2  Feature: base   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  4 days
        License Count: Non-Counted
        License Priority: Low
StoreIndex:  3  Feature: base-ap-count   Version: 1.0
        License Type: Evaluation
        License State: Active, Not in Use, EULA accepted
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  3 days
        License Count: 250/0/0
        License Priority: High
```

- To see the details for a particular license, enter this command:

  show license detail *license_name*

  Information similar to the following appears:

```
Index:  1       Feature: base-ap-count   Version: 1.0
        License Type: Permanent
        License State: Active, Not in Use
        License Count: 12/0/0
        License Priority: Medium
        Store Index: 0
        Store Name: Primary License Storage
Index:  2       Feature: base-ap-count   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  4 days
        License Count: 250/0/0
        License Priority: Low
        Store Index: 3
        Store Name: Evaluation License Storage
```

- To see all expiring, evaluation, permanent, or in-use licenses, enter this command:

  show license {**expiring** | **evaluation** | **permanent** | **in-use**}

  Information similar to the following appears for the **show license in-use** command:

```
StoreIndex:  2  Feature: wplus-ap-count   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: 12/12/0
        License Priority: Medium
StoreIndex:  3  Feature: wplus   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: Non-Counted
        License Priority: Medium
```

- To see the maximum number of access points allowed for this license on the controller, the number of access points currently joined to the controller, and the number of access points that can still join the controller, enter this command:

  show license capacity

  Information similar to the following appears:

```
Licensed Feature    Max Count         Current Count     Remaining Count
----------------- --------------- ------------------- --------------------
AP Count            250               47                203
```

- To see statistics for all licenses on the controller, enter this command:

  show license statistics

  Information similar to the following appears:

```
Administrative statistics
        Install success count:       2
        Install failure count:       0
        Install duplicate count:     0
        Comment add count:           0
        Comment delete count:        0
        Clear count:                 0
        Save count:                  2
        Save cred count:             0
Client status
        Request success count     2
        Request failure count     0
        Release count             0
        Global Notify count     6
```

- To see a summary of license-enabled features, enter this command:

  show license feature

  Information similar to the following appears:

```
       Feature name    Enforcement  Evaluation  Clear Allowed  Enabled
              wplus         yes         yes            yes      yes
     wplus-ap-count         yes         yes            yes      yes
               base          no         yes            yes      no
      base-ap-count         yes         yes            yes      no
```

Choosing the Licensed Feature Set

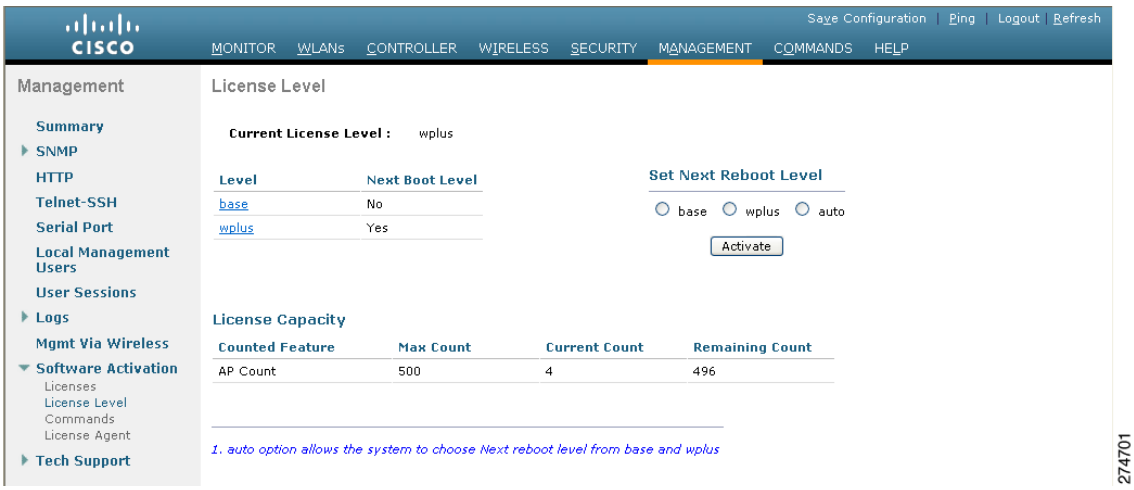
You can configure the controller to specify which feature set it uses (base or wplus). Only the base or wplus license can be active at a time. The currently active license determines the feature set and number of access points supported on the controller.

Using the GUI to Choose the Licensed Feature Set

Using the controller GUI, follow these steps to specify which feature set the controller uses.

Step 1 Choose **Management** > **Software Activation** > **License Level** to open the License Level page (see Figure 6).

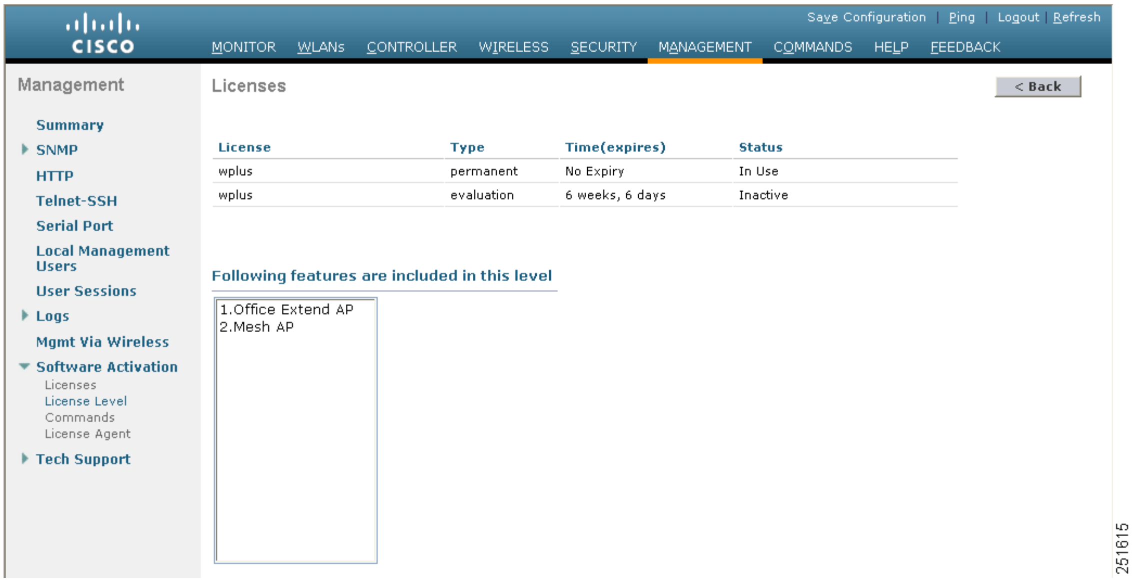
Figure 6 License Level Page



This page shows the current license level (base or wplus) and the level to be used after the next controller reboot. It also shows the maximum number of access points allowed by the license on the controller, the number of access points currently joined to the controller, and the number of access points that can still join the controller.

Step 2 To learn more about the available license levels, click the **base** or **wplus** license level link to open the Licenses page (see Figure 7).

Figure 7 Licenses Page



This page shows the licenses applicable to this level and the list of features supported.

Step 3 Click **Back** to return to the License Level page.

Step 4 If you want to change the license level, follow these steps:

a. Choose the license level to be used on the next reboot: **base**, **wplus**, or **auto**. If you choose **auto**, the licensing software automatically chooses the license level to use on the next reboot. It chooses permanent licenses over evaluation licenses and wplus licenses over base licenses.

Note If you are considering upgrading from a base license to a wplus license, you can try an evaluation wplus license before upgrading to a permanent wplus license. To activate the evaluation license, you need to set the image level to **wplus** in order for the controller to use the wplus evaluation license instead of the base permanent license.

Note To prevent disruptions in operation, the controller does not switch licenses when an evaluation license expires. You must reboot the controller in order to return to a permanent license. Following a reboot, the controller defaults to the same feature set level as the expired evaluation license. If no permanent license at the same feature set level is installed, the controller uses a permanent license at another level or an unexpired evaluation license. If no valid licenses are installed, the controller can always operate in base level.

b. Click **Activate**.

c. Click **OK** when prompted to confirm your decision to change the license level on the next reboot.

d. If you are prompted to accept the end-user license agreement (EULA), read and accept the terms of the agreement and then click **Accept**.. The Next Boot Level field now shows the license level that you specified as the level to be used after the next controller reboot.

e. Reboot the controller so that the specified license level takes effect.

Using the CLI to Choose the Licensed Feature Set

Using the controller CLI, follow these steps to specify the feature set that the controller uses.

Step 1 To see the current license level (base or wplus) and the level to be used after the next controller reboot, enter this command:

show sysinfo

Information similar to the following appears:

```
Product Name..................................... Cisco Controller
Product Version.................................. 6.0.118.0
...
Current Boot License Level....................... wplus
Current Boot License Type........................ Permanent
Next Boot License Level.......................... wplus
Next Boot License Type........................... Permanent
...
```

Step 2 To specify the license level to be used on the next reboot, enter this command:

config license boot {**base** | **wplus** | **auto**}

If you choose **auto**, the licensing software automatically chooses the license level to use on the next reboot. It chooses permanent licenses over evaluation licenses and wplus licenses over base licenses.

Note If you are considering upgrading from a base license to a wplus license, you can try an evaluation wplus license before upgrading to a permanent wplus license. To activate the evaluation license, you need to set the image level to **wplus** in order for the controller to use the wplus evaluation license instead of the base permanent license.

Note To prevent disruptions in operation, the controller does not switch licenses when an evaluation license expires. You must reboot the controller in order to return to a permanent license. Following a reboot, the controller defaults to the same feature set level as the expired evaluation license. If no permanent license at the same feature set level is installed, the controller uses a permanent license at another level or an unexpired evaluation license.

Step 3 If you are prompted to accept the end-user license agreement (EULA), read and accept the terms of the agreement. The EULA appears if no permanent licenses are installed at the specified boot level and the evaluation license has not yet been activated. In this case, the **config license boot** command changes the license level and activates the evaluation license following a reboot.

Step 4 To see the license level to be used after the next controller reboot, enter this command:

show sysinfo

Step 5 To reboot the controller in order to have your changes take effect, enter this command:

reset system

Activating an AP-Count Evaluation License

If you are considering upgrading to a license with a higher access point count, you can try an evaluation license before upgrading to a permanent version of the license. For example, if you are using a permanent license with a 50-access-point count and want to try an evaluation license with a 100-access-point count, you can try out the evaluation license for 60 days.

AP-count evaluation licenses are set to low priority by default so that the controller uses the ap-count permanent license. If you want to try an evaluation license with an increased access point count, you must change its priority to high. If you no longer want to have this higher capacity, you can lower the priority of the ap-count evaluation license, thereby forcing the controller to use the permanent license.

Note If the ap-count evaluation license is a wplus license and the ap-count permanent license is a base license, you must also change the feature set to wplus. See the "Choosing the Licensed Feature Set" section on page 15 for instructions.

Note To prevent disruptions in operation, the controller does not switch licenses when an evaluation license expires. You must reboot the controller in order to return to a permanent license. Following a reboot, the controller defaults to the same feature set level as the expired evaluation license. If no permanent license at the same feature set level is installed, the controller uses a permanent license at another level or an unexpired evaluation license.

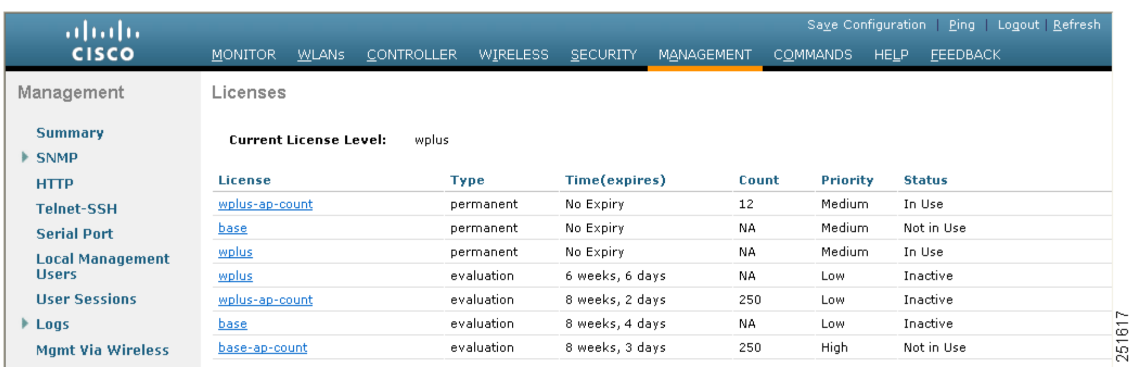
You can activate ap-count evaluation licenses using the controller GUI or CLI.

Using the GUI to Activate an AP-Count Evaluation License

Using the controller GUI, follow these steps to activate an ap-count evaluation license.

Step 1 To see the current status of all the licenses on your controller, choose **Management > Software Activation > Licenses** to open the Licenses page (see Figure 8).

Figure 8 Licenses Page

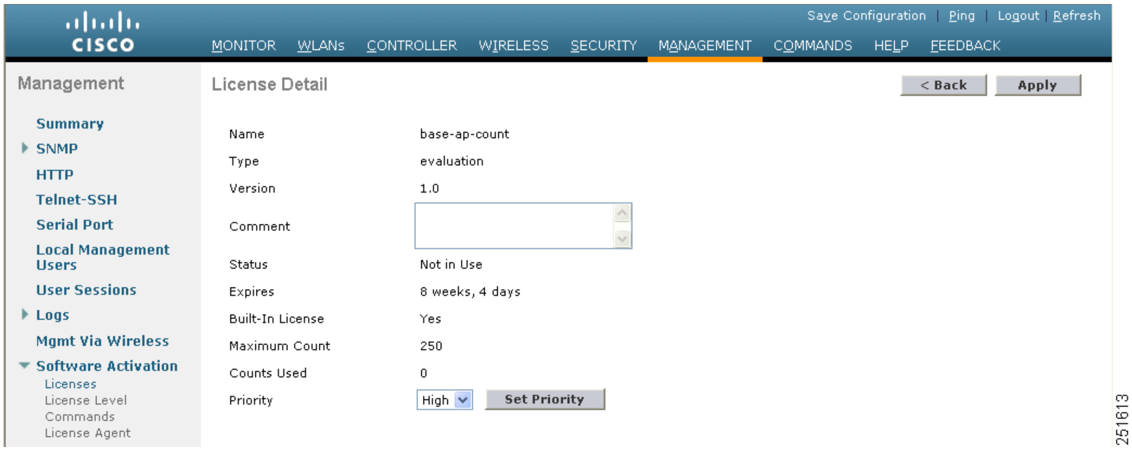


The Status column shows which licenses are currently in use, and the Priority column shows the current priority of each license.

Step 2 To activate an ap-count evaluation license, follow these steps:

a. Click the link for the ap-count evaluation license that you want to activate. The License Detail page appears (see Figure 9).

Figure 9 License Detail Page



b. Choose **High** from the Priority drop-down box and click **Set Priority**.

Note You can set the priority only for ap-count evaluation licenses. AP-count permanent licenses always have a medium priority, which cannot be configured.

c. Click **OK** when prompted to confirm your decision about changing the priority of the license.

d. When the EULA appears, read the terms of the agreement and then click **Accept**.

e. When prompted to reboot the controller, click **OK**.

f. Reboot the controller in order for the priority change to take effect.

g. Click **Licenses** to open the Licenses page and verify that the ap-count evaluation license now has a high priority and is in use. You can use the evaluation license until it expires.

Step 3 If you decide to stop using the ap-count evaluation license and want to revert to using an ap-count permanent license, follow these steps:

a. On the Licenses page, click the link for the ap-count evaluation license that is in use.

b. Choose **Low** from the Priority drop-down box and click **Set Priority**.

Note You can set the priority only for ap-count evaluation licenses. AP-count permanent licenses always have a medium priority, which cannot be configured.

c. Click **OK** when prompted to confirm your decision about changing the priority of the license.

d. When the EULA appears, read the terms of the agreement and then click **Accept**.

e. When prompted to reboot the controller, click **OK**.

f. Reboot the controller in order for the priority change to take effect.

g. Click **Licenses** to open the Licenses page and verify that the ap-count evaluation license now has a low priority and is not in use. Instead, the ap-count permanent license should be in use.

Using the CLI to Activate an AP-Count Evaluation License

Using the controller CLI, follow these steps to activate an ap-count evaluation license.

Step 1 To see the current status of all the licenses on your controller, enter this command:

show license all

Information similar to the following appears:

```
License Store: Primary License Storage
StoreIndex:  0  Feature: base-ap-count   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: 12/0/0
        License Priority: Medium
StoreIndex:  1  Feature: base   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: Non-Counted
        License Priority: Medium
StoreIndex:  2  Feature: wplus-ap-count   Version: 1.0
        License Type: Permanent
        License State: Active, Not in Use
        License Count: 12/12/0
        License Priority: Medium
StoreIndex:  3  Feature: wplus   Version: 1.0
        License Type: Permanent
        License State: Active, Not in Use
        License Count: Non-Counted
        License Priority: Medium
License Store: Evaluation License Storage
StoreIndex:  0  Feature: wplus  Version: 1.0
       License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  6 weeks  6 days
        License Count: Non-Counted
        License Priority: Low
StoreIndex:  1  Feature: wplus-ap-count   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  7 weeks  0 day
        License Count: 250/0/0
        License Priority: Low
StoreIndex:  2  Feature: base   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  4 days
        License Count: Non-Counted
        License Priority: Low
```

```
StoreIndex:  3  Feature: base-ap-count   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  4 days
        License Count: 250/0/0
        License Priority: Low
```

The License State field shows the licenses that are in use, and the License Priority field shows the current priority of each license.

Step 2 To activate an ap-count evaluation license, follow these steps:

a. To raise the priority of the base-ap-count or wplus-ap-count evaluation license, enter this command:

license modify priority *license_name* **high**

Note You can set the priority only for ap-count evaluation licenses. AP-count permanent licenses always have a medium priority, which cannot be configured.

b. To reboot the controller in order for the priority change to take effect, enter this command:

reset system

c. To verify that the ap-count evaluation license now has a high priority and is in use, enter this command:

show license all

You can use the evaluation license until it expires.

Step 3 If you decide to stop using the ap-count evaluation license and want to revert to using an ap-count permanent license, follow these steps:

a. To lower the priority of the ap-count evaluation license, enter this command:

license modify priority *license_name* **low**

b. To reboot the controller in order for the priority change to take effect, enter this command:

reset system

c. To verify that the ap-count evaluation license now has a low priority and is not in use, enter this command:

show license all

Instead, the ap-count permanent license should be in use.

Rehosting a License

Revoking a license from one controller and installing it on another is called *rehosting*. You might want to rehost a license in order to change the purpose of a controller. For example, if you want to move your OfficeExtend or indoor mesh access points to a different controller, you could transfer the wplus license from one controller to another.

In order to rehost a license, you must generate credential information from the controller and use it to obtain a permission ticket to revoke the license from the Cisco licensing site. Next, you must obtain a rehost ticket and use it to obtain a license installation file for the controller on which you want to install the license.

Evaluation licenses and the permanent base image license cannot be rehosted.

Note A revoked license cannot be reinstalled on the same controller.

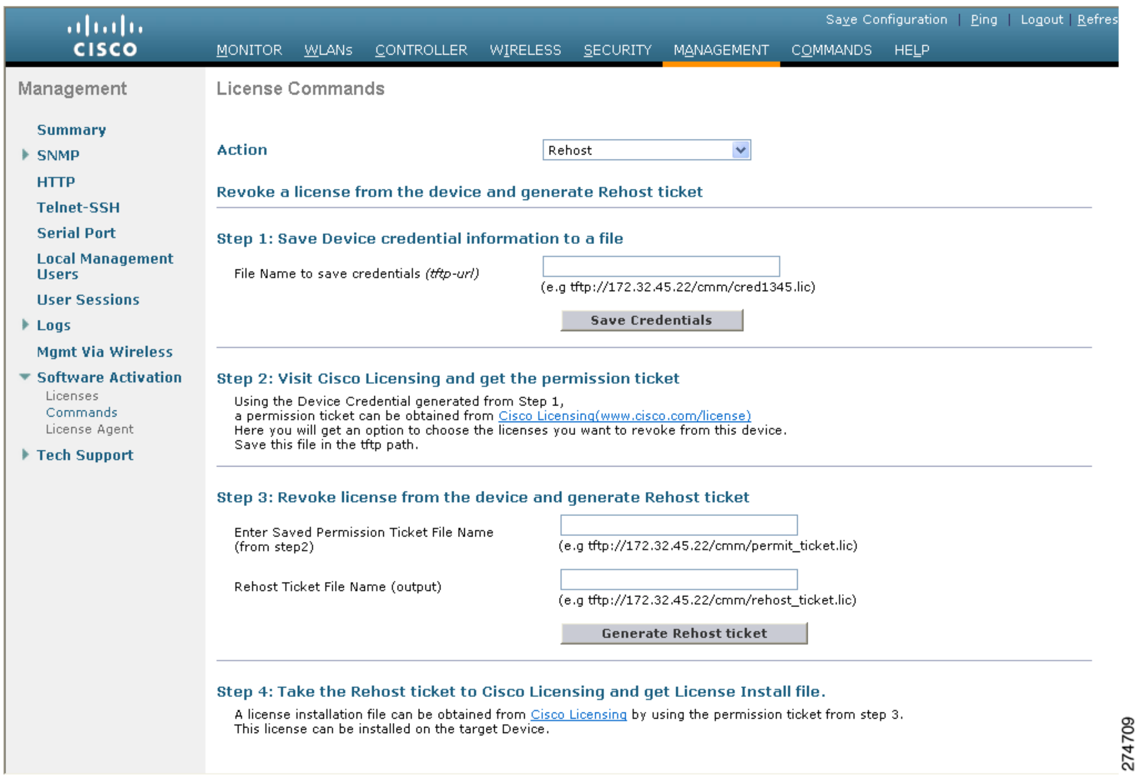
Using the GUI to Rehost a License

Using the controller GUI, follow these steps to rehost a license.

Step 1 Choose **Management** > **Software Activation** > **Commands** to open the License Commands page.

Step 2 From the Action drop-down box, choose **Rehost**. The Revoke a License from the Device and Generate Rehost Ticket section appears (see Figure 10).

Figure 10 License Commands (Rehost) Page

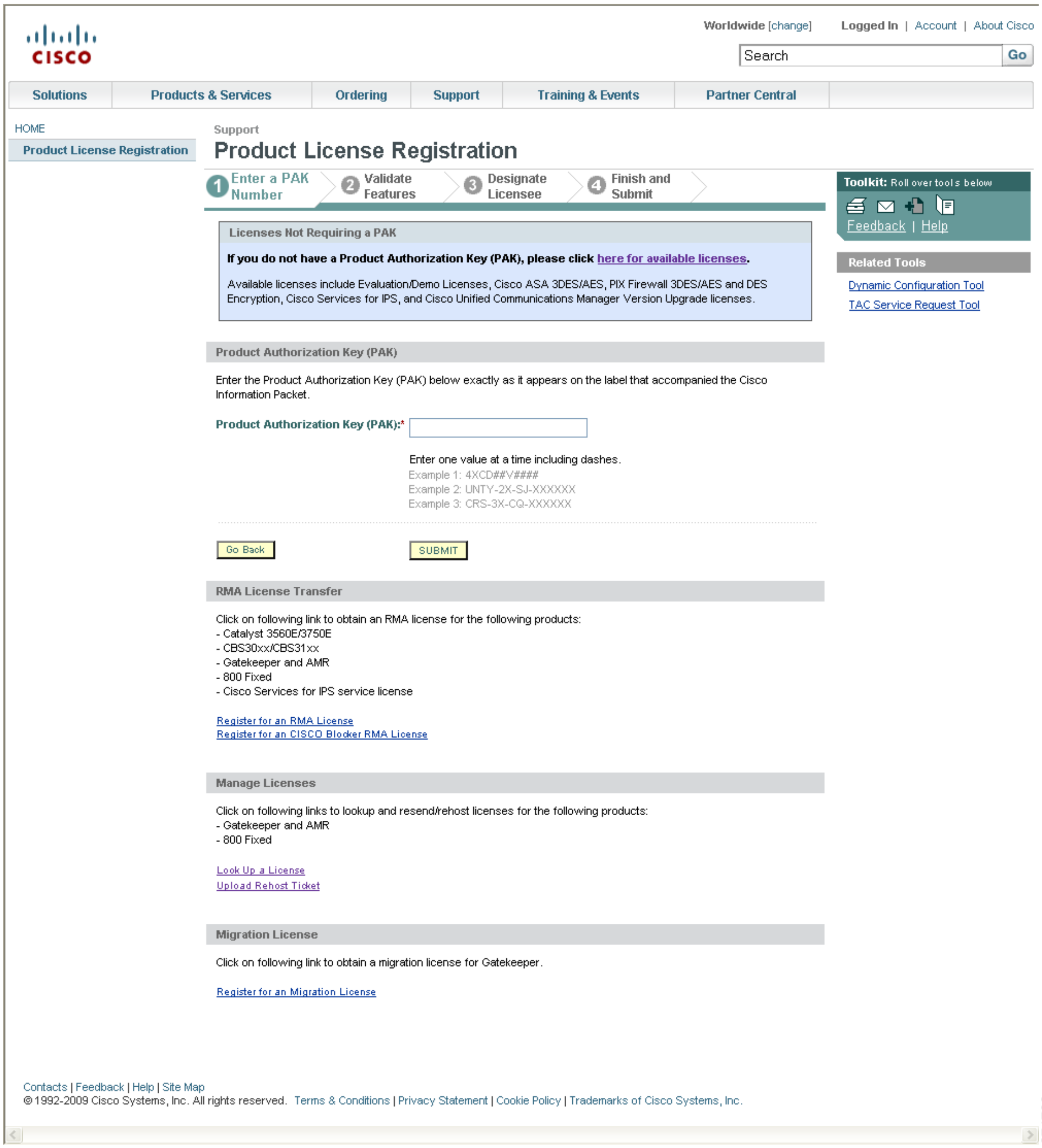


Step 3 In the File Name to Save Credentials field, enter the path on the TFTP server where you want the device credentials to be saved and click **Save Credentials**.

Step 4 To obtain a permission ticket to revoke the license, follow these steps:

a. Click **Cisco Licensing** (http://www.cisco.com/go/license). The Product License Registration page appears (see Figure 11).

Figure 11 Product License Registration Page



274708

b. Under Manage Licenses, click **Look Up a License**.

c. Enter the product ID and serial number for your controller.

Note To find the controller's product ID and serial number, choose **Controller > Inventory** on the controller GUI.

d. Open the device credential information file that you saved in Step 3 and copy and paste the contents of the file into the Device Credentials field.

e. Enter the security code in the blank box and click **Continue**.

f. Choose the licenses that you want to revoke from this controller and click **Start License Transfer**.

g. On the Rehost Quantities page, enter the number of licenses that you want to revoke in the To Rehost field and click **Continue**.

h. On the Designate Licensee page, enter the product ID and serial number of the controller for which you plan to revoke the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the fields on this page, and click **Continue**.

i. On the Review and Submit page, verify that all information is correct and click **Submit**.

j. When a message appears indicating that the registration is complete, click **Download Permission Ticket**. The rehost permission ticket is emailed within 1 hour to the address you specified.

k. After the email arrives, copy the rehost permission ticket to your TFTP server.

Step 5 To use the rehost permission ticket to revoke the license from this controller and generate a rehost ticket, follow these steps on the controller GUI:

a. In the Enter Saved Permission Ticket File Name field, enter the TFTP path and filename (*.lic) for the rehost permission ticket that you generated in Step 4.

b. In the Rehost Ticket File Name field, enter the TFTP path and filename (*.lic) for the ticket that will be used to rehost this license on another controller.

c. Click **Generate Rehost Ticket**.

d. When the end-user license agreement (EULA) acceptance window appears, read the agreement and click **Accept** to accept the terms of the agreement.

Step 6 To use the rehost ticket generated in Step 5 to obtain a license installation file, which can then be installed on another controller, follow these steps:

a. Click **Cisco Licensing**.

b. On the Product License Registration page, click **Upload Rehost Ticket** under Manage Licenses.

c. On the Upload Ticket page, enter the rehost ticket that you generated in Step 5 in the Enter Rehost Ticket field and click **Continue**.

d. On the Validate Features page, verify that the license information for your controller is correct, enter the rehost quantity, and click **Continue**.

e. On the Designate Licensee page, enter the product ID and serial number of the controller on which you plan to use the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the fields on this page, and click **Continue**.

f. On the Review and Submit page, verify that all information is correct and click **Submit**.

g. When a message appears indicating that the registration is complete, click **Download License**. The rehost license key is emailed within 1 hour to the address you specified.

h. After the email arrives, copy the rehost license key to your TFTP server.

i. Follow the instructions in the "Installing a License" section on page 8 to install this license on another controller.

Using the CLI to Rehost a License

Using the controller CLI, follow these steps to rehost a license.

Step 1 To save device credential information to a file, enter this command:

license save credential *url*

where *url* is tftp://*server_ip*/*path*/*filename*.

Step 2 To obtain a permission ticket to revoke the license, follow these steps:

a. Go to http://www.cisco.com/go/license. The Product License Registration page appears (see Figure 11).

b. Under Manage Licenses, click **Look Up a License**.

c. Enter the product ID and serial number for your controller.

Note To find the controller's product ID and serial number, enter the **show license udi** command on the controller CLI.

d. Open the device credential information file that you saved in Step 1 and copy and paste the contents of the file into the Device Credentials field.

e. Enter the security code in the blank box and click **Continue**.

f. Choose the licenses that you want to revoke from this controller and click **Start License Transfer**.

g. On the Rehost Quantities page, enter the number of licenses that you want to revoke in the To Rehost field and click **Continue**.

h. On the Designate Licensee page, enter the product ID and serial number of the controller for which you plan to revoke the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the fields on this page, and click **Continue**.

i. On the Review and Submit page, verify that all information is correct and click **Submit**.

j. When a message appears indicating that the registration is complete, click **Download Permission Ticket**. The rehost permission ticket is emailed within 1 hour to the address you specified.

k. After the email arrives, copy the rehost permission ticket to your TFTP server.

Step 3 To use the rehost permission ticket to revoke the license from this controller and generate a rehost ticket, follow these steps on the controller CLI:

a. To revoke the license from the controller, enter this command:

license revoke *permission_ticket_url*

where *permission_ticket_url* is tftp://*server_ip*/*path*/*filename*.

b. To generate the rehost ticket, enter this command:

license revoke rehost *rehost_ticket_url*

where *rehost_ticket_url* is tftp://*server_ip*/*path*/*filename*.

c. If prompted, read and accept the terms of the end-user license agreement (EULA).

Step 4 To use the rehost ticket generated in Step 3 to obtain a license installation file, which can then be installed on another controller, follow these steps:

a. Go to http://www.cisco.com/go/license.

b. On the Product License Registration page, click **Upload Rehost Ticket** under Manage Licenses.

c. On the Upload Ticket page, enter the rehost ticket that you generated in Step 3 in the Enter Rehost Ticket field and click **Continue**.

d. On the Validate Features page, verify that the license information for your controller is correct, enter the rehost quantity, and click **Continue**.

e. On the Designate Licensee page, enter the product ID and serial number of the controller on which you plan to use the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the fields on this page, and click **Continue**.

f. On the Review and Submit page, verify that all information is correct and click **Submit**.

g. When a message appears indicating that the registration is complete, click **Download License**. The rehost license key is emailed within 1 hour to the address you specified.

h. After the email arrives, copy the rehost license key to your TFTP server.

i. Follow the instructions in the "Installing a License" section on page 8 to install this license on another controller.

Transferring Licenses to a Replacement Controller after an RMA

If you return a 5500 series controller to Cisco as part of the Return Material Authorization (RMA) process, you must transfer that controller's licenses within 60 days to a replacement controller that you receive from Cisco.

Replacement controllers come preinstalled with the following licenses: permanent base and evaluation base, base-ap-count, wplus, and wplus-ap-count. No other permanent licenses are installed. The SKU for replacement controllers is AIR-CT5508-CA-K9.

Because licenses are registered to the serial number of a controller, you can use the licensing portal on Cisco.com to request that the license from your returned controller be revoked and authorized for use on the replacement controller. After your request is approved, you can install the old license on the replacement controller. Before you begin, you need the product ID and serial number of both the returned controller and the replacement controller. This information is included in your purchase records.

Note The evaluation licenses on the replacement controller are designed for temporary use and expire after 60 days. To prevent disruptions in operation, the controller does not switch licenses when an evaluation license expires. You must reboot the controller in order to return to a permanent license. If the evaluation licenses expire before you transfer the permanent licenses from your defective controller to your replacement controller, the replacement controller remains up and running using the permanent base license, but access points are no longer able to join the controller.

Step 1 Go to http://www.cisco.com/go/license.

Step 2 On the main Product License Registration page, click **Register for an RMA License** under RMA License Transfer.

Step 3 In the Select a Product drop-down box, choose **Cisco 5500 Series Wireless Controllers**.

Step 4 Enter the security code in the blank box and click **Go to RMA Portal**.

Step 5 On the RMA License Transfer page, enter the product ID and serial number of the controller that you returned and your RMA service contract number. Then click **Continue**.

Step 6 On the Validate Features page, verify that the license information for your controller is correct, and click **Continue**.

Step 7 On the Designate Licensee page, enter the product ID and serial number of the replacement controller.

Step 8 Read and accept the conditions of the end-user license agreement (EULA), complete the rest of the fields on this page, and click **Submit**.

Step 9 On the Review and Submit page, verify that all information is correct and click **Submit**. A message appears indicating that your registration request has been submitted, and you receive an email containing your RMA request ID.

Step 10 To check the status of your RMA registration request, follow the instructions provided in the email.

Step 11 After you receive another email notifying you that your RMA registration request is approved (usually within 1 hour), follow the instructions in the "Installing a License" section on page 8 to install the license on the replacement controller.

Configuring the License Agent

If your network contains various Cisco licensed devices, you might want to consider using the Cisco License Manager (CLM) to manage all of the licenses using a single application. CLM is a secure client/server application that manages Cisco software licenses network wide.

The license agent is an interface module that runs on the controller and mediates between CLM and the controller's licensing infrastructure. CLM can communicate with the controller using various channels, such as HTTP, Telnet, and so on. If you want to use HTTP as the communication method, you must enable the license agent on the controller.

The license agent receives requests from CLM and translates them into license commands. It also sends notifications to CLM. It uses XML messages over HTTP or HTTPS to receive the requests and send the notifications. For example, CLM sends a **license install** command, and the agent notifies CLM after the license expires.

Note You can download the CLM software and access user documentation at this URL:

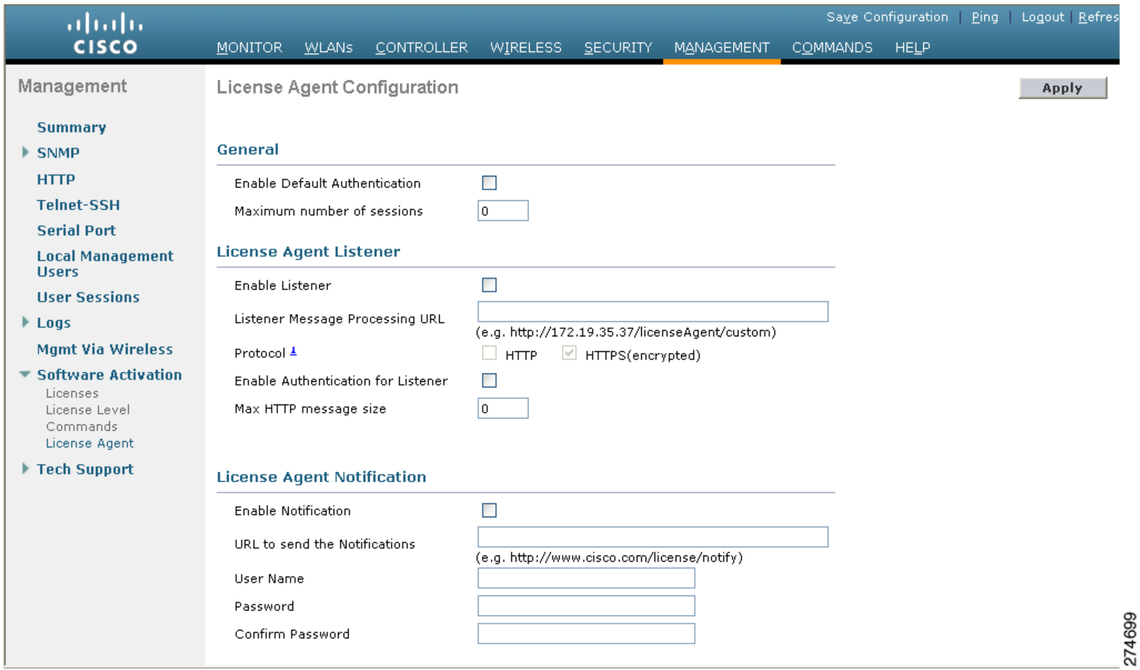
http://www.cisco.com/go/clm

Using the GUI to Configure the License Agent

Using the controller GUI, follow these steps to configure the license agent on the controller.

Step 1 Choose **Management > Software Activation > License Agent** to open the License Agent Configuration page (see Figure 12).

Figure 12 License Agent Configuration Page



Step 2 Check the **Enable Default Authentication** check box to enable the license agent, or leave it unchecked to disable this feature. The default value is unchecked.

Step 3 In the Maximum Number of Sessions field, enter the maximum number of sessions for the license agent. The valid range is 1 to 25 sessions (inclusive).

Step 4 To configure the license agent to listen for requests from the CLM, follow these steps:

a. Check the **Enable Listener** check box to enable the license agent to receive license requests from the CLM, or uncheck this check box to disable this feature. The default value is unchecked.

b. In the Listener Message Processing URL field, enter the URL where the license agent receives license requests (for example, http://172.19.35.37/licenseAgent/custom). The Protocol parameter indicates whether the URL requires HTTP or HTTPS.

Note You can specify the protocol to use on the HTTP Configuration page. Refer to the "Enabling Web and Secure Web Modes" section on page 18 for more information.

c. Check the **Enable Authentication for Listener** check box to enable authentication for the license agent when it is receiving license requests, or uncheck this check box to disable this feature. The default value is unchecked.

d. In the Max HTTP Message Size field, enter the maximum size for license requests. The valid range is 0 to 9999 bytes, and the default value is 0.

Step 5 To configure the license agent to send license notifications to the CLM, follow these steps:

a. Check the **Enable Notification** check box to enable the license agent to send license notifications to the CLM, or uncheck this check box to disable this feature. The default value is unchecked.

b. In the URL to Send the Notifications field, enter the URL where the license agent sends the notifications (for example, http://www.cisco.com/license/notify).

c. In the User Name field, enter the username required in order to view the notification messages at this URL.

d. In the Password and Confirm Password fields, enter the password required in order to view the notification messages at this URL.

Step 6 To commit your changes, click **Apply**.

Step 7 To save your changes, click **Save Configuration**.

Using the CLI to Configure the License Agent

Using the controller CLI, follow these steps to configure the license agent on the controller.

Step 1 To enable the license agent, enter one of these commands:

- **config license agent default authenticate**—Enables the license agent default listener with authentication.
- **config license agent default authenticate none**—Enables the license agent default listener without authentication.

Note To disable the license agent default listener, enter **config license agent default disable**. The default value is disabled.

Step 2 To specify the maximum number of sessions for the license agent, enter this command:

config license agent max-sessions *sessions*

The valid range for the *sessions* parameter is 1 to 25 (inclusive), and the default value is 9.

Step 3 To enable the license agent to receive license requests from the CLM and to specify the URL where the license agent receives the requests, enter this command:

config license agent listener http {**plaintext** | **encrypt**} *url* **authenticate** [**none**] [**max-message** *size*] [**acl** *acl*]

The valid range for the *size* parameter is 0 to 65535 bytes, and the default value is 0.

Note To prevent the license agent from receiving license requests from the CLM, enter **config license agent listener http disable**. The default value is disabled.

Step 4 To configure the license agent to send license notifications to the CLM and to specify the URL where the license agent sends the notifications, enter this command:

config license agent notify *url username password*

Note To prevent the license agent from sending license notifications to the CLM, enter **config license agent notify disable** *username password*. The default value is disabled.

Step 5 To save your changes, enter this command:

save config

Step 6 To see statistics for the license agent's counters or sessions, enter this command:

show license agent {**counters** | **sessions**}

Information similar to the following appears for the **show license agent counters** command:

```
License Agent Counters
Request Messages Received:10: Messages with Errors:1
Request Operations Received:9: Operations with Errors:0
Notification Messages Sent:12: Transmission Errors:0: Soap Errors:0
```

Information similar to the following appears for the **show license agent sessions** command:

```
License Agent Sessions: 1 open, maximum is 9
```

Note To clear the license agent's counter or session statistics, enter **clear license agent** {**counters** | **sessions**}.

Configuring 802.11 Bands

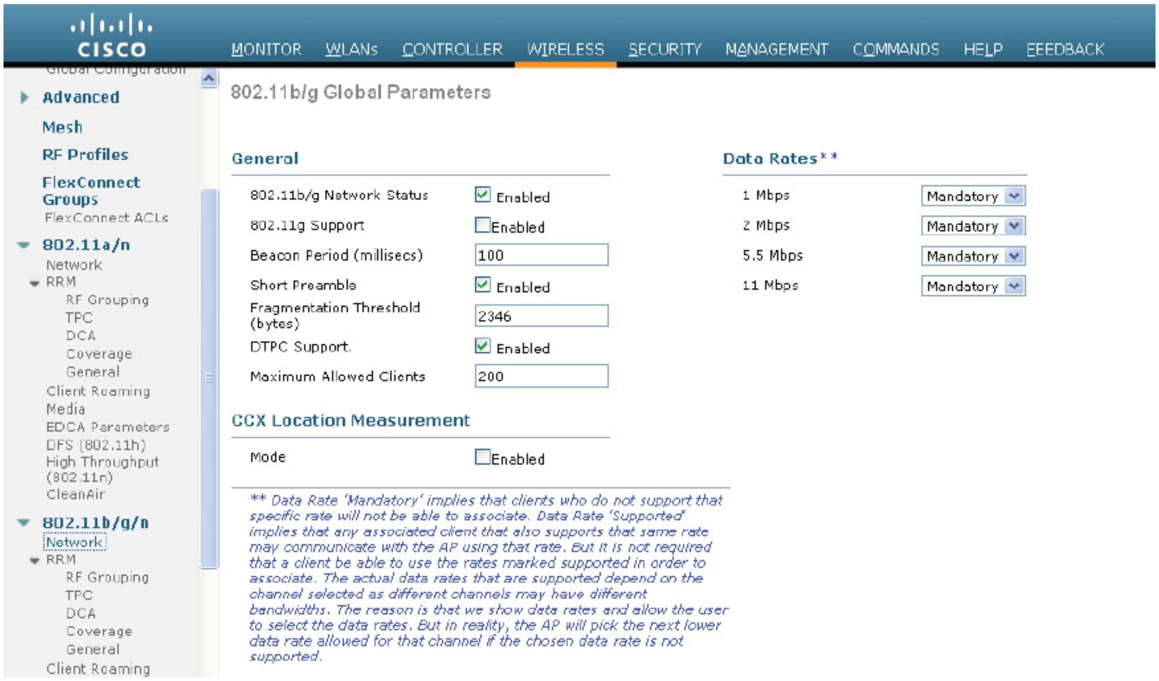
You can configure the 802.11b/g/n (2.4-GHz) and 802.11a/n (5-GHz) bands for the controller to comply with the regulatory requirements in your country. By default, both 802.11b/g/n and 802.11a/n are enabled.

Using the GUI to Configure 802.11 Bands

Using the controller GUI, follow these steps to configure 802.11 bands.

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page (see Figure 13).

Figure 13 802.11a Global Parameters Page



Step 2 To enable the 802.11a or 802.11b/g band, check the **802.11a** (or **802.11b/g**) **Network Status** check box. To disable the band, uncheck the check box. The default value is enabled. You can enable both the 802.11a and 802.11b/g bands.

Step 3 If you enabled the 802.11b/g band in Step 2, check the **802.11g Support** check box if you want to enable 802.11g network support. The default value is enabled. If you disable this feature, the 802.11b band is enabled without 802.11g support.

Step 4 To specify the rate at which the SSID is broadcast by the access point, enter a value between 100 and 600 milliseconds (inclusive) in the Beacon Period field. The default value is 100 milliseconds.

Step 5 To specify the size at which packets are fragmented, enter a value between 256 and 2346 bytes (inclusive) in the Fragmentation Threshold field. Enter a low number for areas where communication is poor or where there is a great deal of radio interference.

Step 6 To make access points advertise their channel and transmit power level in beacons and probe responses, check the **DTPC Support** check box. Otherwise, uncheck this check box. The default value is enabled.

Client devices using dynamic transmit power control (DTPC) receive the channel and power level information from the access points and adjust their settings automatically. For example, a client device used primarily in Japan could rely on DTPC to adjust its channel and power settings automatically when it travels to Italy and joins a network there.

Note On access points that run Cisco IOS software, this feature is called *world mode*.

Note DTPC and 801.11h power constraint cannot be enabled simultaneously.

Step 7 Use the Data Rates options to specify the rates at which data can be transmitted between the access point and the client. These data rates are available:

- 802.11a—6, 9, 12, 18, 24, 36, 48, and 54 Mbps
- 802.11b/g—1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, or 54 Mbps

For each data rate, choose one of these options:

- **Mandatory**—Clients must support this data rate in order to associate to an access point on the controller.
- **Supported**—Any associated clients that support this data rate may communicate with the access point using that rate. However, the clients are not required to be able to use this rate in order to associate.
- **Disabled**—The clients specify the data rates used for communication.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure 802.11 Bands

Using the controller CLI, follow these steps to configure 802.11 bands.

Step 1 To disable the 802.11a band, enter this command:

config 802.11a disable network

Note The 802.11a band must be disabled before you can configure the 802.11a network parameters in this section.

Step 2 To disable the 802.11b/g band, enter this command:

config 802.11b disable network

Note The 802.11b band must be disabled before you can configure the 802.11b network parameters in this section.

Step 3 To specify the rate at which the SSID is broadcast by the access point, enter this command:

config {**802.11a** | **802.11b**} **beaconperiod** *time_unit*

where *time_unit* is the beacon interval in time units (TU). One TU is 1024 micro seconds. You can configure the access point to send a beacon every 20 to 1000 milliseconds.

Step 4 To specify the size at which packets are fragmented, enter this command:

config {**802.11a** | **802.11b**} **fragmentation** *threshold*

where *threshold* is a value between 256 and 2346 bytes (inclusive). Specify a low number for areas where communication is poor or where there is a great deal of radio interference.

Step 5 To make access points advertise their channel and transmit power level in beacons and probe responses, enter this command:

config {**802.11a** | **802.11b**} **dtpc** {**enable** | **disable**}

The default value is enabled. Client devices using dynamic transmit power control (DTPC) receive the channel and power level information from the access points and adjust their settings automatically. For example, a client device used primarily in Japan could rely on DTPC to adjust its channel and power settings automatically when it travels to Italy and joins a network there.

Note On access points that run Cisco IOS software, this feature is called *world mode*.

Step 6 To specify the rates at which data can be transmitted between the controller and the client, enter this command:

config {**802.11a** | **802.11b**} **rate** {**disabled** | **mandatory** | **supported**} *rate*

where

- **disabled**—The clients specify the data rates used for communication.
- **mandatory**—Specifies that clients support this data rate in order to associate to an access point on the controller.
- **supported**—Any associated clients that support this data rate may communicate with the access point using that rate. However, the clients are not required to be able to use this rate in order to associate.
- *rate*—The rate at which data is transmitted:
  - 6, 9, 12, 18, 24, 36, 48, and 54 Mbps (802.11a)
  - 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, or 54 Mbps (802.11b/g)

Step 7 To enable the 802.11a band, enter this command:

config 802.11a enable network

The default value is enabled.

Step 8 To enable the 802.11b band, enter this command:

config 802.11b enable network

The default value is enabled.

Step 9 To enable or disable 802.11g network support, enter this command:

config 802.11b 11gSupport {**enable** | **disable**}

The default value is enabled. You can use this command only if the 802.11b band is enabled. If you disable this feature, the 802.11b band is enabled without 802.11g support.

Step 10 To save your changes, enter this command:

save config

Step 11 To view the configuration settings for the 802.11a or 802.11b/g band, enter this command:

show {**802.11a** | **802.11b**}

Information similar to the following appears:

```
802.11a Network.............................. Enabled
11nSupport.................................. Enabled
    802.11a Low Band......................... Enabled
    802.11a Mid Band......................... Enabled
    802.11a High Band........................ Enabled
802.11a Operational Rates
   802.11a 6M Rate............................ Mandatory
   802.11a 9M Rate............................ Supported
   802.11a 12M Rate........................... Mandatory
   802.11a 18M Rate........................... Supported
   802.11a 24M Rate........................... Mandatory
   802.11a 36M Rate........................... Supported
   802.11a 48M Rate........................... Supported
   802.11a 54M Rate........................... Supported
...
Beacon Interval................................ 100
...
Default Channel.............................. 36
Default Tx Power Level....................... 1
DTPC Status.................................. Enabled
Fragmentation Threshold...................... 2346
...
```

Configuring 802.11n Parameters

This section provides instructions for managing 802.11n devices such as the Cisco Aironet 1140 and 1250 Series Access Points on your network. The 802.11n devices support the 2.4- and 5-GHz bands and offer high-throughput data rates.

Note The 802.11n high-throughput rates are available only on 1140 and 1250 series access points for WLANs using WMM with no Layer 2 encryption or with WPA2/AES encryption enabled.

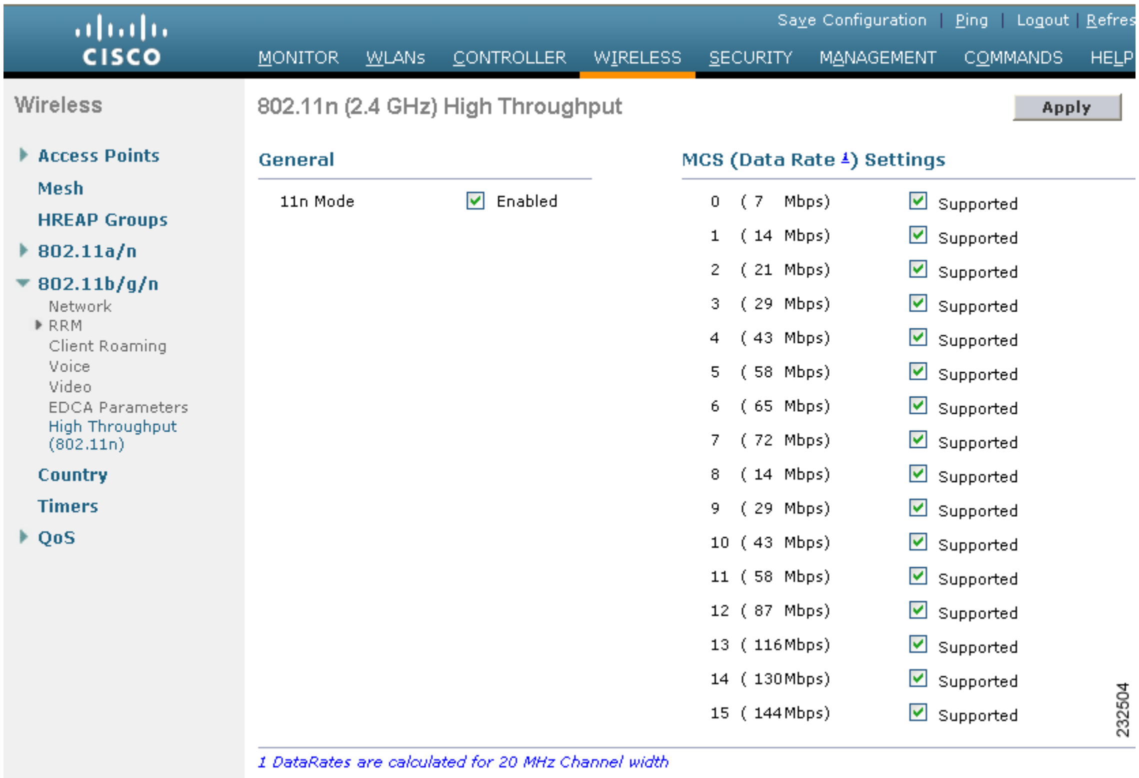
Note For information on configuring radio resource management (RRM) parameters or statically assigning radio parameters for 802.11n access points, refer to the *Configuring Radio Resource Management* chapter.

Using the GUI to Configure 802.11n Parameters

Using the controller GUI, follow these steps to configure 802.11n parameters.

Step 1 Choose **Wireless > 802.11a/n** or **802.11b/g/n > High Throughput (802.11n)** to open the 802.11n (5 GHz or 2.4 GHz) High Throughput page (see Figure 14).

Figure 14 802.11n (2.4 GHz) High Throughput Page



Step 2 Check the **11n Mode** check box to enable 802.11n support on the network. The default value is enabled.

Step 3 To specify the modulation and coding scheme (MCS) rates at which data can be transmitted between the access point and the client, check the check boxes of the desired rates. These data rates, which are calculated for a 20-MHz channel width using a short guard interval, are available:

- 0 (7 Mbps)
- 1 (14 Mbps)
- 2 (21 Mbps)
- 3 (29 Mbps)
- 4 (43 Mbps)
- 5 (58 Mbps)
- 6 (65 Mbps)
- 7 (72 Mbps)
- 8 (14 Mbps)
- 9 (29 Mbps)
- 10 (43 Mbps)
- 11 (58 Mbps)
- 12 (87 Mbps)
- 13 (116 Mbps)

- 14 (130 Mbps)
- 15 (144 Mbps)

Any associated clients that support the selected rates may communicate with the access point using those rates. However, the clients are not required to be able to use this rate in order to associate. The MCS settings determine the number of spatial streams, the modulation, the coding rate, and the data rate values that are used.

Step 4 Click **Apply** to commit your changes.

Step 5 To use the 802.11n data rates that you configured, you need to enable WMM on the WLAN. Follow these steps to do so:

a. Choose **WLANs** to open the WLANs page.

b. Click the ID number of the WLAN for which you want to configure WMM mode.

c. When the WLANs > Edit page appears, choose the **QoS** tab to open the WLANs > Edit (Qos) page.

d. From the WMM Policy drop-down box, choose **Required** or **Allowed** to require or allow client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

e. Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Note To determine if an access point supports 802.11n, look at the 11n Supported field on either the 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page or the 802.11a/n (or 802.11b/g/n) AP Interfaces > Details page.

Using the CLI to Configure 802.11n Parameters

Using the controller CLI, follow these steps to configure 802.11n parameters.

Step 1 To enable 802.11n support on the network, enter this command:

config {**802.11a** | **802.11b**} **11nsupport** {**enable** | **disable**}

Step 2 To specify the modulation and coding scheme (MCS) rates at which data can be transmitted between the access point and the client, enter this command:

config {**802.11a** | **802.11b**} **11nsupport mcs tx** {**0-15**} {**enable** | **disable**}

See the descriptions of the 0 through 15 MCS data rates in the "Using the GUI to Configure 802.11n Parameters" section on page 34.

Step 3 To use the 802.11n data rates that you configured, you need to enable WMM on the WLAN. Enter this command to do so:

config wlan wmm required *wlan_id*

The **required** parameter requires client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

Step 4 To specify the aggregation method used for 802.11n packets, follow these steps:

a. To disable the network, enter this command:

config {**802.11a** | **802.11b**} **disable network**

b. To specify the aggregation method, enter this command:

config {**802.11a** | **802.11b**} **11nsupport a-mpdu tx priority {0-7 | all} {enable | disable**}

Aggregation is the process of grouping packet data frames together rather than transmitting them separately. Two aggregation methods are available: Aggregated MAC Protocol Data Unit (A-MPDU) and Aggregated MAC Service Data Unit (A-MSDU). A-MPDU is performed in the software whereas A-MSDU is performed in the hardware.

You can specify the aggregation method for various types of traffic from the access point to the clients. Table 1 defines the priority levels (0-7) assigned per traffic type.

Table 1 Traffic Type Priority Levels

User Priority	Traffic Type
0	Best effort
1	Background
2	Spare
3	Excellent effort
4	Controlled load
5	Video, less than 100-ms latency and jitter
6	Voice, less than 10-ms latency and jitter
7	Network control

You can configure each priority level independently, or you can use the **all** parameter to configure all of the priority levels at once. When you use the **enable** command, the traffic associated with that priority level uses A-MPDU transmission. When you use the **disable** command, the traffic associated with that priority level uses A-MSDU transmission. Configure the priority levels to match the aggregation method used by the clients. By default, only priority level 0 is enabled.

c. To re-enable the network, enter this command:

config {**802.11a** | **802.11b**} **enable network**

Step 5 To save your changes, enter this command:

save config

Step 6 To view the configuration settings for the 802.11a/n or 802.11b/g/n band, enter this command:

show {**802.11a** | **802.11b**}

Information similar to the following appears:

```
802.11a Network............................... Enabled
11nSupport.................................... Enabled
    802.11a Low Band.......................... Enabled
    802.11a Mid Band.......................... Enabled
    802.11a High Band......................... Enabled
802.11a Operational Rates
   802.11a 6M Rate............................ Mandatory
   802.11a 9M Rate............................ Supported
   802.11a 12M Rate........................... Mandatory
```

```
    802.11a 18M Rate............................ Supported
    802.11a 24M Rate............................ Mandatory
    802.11a 36M Rate............................ Supported
    802.11a 48M Rate............................ Supported
    802.11a 54M Rate............................ Supported
802.11n MCS Settings:
MCS 0...................................... Supported
    MCS 1.................................... Supported
    MCS 2.................................... Supported
    MCS 3.................................... Supported
    MCS 4.................................... Supported
    MCS 5.................................... Supported
   MCS 6.................................... Supported
    MCS 7.................................... Supported
    MCS 8.................................... Supported
    MCS 9.................................... Supported
    MCS 10................................... Supported
    MCS 11................................... Supported
    MCS 12................................... Supported
    MCS 13................................... Supported
    MCS 14................................... Supported
   MCS 15...................................... Supported
802.11n Status:
    A-MPDU Tx ................................. Enabled
        Priority 0............................. Enabled
        Priority 1............................. Enabled
        Priority 2............................. Enabled
        Priority 3............................. Enabled
        Priority 4............................. Enabled
        Priority 5............................. Disabled
        Priority 6............................. Disabled
        Priority 7............................. Enabled
    A-MSDU Tx ................................. Enabled
      Rifs Tx ................................... Enabled
    Guard Interval ........................... Short
Beacon Interval.............................. 100
CF Pollable mandatory......................... Disabled
CF Poll Request mandatory..................... Disabled
CFP Period...................................... 4
CFP Maximum Duration........................... 60
Default Channel................................ 36
Default Tx Power Level......................... 1
DTPC Status.................................Enabled
Fragmentation Threshold...................... 2346
Long Retry Limit................................ 4
Maximum Rx Life Time.......................... 512
Max Tx MSDU Life Time.......................... 512
Medium Occupancy Limit......................... 100
Pico-Cell Status............................... Disabled
Pico-Cell-V2 Status............................ Disabled
RTS Threshold.................................. 2347
Short Retry Limit.............................. 7
TI Threshold................................... -50
Traffic Stream Metrics Status.................. Enabled
Expedited BW Request Status.................... Disabled
EDCA profile type.............................. default-wmm
Voice MAC optimization status.................. Disabled
Call Admission Control (CAC) configuration
   Voice AC - Admission control (ACM)............ Enabled
   Voice max RF bandwidth....................... 75
   Voice reserved roaming bandwidth............. 6
   Voice load-based CAC mode.................... Disabled
   Voice tspec inactivity timeout............... Disabled
   Video AC - Admission control (ACM)............ Enabled
```

```
Voice Stream-Size............................ 84000
Voice Max-Streams............................ 2
Video max RF bandwidth....................... Infinite
Video reserved roaming bandwidth........... 0
```

Configuring 802.11h Parameters

802.11h informs client devices about channel changes and can limit the transmit power of those client devices. You can configure the 802.11h parameters using the controller GUI or CLI.

Using the GUI to Configure 802.11h Parameters

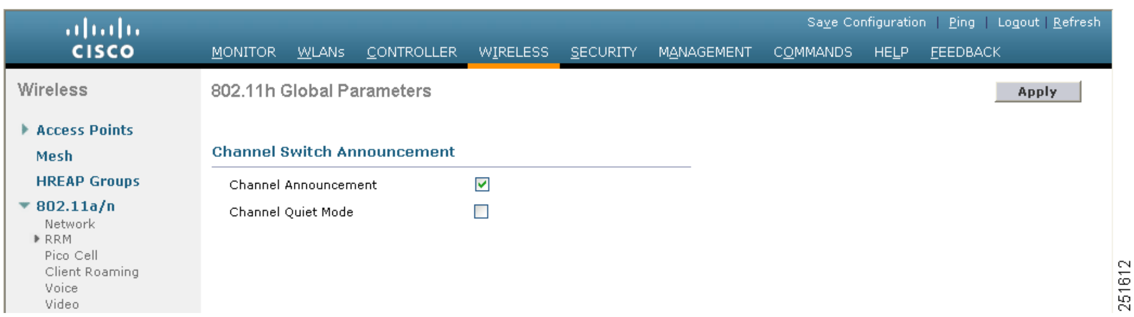
Using the controller GUI, follow these steps to configure 802.11h parameters.

Step 1 To disable the 802.11a band, follow these steps:

- **a.** Choose **Wireless** > **802.11a/n** > **Network** to open the 802.11a Global Parameters page.
- **b.** Uncheck the **802.11a Network Status** check box.
- **c.** Click **Apply** to commit your change.

Step 2 Choose **Wireless** > **802.11a/n** > **DFS (802.11h)** to open the 802.11h Global Parameters page (see Figure 15).

Figure 15 802.11h Global Parameters Page



Step 3 Check the **Channel Announcement** check box if you want the access point to announce when it is switching to a new channel and the new channel number, or uncheck this check box to disable channel announcement. The default value is disabled.

Step 4 If you enabled channel announcement in Step 3, the Channel Quiet Mode check box appears. Check this check box if you want the access point to stop transmitting on the current channel, or uncheck this check box to disable quiet mode. The default value is disabled.

Step 5 Click **Apply** to commit your changes.

Step 6 To re-enable the 802.11a band, follow these steps:

a. Choose **Wireless** > **802.11a/n** > **Network** to open the 802.11a Global Parameters page.

b. Check the **802.11a Network Status** check box.

c. Click **Apply** to commit your change.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure 802.11h Parameters

Using the controller CLI, follow these steps to configure 802.11h parameters.

Step 1 To disable the 802.11a network, enter this command:

config 802.11a disable network

Step 2 To enable or disable the access point to announce when it is switching to a new channel and the new channel number, enter this command:

config 802.11h channelswitch {**enable** | **disable**} *switch_mode*

You can enter a 0 or 1 for the *switch_mode* parameter to specify whether transmissions are restricted until the actual channel switch (0) or are not restricted (1). The default value is disabled.

Step 3 To configure a new channel using the 802.11h channel announcement, enter this command:

config 802.11h setchannel channel *channel*

Step 4 To configure the 802.11h power constraint value, enter this command:

config 802.11h powerconstraint *value*

The default value for the *value* parameter is 3 dB.

Step 5 To re-enable the 802.11a network, enter this command:

config 802.11a enable network

Step 6 To see the status of 802.11h parameters, enter this command:

show 802.11h

Information similar to the following appears:

```
Power Constraint................................. 0
Channel Switch................................... Disabled
Channel Switch Mode.............................. 0
```

Configuring DHCP Proxy

When DHCP proxy is enabled on the controller, the controller unicasts DHCP requests from the client to the configured servers. Consequently, at least one DHCP server must be configured on either the interface associated with the WLAN or the WLAN itself.

When DHCP proxy is disabled on the controller, those DHCP packets transmitted to and from the clients are bridged by the controller without any modification to the IP portion of the packet. Packets received from the client are removed from the CAPWAP tunnel and transmitted on the upstream VLAN. DHCP packets directed to the client are received on the upstream VLAN, converted to 802.11, and transmitted through a CAPWAP tunnel toward the client. As a result, the internal DHCP server cannot be used when DHCP proxy is disabled. The ability to disable DHCP proxy allows organizations to use DHCP servers that do not support Cisco's native proxy mode of operation. It should be disabled only when required by the existing infrastructure.

You can use the controller GUI or CLI to enable or disable DHCP proxy on a global basis, rather than on a WLAN basis. DHCP proxy is enabled by default.

Note DHCP proxy must be enabled in order for DHCP option 82 to operate correctly. Refer to the "Configuring DHCP Option 82" section on page 55 for information on DHCP option 82.

Note All controllers that will communicate must have the same DHCP proxy setting.

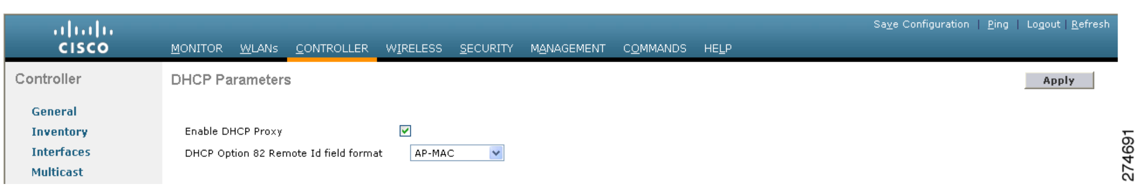
Note Refer to the *Configuring WLANs* chapter for information on configuring DHCP servers.

Using the GUI to Configure DHCP Proxy

Using the controller GUI, follow these steps to configure DHCP proxy.

Step 1 Choose **Controller** > **Advanced** > **DHCP** to open the DHCP Parameters page (see Figure 16).

Figure 16 ***DHCP Parameters Page***



Step 2 To enable DHCP proxy on a global basis, check the **Enable DHCP Proxy** check box. Otherwise, uncheck the check box. The default value is checked.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure DHCP Proxy

Using the controller CLI, follow these steps to configure DHCP proxy.

Step 1 To enable or disable DHCP proxy, enter this command:

config dhcp proxy {**enable** | **disable**}

Step 2 To view the DHCP proxy configuration, enter this command:

show dhcp proxy

Information similar to the following appears:

```
DHCP Proxy Behavior: enabled
```

Configuring Administrator Usernames and Passwords

You can configure administrator usernames and passwords to prevent unauthorized users from reconfiguring the controller and viewing configuration information. This section provides instructions for initial configuration and for password recovery.

Configuring Usernames and Passwords

Using the controller CLI, follow these steps to configure administrator usernames and passwords:

Step 1 To configure a username and password, enter one of these commands:

- **config mgmtuser add** *username password* **read-write**—Creates a username-password pair with read-write privileges.
- **config mgmtuser add** *username password* **read-only**—Creates a username-password pair with read-only privileges.

Usernames and passwords are case-sensitive and can contain up to 24 ASCII characters. Usernames and passwords cannot contain spaces.

Note If you ever need to change the password for an existing username, enter this command: **config mgmtuser password** *username new_password*

Step 2 To list configured users, enter this command:

show mgmtuser

Restoring Passwords

If you ever forget your password, follow these steps to configure a new username and password at boot-up using the CLI from the controller's serial console:

Step 1 After the controller boots up, enter **Restore-Password** at the User prompt.

> **Note** For security reasons, the text that you enter does not appear on the controller console.

Step 2 At the Enter User Name prompt, enter a new username.

Step 3 At the Enter Password prompt, enter a new password.

Step 4 At the Re-enter Password prompt, re-enter the new password. The controller validates and stores your entries in the database.

Step 5 When the User prompt reappears, enter your new username.

Step 6 When the Password prompt appears, enter your new password. The controller logs you in with your new username and password.

Configuring SNMP

Cisco recommends that you use the GUI to configure SNMP settings on the controller. To use the CLI, follow these steps:

Step 1 Enter **config snmp community create** *name* to create an SNMP community name.

Step 2 Enter **config snmp community delete** *name* to delete an SNMP community name.

Step 3 Enter **config snmp community accessmode ro** *name* to configure an SNMP community name with read-only privileges. Enter **config snmp community accessmode rw** *name* to configure an SNMP community name with read-write privileges.

Step 4 Enter **config snmp community ipaddr** *ip-address ip-mask name* to configure an IP address and subnet mask for an SNMP community.

> **Note** This command behaves like an SNMP access list. It specifies the IP address from which the device accepts SNMP packets with the associated community. The requesting entity's IP address is ANDed with the subnet mask before being compared to the IP address. If the subnet mask is set to 0.0.0.0, an IP address of 0.0.0.0 matches to all IP addresses. The default value is 0.0.0.0.

> **Note** The controller can use only one IP address range to manage an SNMP community.

Step 5 Enter **config snmp community mode enable** to enable a community name. Enter **config snmp community mode disable** to disable a community name.

Step 6 Enter **config snmp trapreceiver create** *name ip-address* to configure a destination for a trap.

Step 7 Enter **config snmp trapreceiver delete** *name* to delete a trap.

Step 8 Enter **config snmp trapreceiver ipaddr** *old-ip-address name new-ip-address* to change the destination for a trap.

Step 9 Enter **config snmp trapreceiver mode enable** to enable traps. Enter **config snmp trapreceiver mode disable** to disable traps.

Step 10 Enter **config snmp syscontact** *syscontact-name* to configure the name of the SNMP contact. Enter up to 31 alphanumeric characters for the contact name.

Step 11 Enter **config snmp syslocation** *syslocation-name* to configure the SNMP system location. Enter up to 31 alphanumeric characters for the location.

Step 12 Use the **show snmpcommunity** and **show snmptrap** commands to verify that the SNMP traps and communities are correctly configured.

Step 13 Use the **show trapflags** command to see the enabled and disabled trapflags. If necessary, use the **config trapflags** commands to enable or disable trapflags.

Changing the Default Values of SNMP Community Strings

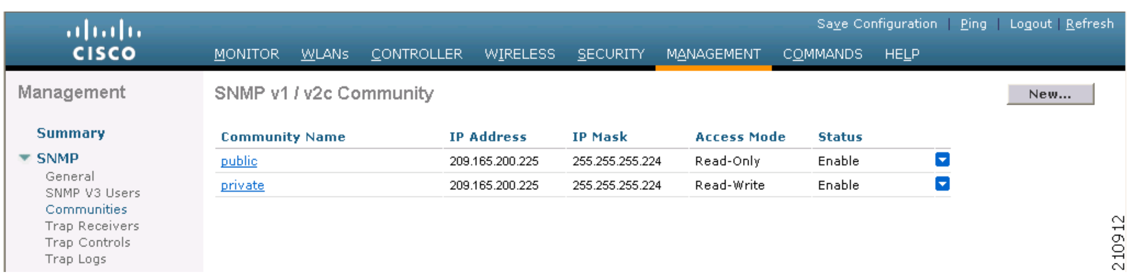
The controller has commonly known default values of “public” and “private” for the read-only and read-write SNMP community strings. Using these standard values presents a security risk. Therefore, Cisco strongly advises that you change these values.

Using the GUI to Change the SNMP Community String Default Values

Follow these steps to change the SNMP community string default values through the controller GUI.

Step 1 Choose **Management** and then **Communities** under SNMP. The SNMP v1 / v2c Community page appears (see Figure 17).

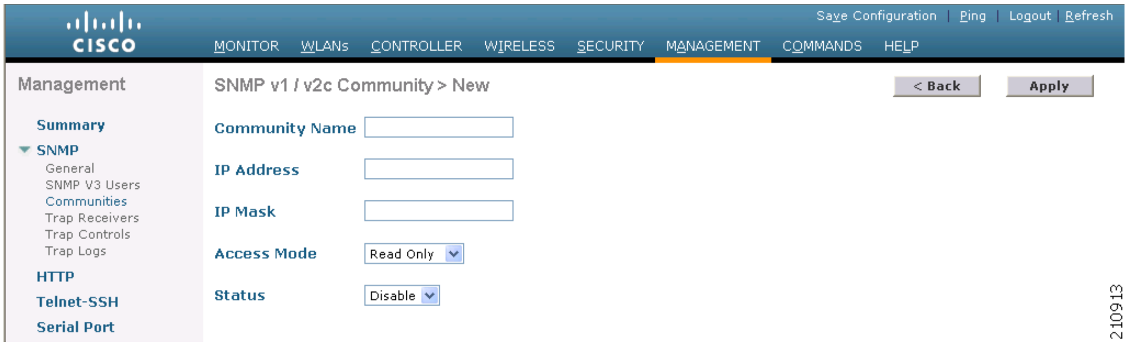
Figure 17 SNMP v1 / v2c Community Page



Step 2 If “public” or “private” appears in the Community Name column, hover your cursor over the blue drop-down arrow for the desired community and choose **Remove** to delete this community.

Step 3 Click **New** to create a new community. The SNMP v1 / v2c Community > New page appears (see Figure 18).

Figure 18 SNMP v1 / v2c Community > New Page



Step 4 In the Community Name field, enter a unique name containing up to 16 alphanumeric characters. Do not enter "public" or "private."

Step 5 In the next two fields, enter the IP address from which this device accepts SNMP packets with the associated community and the IP mask.

Step 6 Choose **Read Only** or **Read/Write** from the Access Mode drop-down box to specify the access level for this community.

Step 7 Choose **Enable** or **Disable** from the Status drop-down box to specify the status of this community.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your settings.

Step 10 Repeat this procedure if a "public" or "private" community still appears on the SNMP v1 / v2c Community page.

Using the CLI to Change the SNMP Community String Default Values

Follow these steps to change the SNMP community string default values through the controller CLI.

Step 1 To see the current list of SNMP communities for this controller, enter this command:

show snmp community

Step 2 If "public" or "private" appears in the SNMP Community Name column, enter this command to delete this community:

config snmp community delete *name*

The *name* parameter is the community name (in this case, "public" or "private").

Step 3 To create a new community, enter this command:

config snmp community create *name*

Enter up to 16 alphanumeric characters for the *name* parameter. Do not enter "public" or "private."

Step 4 To enter the IP address from which this device accepts SNMP packets with the associated community, enter this command:

config snmp community ipaddr *ip_address ip_mask name*

Step 5 To specify the access level for this community, enter this command, where **ro** is read-only mode and **rw** is read/write mode:

config snmp community accessmode {**ro** | **rw**} *name*

Step 6 To enable or disable this SNMP community, enter this command:

config snmp community mode {**enable** | **disable**} *name*

Step 7 To save your changes, enter **save config**.

Step 8 Repeat this procedure if you still need to change the default values for a "public" or "private" community string.

Changing the Default Values for SNMP v3 Users

The controller uses a default value of "default" for the username, authentication password, and privacy password for SNMP v3 users. Using these standard values presents a security risk. Therefore, Cisco strongly advises that you change these values.

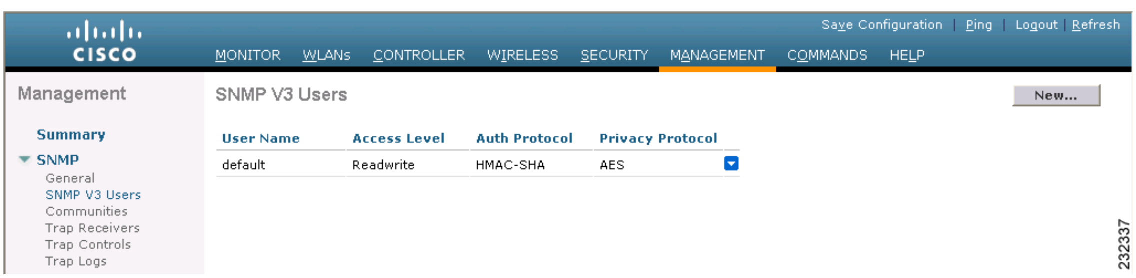
Note SNMP v3 is time sensitive. Make sure that you have configured the correct time and time zone on your controller.

Using the GUI to Change the SNMP v3 User Default Values

Follow these steps to change the SNMP v3 user default values through the controller GUI.

Step 1 Choose **Management** > **SNMP** > **SNMP V3 Users** to open the SNMP V3 Users page (see Figure 19).

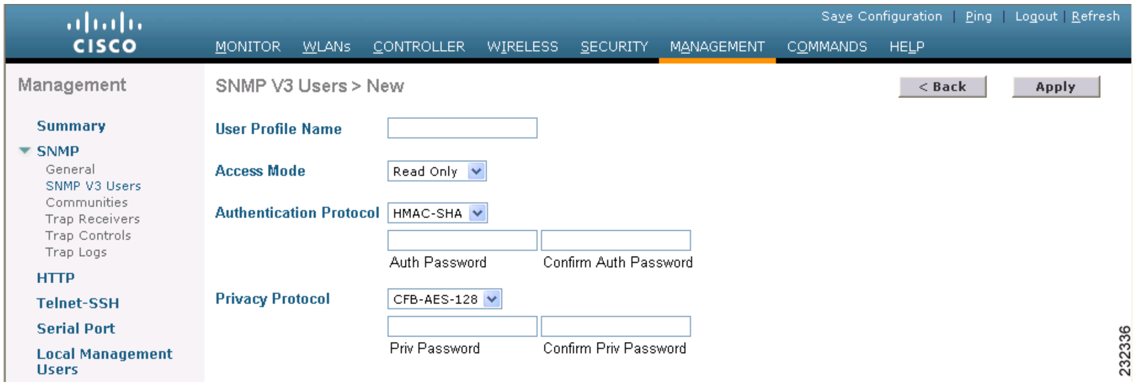
Figure 19 SNMP V3 Users Page



Step 2 If "default" appears in the User Name column, hover your cursor over the blue drop-down arrow for the desired user and choose **Remove** to delete this SNMP v3 user.

Step 3 Click **New** to add a new SNMP v3 user. The SNMP V3 Users > New page appears (see Figure 20).

Figure 20 SNMP V3 Users > New Page



Step 4 In the User Profile Name field, enter a unique name. Do not enter "default."

Step 5 Choose **Read Only** or **Read Write** from the Access Mode drop-down box to specify the access level for this user. The default value is Read Only.

Step 6 From the Authentication Protocol drop-down box, choose the desired authentication method: **None**, **HMAC-MD5** (Hashed Message Authentication Coding-Message Digest 5), or **HMAC-SHA** (Hashed Message Authentication Coding-Secure Hashing Algorithm). The default value is HMAC-SHA.

Step 7 In the Auth Password and Confirm Auth Password fields, enter the shared secret key to be used for authentication. You must enter at least 12 characters.

Step 8 From the Privacy Protocol drop-down box, choose the desired encryption method: **None**, **CBC-DES** (Cipher Block Chaining-Digital Encryption Standard), or **CFB-AES-128** (Cipher Feedback Mode-Advanced Encryption Standard-128). The default value is CFB-AES-128.

Note In order to configure CBC-DES or CFB-AES-128 encryption, you must have selected either HMAC-MD5 or HMAC-SHA as the authentication protocol in Step 6.

Step 9 In the Priv Password and Confirm Priv Password fields, enter the shared secret key to be used for encryption. You must enter at least 12 characters.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your settings.

Step 12 Reboot the controller so that the SNMP v3 user that you added takes effect.

Using the CLI to Change the SNMP v3 User Default Values

Follow these steps to change the SNMP v3 user default values through the controller CLI.

Step 1 To see the current list of SNMP v3 users for this controller, enter this command:

show snmpv3user

Step 2 If "default" appears in the SNMP v3 User Name column, enter this command to delete this user:

config snmp v3user delete *username*

The *username* parameter is the SNMP v3 username (in this case, "default").

Step 3 To create a new SNMP v3 user, enter this command:

config snmp v3user create *username* {**ro** | **rw**} {**none** | **hmacmd5** | **hmacsha**} {**none** | **des** | **aescfb128**} *auth_key encrypt_key*

where

- *username* is the SNMP v3 username;
- **ro** is read-only mode and **rw** is read-write mode;
- **none**, **hmacmd5**, and **hmacsha** are the authentication protocol options;
- **none**, **des**, and **aescfb128** are the privacy protocol options;
- *auth_key* is the authentication shared secret key; and
- *encrypt_key* is the encryption shared secret key.

Do not enter "default" for the *username*, *auth_key*, and *encrypt_key* parameters.

Step 4 To save your changes, enter **save config**.

Step 5 To reboot the controller so that the SNMP v3 user that you added takes effect, enter **reset system**.

Configuring Aggressive Load Balancing

Enabling aggressive load balancing on the controller allows lightweight access points to load balance wireless clients across access points. You can enable aggressive load balancing using the controller GUI or CLI.

Note Clients are load balanced between access points on the same controller. Load balancing does not occur between access points on different controllers.

When a wireless client attempts to associate to a lightweight access point, association response packets are sent to the client with an 802.11 response packet including status code 17. This code indicates whether the access point can accept any more associations. If the access point is too busy, the client attempts to associate to a different access point in the area. The system determines if an access point is relatively more busy than its neighbor access points that are also accessible to the client.

For example, if the number of clients on AP1 is more than the number of clients on AP2 plus the load-balancing window, then AP1 is considered to be busier than AP2. When a client attempts to associate to AP1, it receives an 802.11 response packet with status code 17, indicating that the access point is busy, and the client attempts to associate to a different access point.

In previous software releases, the controller denies a client only once and allows the client to associate to the access point on a second attempt. In software release 6.0.188.0, you can configure the controller to deny client associations up to 10 times. In addition, you can now enable or disable load balancing on a particular WLAN, which is useful if you want to disable load balancing for a select group of clients (such as time-sensitive voice clients).

Note These new aggressive load-balancing options in software release 6.0 are available only in the controller CLI.

Note Load-balancing-enabled WLANs do not support time-sensitive applications like voice and video because of roaming delays.

Note When you use Cisco 7921 and 7920 Wireless IP Phones with controllers, make sure that aggressive load balancing is disabled on the voice WLANs for each controller. Otherwise, the initial roam attempt by the phone might fail, causing a disruption in the audio path.

Using the CLI to Configure Aggressive Load Balancing

Using the controller CLI, follow these steps to configure aggressive load balancing.

Step 1 To globally enable or disable aggressive load balancing on the controller, enter this command:

config load-balancing aggressive {**enable** | **disable**}

The default value is disabled.

Step 2 To set the load-balancing window for aggressive load balancing, enter this command:

config load-balancing window *clients*

You can enter a value between 1 and 20 for the *clients* parameter. The load-balancing window becomes part of the algorithm that determines whether an access point is too heavily loaded to accept more client associations:

load-balancing window + client associations on AP with lightest load = load-balancing threshold

In the group of access points accessible to a client device, each access point has a different number of client associations. The access point with the lowest number clients has the lightest load. The load-balancing window plus the number of clients on the access point with the lightest load forms the threshold. Access points with more client associations than this threshold is considered busy, and clients can associate only to access points with client counts lower than the threshold.

Step 3 To set the maximum number of association denials during load balancing, enter this command:

config load-balancing denial *denials*

You can enter a value between 0 and 10 for the *denials* parameter.

Step 4 To save your changes, enter this command:

save config

Step 5 To verify your settings, enter this command:

show load-balancing

Information similar to the following appears:

```
Aggressive Load Balancing........................ Enabled
Aggressive Load Balancing Window................. 0 clients
Aggressive Load Balancing Denial Count........... 3

Statistics
Total Denied Count............................... 10 clients
Total Denial Sent................................ 20 messages
```

```
Exceeded Denial Max Limit Count.................. 0 times
None 5G Candidate Count.......................... 0 times
None 2.4G Candidate Count........................ 0 times
```

Step 6 If client load balancing is enabled globally, you can enable or disable this feature on a per-WLAN basis using the following command:

config wlan load-balance allow {**enable** | **disable**} *wlan_id*

By default, load balancing is allowed on all WLANs.

Step 7 To save your changes, enter this command:

save config

Configuring Band Selection

The 2.4-GHz band is often congested. Clients on this band typically experience interference from Bluetooth devices, microwave ovens, and cordless phones as well as co-channel interference from other access points because of the 802.11b/g limit of three non-overlapping channels. To combat these sources of interference and improve overall network performance, controller software release 6.0 enables you to configure band selection on the controller. This feature enables client radios that are capable of dual-band (2.4- and 5-GHz) operation to move to a less congested 5-GHz access point.

Band selection works by regulating probe responses to clients. It makes 5-GHz channels more attractive to clients by delaying probe responses to clients on 2.4-GHz channels.

Using the controller CLI, you can globally enable band selection on the controller, or you can enable or disable band selection for a particular WLAN, which is useful if you want to disable it for a select group of clients (such as time-sensitive voice clients).

Note Band-selection-enabled WLANs do not support time-sensitive applications like voice and video because of roaming delays.

Guidelines for Using Band Selection

Follow these guidelines when using band selection on your controller:

- Band selection can be used only with Cisco Aironet 1140 and 1250 series access points.
- Band selection operates only on access points that are connected to a controller. A hybrid-REAP access point without a controller connection does not perform band selection after a reboot.
- The band-selection algorithm directs dual-band clients only from the 2.4-GHz radio to the 5-GHz radio of the same access point, and it only runs on an access point when both the 2.4-GHz and 5-GHz radios are up and running.
- You can enable both band selection and aggressive load balancing on the controller. They run independently and do not impact one another.

Using the CLI, follow these steps to configure band selection on the controller:

Step 1 To globally enable or disable band selection on the controller, enter this command:

config band-select probe-response {**enable** | **disable**}

The default value is disabled.

Step 2 To set the number of suppression cycles for a new client, enter this command:

config band-select cycle-count *cycles*

You can enter a value between 1 and 10 for the *cycles* parameter. The default cycle count is 2.

Step 3 To set the time threshold during which new probe requests from a client come from a new scanning cycle, enter this command:

config band-select cycle-threshold *milliseconds*

You can enter a value between 1 and 1000 for the *milliseconds* parameter. The default cycle threshold is 200 milliseconds.

Step 4 To set the expiration time for pruning previously known 802.11b/g clients, enter this command:

config band-select expire suppression *seconds*

You can enter a value between 10 and 200 for the *seconds* parameter. The default value is 20 seconds. After this time elapses, clients become new and are subject to probe response suppression.

Step 5 To set the expiration time for pruning previously known dual-band clients, enter this command:

config band-select expire dual-band *seconds*

You can enter a value between 10 and 300 for the *seconds* parameter. The default value is 60 seconds. After this time elapses, clients become new and are subject to probe response suppression.

Step 6 To set the minimum RSSI for a client to respond to a probe, enter this command:

config band-select client-rssi *dBm*

You can enter a value between –20 and –90 for the *dBm* parameter. The default value is –80 dBm.

Step 7 To save your changes, enter this command:

save config

Step 8 If band select is enabled globally, you can enable or disable this feature on a per-WLAN basis using the following command.

config wlan band-select allow {enable | disable} *wlan_ID*

You can enter a value between 1 and 512 for *wlan_ID* parameter.

Step 9 To see a summary of dual-band clients and suppressed clients, enter this command:

show ap stats {**802.11a** | **802.11b**} *Cisco_AP*

Information similar to the following appears:

```
Band Select Stats
  Num of dual band client ....................... 10
  Num of dual band client added.................. 0
  Num of dual band client expired ............... 4
  Num of dual band client replaced............... 0
  Num of dual band client detected .............. 9
  Num of suppressed client ...................... 8
  Num of suppressed client expired............... 8
  Num of suppressed client replaced........... 0
```

Note These counters return to 0 when the access point radio is reset or shut down because all the clients are disconnected.

Step 10 To override the global configuration and enable or disable band selection on a particular WLAN, enter this command:

config wlan band-select allow {**enable** | **disable**} *wlan_id*

By default, band selection is allowed on all WLANs.

Step 11 To save your changes, enter this command:

save config

Configuring Fast SSID Changing

When fast SSID changing is enabled, the controller allows clients to move between SSIDs. When the client sends a new association for a different SSID, the client entry in the controller connection table is cleared before the client is added to the new SSID. When fast SSID changing is disabled, the controller enforces a delay before clients are allowed to move to a new SSID.

Using the GUI to Configure Fast SSID Changing

Using the controller GUI, follow these steps to configure fast SSID changing for mobile clients.

Step 1 Choose **Controller** to open the General page.

Step 2 From the Fast SSID Change drop-down box, choose **Enabled** to enable this feature or **Disabled** to disable it. The default value is disabled.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure Fast SSID Changing

Using the controller CLI, follow these steps to configure fast SSID changing for mobile clients.

Step 1 To enable or disable fast SSID changing, enter this command:

config network fast-ssid-change {**enable** | **disable**}

Step 2 To save your changes, enter this command:

save config

Enabling 802.3X Flow Control

802.3X Flow Control is disabled by default. To enable it, enter **config switchconfig flowcontrol enable**.

Configuring 802.3 Bridging

The controller supports 802.3 frames and the applications that use them, such as those typically used for cash registers and cash register servers. However, to make these applications work with the controller, the 802.3 frames must be bridged on the controller.

Support for raw 802.3 frames allows the controller to bridge non-IP frames for applications not running over IP. Only this raw 802.3 frame format is currently supported:

```
+-------------------+---------------------+-----------------+------------------------+
| Destination       | Source              | Total packet | Payload .....
| MAC address       | MAC address         | length          |
+-------------------+---------------------+-----------------+------------------------
```

You can configure 802.3 bridging through the controller GUI in software release 4.1 or later and through the controller CLI in software release 4.0 or later.

Note In controller software release 5.2 or later, the software-based forwarding architecture for 2100-series-based controllers is being replaced with a new forwarding plane architecture. As a result, 2100 series controllers and the Cisco Wireless LAN Controller Network Module for Cisco Integrated Services Routers (as well as 5500 series controllers) bridge 802.3 packets by default. Therefore, 802.3 bridging can now be disabled only on 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Wireless LAN Controller Switch.

Note By default, 2100-series-based controllers running software release 5.2 or later and 5500 series controllers bridge all non-IPv4 packets (such as Appletalk, IPv6, and so on). If desired, you can use ACLs to block the bridging of these protocols.

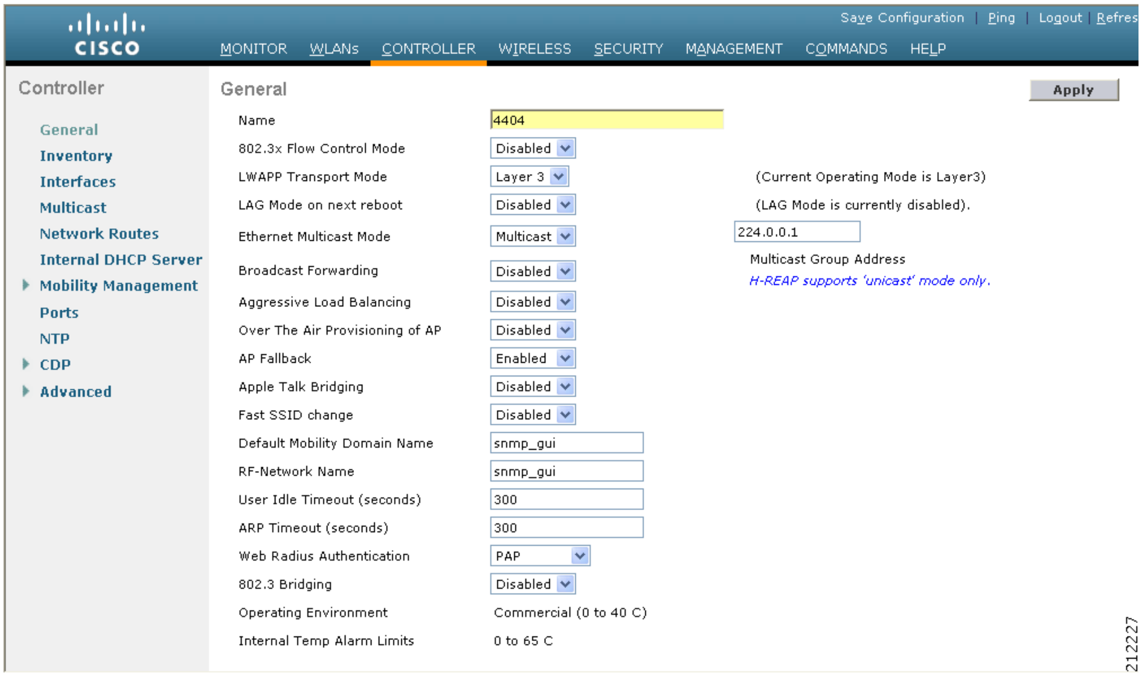
Note You can also configure 802.3 bridging using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to Configure 802.3 Bridging

Follow these steps to configure 802.3 bridging using the controller GUI.

Step 1 Choose **Controller** > **General** to open the General page (see Figure 21).

Figure 21 General Page



Step 2 From the 802.3 Bridging drop-down box, choose **Enabled** to enable 802.3 bridging on your controller or **Disabled** to disable this feature. The default value is Disabled.

> **Note** In controller software release 5.2 or later, you can disable 802.3 bridging only for 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Wireless LAN Controller Switch.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure 802.3 Bridging

Follow these steps to configure 802.3 bridging using the controller CLI.

Step 1 To see the current status of 802.3 bridging for all WLANs, enter this command:

show network

Step 2 To enable or disable 802.3 bridging globally on all WLANs, enter this command:

config network 802.3-bridging {**enable** | **disable**}

The default value is disabled.

> **Note** In controller software release 5.2 or later, you can disable 802.3 bridging only for 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Wireless LAN Controller Switch.

Step 3 To save your settings, enter this command:

save config

Configuring Multicast Mode

If your network supports packet multicasting, you can configure the multicast method that the controller uses. The controller performs multicasting in two modes:

- **Unicast mode**—In this mode, the controller unicasts every multicast packet to every access point associated to the controller. This mode is inefficient but might be required on networks that do not support multicasting.
- **Multicast mode**—In this mode, the controller sends multicast packets to a CAPWAP multicast group. This method reduces overhead on the controller processor and shifts the work of packet replication to your network, which is much more efficient than the unicast method.

You can enable multicast mode using the controller GUI or CLI.

Understanding Multicast Mode

When you enable multicast mode and the controller receives a multicast packet from the wired LAN, the controller encapsulates the packet using CAPWAP and forwards the packet to the CAPWAP multicast group address. The controller always uses the management interface for sending multicast packets. Access points in the multicast group receive the packet and forward it to all the BSSIDs mapped to the interface on which clients receive multicast traffic. From the access point perspective, the multicast appears to be a broadcast to all SSIDs.

In controller software release 4.2 or later, Internet Group Management Protocol (IGMP) snooping is introduced to better direct multicast packets. When this feature is enabled, the controller gathers IGMP reports from the clients, processes them, creates unique multicast group IDs (MGIDs) from the IGMP reports after checking the Layer 3 multicast address and the VLAN number, and sends the IGMP reports to the infrastructure switch. The controller sends these reports with the source address as the interface address on which it received the reports from the clients. The controller then updates the access point MGID table on the access point with the client MAC address. When the controller receives multicast traffic for a particular multicast group, it forwards it to all the access points, but only those access points that have active clients listening or subscribed to that multicast group send multicast traffic on that particular WLAN. IP packets are forwarded with an MGID that is unique for an ingress VLAN and the destination multicast group. Layer 2 multicast packets are forwarded with an MGID that is unique for the ingress interface.

When IGMP snooping is disabled, the following is true:

- The controller always uses Layer 2 MGID when it sends multicast data to the access point. Every interface created is assigned one Layer 2 MGID. For example, the management interface has an MGID of 0, and the first dynamic interface created is assigned an MGID of 8, which increments as each dynamic interface is created.
- The IGMP packets from clients are forwarded to the router. As a result, the router IGMP table is updated with the IP address of the clients as the last reporter.

When IGMP snooping is enabled, the following is true:

- The controller always uses Layer 3 MGID for all Layer 3 multicast traffic sent to the access point. For all Layer 2 multicast traffic, it continues to use Layer 2 MGID.
- IGMP report packets from wireless clients are consumed or absorbed by the controller, which generates a query for the clients. After the router sends the IGMP query, the controller sends the IGMP reports with its interface IP address as the listener IP address for the multicast group. As a result, the router IGMP table is updated with the controller IP address as the multicast listener.
- When the client that is listening to the multicast groups roams from one controller to another, the first controller transmits all the multicast group information for the listening client to the second controller. As a result, the second controller can immediately create the multicast group information for the client. The second controller sends the IGMP reports to the network for all multicast groups to which the client was listening. This process aids in the seamless transfer of multicast data to the client.
- If the listening client roams to a controller in a different subnet, the multicast packets are tunneled to the anchor controller of the client to avoid the reverse path filtering (RPF) check. The anchor then forwards the multicast packets to the infrastructure switch.

Note The MGIDs are controller specific. The same multicast group packets coming from the same VLAN in two different controllers may be mapped to two different MGIDs.

Note If Layer 2 multicast is enabled, a single MGID is assigned to all the multicast addresses coming from an interface (see Figure 23).

Guidelines for Using Multicast Mode

Follow these guidelines when you enable multicast mode on your network:

- The Cisco Unified Wireless Network solution uses some IP address ranges for specific purposes, and you should keep these ranges in mind when configuring a multicast group:
  - 224.0.0.0 through 224.0.0.255—Reserved link local addresses
  - 224.0.1.0 through 238.255.255.255—Globally scoped addresses
  - 239.0.0.0 through 239.255.x.y /16—Limited scope addresses
- When you enable multicast mode on the controller, you also must configure a CAPWAP multicast group address. Access points subscribe to the CAPWAP multicast group using IGMP.
- Cisco 1100, 1130, 1200, 1230, and 1240 access points use IGMP versions 1, 2, and 3.
- Access points in monitor mode, sniffer mode, or rogue detector mode do not join the CAPWAP multicast group address.
- The CAPWAP multicast group configured on the controllers should be different for different controllers.
- Multicast mode does not operate across intersubnet mobility events such as guest tunneling. It does, however, operate with interface overrides using RADIUS (but only when IGMP snooping is enabled) and with site-specific VLANs (access point group VLANs).

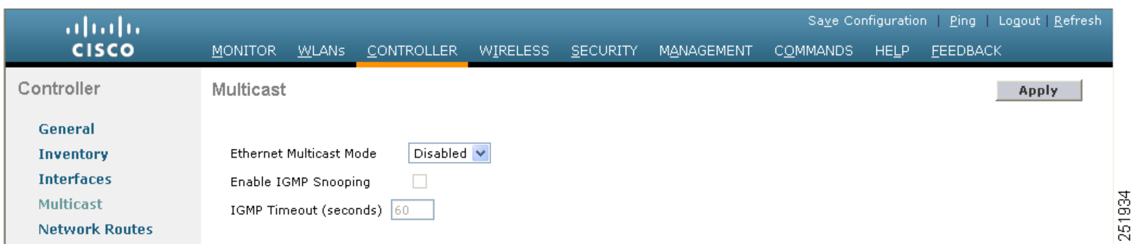
- For LWAPP, the controller drops multicast packets sent to UDP control port 12223. For CAPWAP, the controller drops multicast packets sent to UDP control and data ports 5246 and 5247, respectively. Therefore, you may want to consider not using these port numbers with the multicast applications on your network.
- Cisco recommends that any multicast applications on your network not use the multicast address configured as the CAPWAP multicast group address on the controller.
- 2100 series controllers do not support multicast-unicast mode. They do, however, support multicast-multicast mode, except when access points are connected directly to the local port of a 2100 series controller.

Using the GUI to Enable Multicast Mode

Follow these steps to enable multicast mode using the controller GUI.

Step 1 Choose **Controller** > **Multicast** to open the Multicast page (see Figure 22).

Figure 22 Multicast Page



Step 2 Choose one of the following options from the Ethernet Multicast Mode drop-down box:

- **Disabled**—Disables multicasting on the controller. This is the default value.
- **Unicast**—Configures the controller to use the unicast method to send multicast packets.
- **Multicast**—Configures the controller to use the multicast method to send multicast packets to a CAPWAP multicast group.

Note Hybrid REAP supports unicast mode only.

Step 3 If you chose Multicast in Step 2, enter the IP address of the multicast group in the Multicast Group Address field.

Step 4 If you want to enable IGMP snooping, check the **Enable IGMP Snooping** check box. If you want to disable IGMP snooping, leave the check box unchecked. The default value is disabled.

Step 5 To set the IGMP timeout, enter a value between 30 and 7200 seconds in the **IGMP Timeout** field. The controller sends three queries in one timeout value at an interval of *timeout*/3 (if the timeout value is more than 360 seconds, controller sends one query every 120 seconds, irrespective of the value configured) to see if any clients exist for a particular multicast group. If the controller does not receive a response through an IGMP report from the client, the controller times out the client entry from the MGID table. When no clients are left for a particular multicast group, the controller waits for the IGMP timeout value (if the timeout value is more than 360 seconds, controller waits for 360 seconds irrespective of the value configured) to expire and then deletes the MGID entry from the controller. The controller always generates a general IGMP query (that is, to destination address 224.0.0.1) and sends it on all WLANs with an MGID value of 1.

Step 6 Click **Apply** to commit your changes.

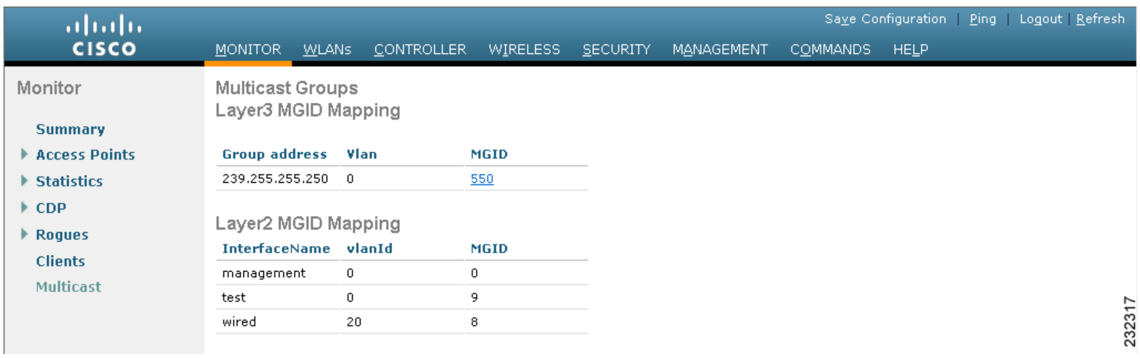
Step 7 Click **Save Configuration** to save your changes.

Using the GUI to View Multicast Groups

Follow these steps to view multicast groups using the controller GUI.

Step 1 Choose **Monitor** > **Multicast**. The Multicast Groups page appears (see Figure 23).

Figure 23 Multicast Groups Page



This page shows all the multicast groups and their corresponding MGIDs.

Step 2 Click the link for a specific MGID (such as MGID 550) to see a list of all the clients joined to the multicast group in that particular MGID.

Using the CLI to Enable Multicast Mode

Follow these steps to enable multicast mode using the controller CLI.

Step 1 To enable or disable multicasting on the controller, enter this command:

config network multicast global {**enable** | **disable**}

The default value is disabled.

> **Note** The **config network broadcast** {**enable** | **disable**} command allows you to enable or disable broadcasting without enabling or disabling multicasting as well. This command uses the multicast mode currently on the controller to operate.

Step 2 Perform one of the following:

a. To configure the controller to use the unicast method to send multicast packets, enter this command:

config network multicast mode unicast

b. To configure the controller to use the multicast method to send multicast packets to a CAPWAP multicast group, enter this command:

config network multicast mode multicast *multicast_group_ip_address*

Step 3 To enable or disable IGMP snooping, enter this command:

config network multicast igmp snooping {**enable** | **disable**}

The default value is disabled.

Step 4 To set the IGMP timeout value, enter this command:

config network multicast igmp timeout *timeout*

You can enter a *timeout* value between 30 and 300 seconds. The controller sends three queries in one timeout value at an interval of *timeout*/3 to see if any clients exist for a particular multicast group. If the controller does not receive a response through an IGMP report from the client, the controller times out the client entry from the MGID table. When no clients are left for a particular multicast group, the controller waits for the IGMP timeout value to expire and then deletes the MGID entry from the controller. The controller always generates a general IGMP query (that is, to destination address 224.0.0.1) and sends it on all WLANs with an MGID value of 1.

Step 5 To save your changes, enter this command:

save config

Using the CLI to View Multicast Groups

Use these commands to view multicast groups using the controller CLI.

- To see all the multicast groups and their corresponding MGIDs, enter this command:

  show network multicast mgid summary

  Information similar to the following appears:

```
Layer2 MGID Mapping:
-------------------
InterfaceName                    vlanId   MGID
-------------------------------- ------   ----
management                       0        0
test                             0        9
wired                            20       8

Layer3 MGID Mapping:
-------------------
Number of Layer3 MGIDs........................... 1

 Group address    Vlan  MGID
 ---------------  ----  ----
 239.255.255.250  0     550
```

- To see all the clients joined to the multicast group in a specific MGID, enter this command:

  show network multicast mgid detail *mgid_value* where the *mgid_value* parameter is a number between 550 and 4095.

Information similar to the following appears:

```
Mgid........................................ 550
Multicast Group Address..................... 239.255.255.250
Vlan........................................ 0
Rx Packet Count............................. 807399588
No of clients............................... 1
Client List.................................
        Client MAC             Expire Time (mm:ss)
        00:13:02:23:82:ad      0:20
```

Using the CLI to View an Access Point's Multicast Client Table

To help troubleshoot roaming events, you can view an access point's multicast client table from the controller by performing a remote debug of the access point. Follow these steps to do so using the controller CLI:

Step 1 To initiate a remote debug of the access point, enter this command:

debug ap enable *Cisco_AP*

Step 2 To see all of the MGIDs on the access point and the number of clients per WLAN, enter this command:

debug ap command "**show capwap mcast mgid all**" *Cisco_AP*

Step 3 To see all of the clients per MGID on the access point and the number of clients per WLAN, enter this command:

debug ap command "**show capwap mcast mgid id** *mgid_value*" *Cisco_AP*

Configuring Client Roaming

The Cisco UWN Solution supports seamless client roaming across lightweight access points managed by the same controller, between controllers in the same mobility group on the same subnet, and across controllers in the same mobility group on different subnets. Also, in controller software release 4.1 or later, client roaming with multicast packets is supported.

You can adjust the default RF settings (RSSI, hysteresis, scan threshold, and transition time) to fine-tune the operation of client roaming using the controller GUI or CLI.

Intra-Controller Roaming

Each controller supports same-controller client roaming across access points managed by the same controller. This roaming is transparent to the client as the session is sustained, and the client continues using the same DHCP-assigned or client-assigned IP address. The controller provides DHCP functionality with a relay function. Same-controller roaming is supported in single-controller deployments and in multiple-controller deployments.

Inter-Controller Roaming

Multiple-controller deployments support client roaming across access points managed by controllers in the same mobility group and on the same subnet. This roaming is also transparent to the client because the session is sustained and a tunnel between controllers allows the client to continue using the same DHCP- or client-assigned IP address as long as the session remains active. The tunnel is torn down, and the client must reauthenticate when the client sends a DHCP Discover with a 0.0.0.0 client IP address or a 169.254.*.* client auto-IP address or when the operator-set session timeout is exceeded.

Inter-Subnet Roaming

Multiple-controller deployments support client roaming across access points managed by controllers in the same mobility group on different subnets. This roaming is transparent to the client because the session is sustained and a tunnel between the controllers allows the client to continue using the same DHCP-assigned or client-assigned IP address as long as the session remains active. The tunnel is torn down, and the client must reauthenticate when the client sends a DHCP Discover with a 0.0.0.0 client IP address or a 169.254.*.* client auto-IP address or when the operator-set user timeout is exceeded.

Voice-over-IP Telephone Roaming

802.11 voice-over-IP (VoIP) telephones actively seek out associations with the strongest RF signal to ensure the best quality of service (QoS) and the maximum throughput. The minimum VoIP telephone requirement of 20-millisecond or shorter latency time for the roaming handover is easily met by the Cisco UWN Solution, which has an average handover latency of 5 or fewer milliseconds when open authentication is used. This short latency period is controlled by controllers rather than allowing independent access points to negotiate roaming handovers.

The Cisco UWN Solution supports 802.11 VoIP telephone roaming across lightweight access points managed by controllers on different subnets, as long as the controllers are in the same mobility group. This roaming is transparent to the VoIP telephone because the session is sustained and a tunnel between controllers allows the VoIP telephone to continue using the same DHCP-assigned IP address as long as the session remains active. The tunnel is torn down, and the VoIP client must reauthenticate when the VoIP telephone sends a DHCP Discover with a 0.0.0.0 VoIP telephone IP address or a 169.254.*.* VoIP telephone auto-IP address or when the operator-set user timeout is exceeded.

CCX Layer 2 Client Roaming

The controller supports five CCX Layer 2 client roaming enhancements:

- **Access point assisted roaming**—This feature helps clients save scanning time. When a CCXv2 client associates to an access point, it sends an information packet to the new access point listing the characteristics of its previous access point. Roaming time decreases when the client recognizes and uses an access point list built by compiling all previous access points to which each client was associated and sent (unicast) to the client immediately after association. The access point list contains the channels, BSSIDs of neighbor access points that support the client's current SSID(s), and time elapsed since disassociation.
- **Enhanced neighbor list**—This feature focuses on improving a CCXv4 client's roam experience and network edge performance, especially when servicing voice applications. The access point provides its associated client information about its neighbors using a neighbor-list update unicast message.

- **Enhanced neighbor list request (E2E)**—The End-2-End specification is a Cisco and Intel joint program that defines new protocols and interfaces to improve the overall voice and roaming experience. It applies only to Intel clients in a CCX environment. Specifically, it enables Intel clients to request a neighbor list at will. When this occurs, the access point forwards the request to the controller. The controller receives the request and replies with the current CCX roaming sublist of neighbors for the access point to which the client is associated.

  Note To see whether a particular client supports E2E, choose **Wireless** > **Clients** on the controller GUI, click the **Detail** link for the desired client, and look at the E2E Version field under Client Properties.

- **Roam reason report**—This feature enables CCXv4 clients to report the reason why they roamed to a new access point. It also allows network administrators to build and monitor a roam history.
- **Directed roam request**—This feature enables the controller to send directed roam requests to the client in situations when the controller can better service the client on an access point different from the one to which it is associated. In this case, the controller sends the client a list of the best access points that it can join. The client can either honor or ignore the directed roam request. Non-CCX clients and clients running CCXv3 or below must not take any action. No configuration is required for this feature.

Controller software release 4.2 or later supports CCX versions 1 through 5. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. The controller stores the CCX version of the client in its client database and uses it to generate and respond to CCX frames appropriately. Clients must support CCXv4 or v5 (or CCXv2 for access point assisted roaming) in order to utilize these roaming enhancements. See the "Configuring Cisco Client Extensions" section on page 49 for more information on CCX.

The roaming enhancements mentioned above are enabled automatically, with the appropriate CCX support.

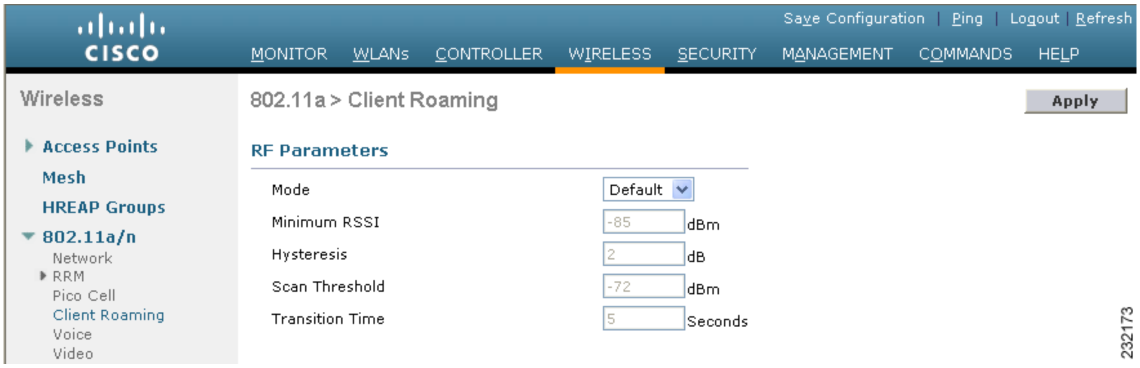
Note Hybrid-REAP access points in standalone mode do not support CCX Layer 2 roaming.

Using the GUI to Configure CCX Client Roaming Parameters

Follow these steps to configure CCX client roaming parameters using the GUI.

Step 1 Choose **Wireless** > **802.11a/n** (or **802.11b/g/n**) > **Client Roaming**. The 802.11a (or 802.11b) > Client Roaming page appears (see Figure 24).

Figure 24 802.11a > Client Roaming Page



Step 2 If you want to fine-tune the RF parameters that affect client roaming, choose **Custom** from the Mode drop-down box and go to Step 3. If you want to leave the RF parameters at their default values, choose **Default** and go to Step 8.

Step 3 In the Minimum RSSI field, enter a value for the minimum received signal strength indicator (RSSI) required for the client to associate to an access point. If the client's average received signal power dips below this threshold, reliable communication is usually impossible. Therefore, clients must already have found and roamed to another access point with a stronger signal before the minimum RSSI value is reached.

Range: –80 to –90 dBm

Default: –85 dBm

Step 4 In the Hysteresis field, enter a value to indicate how much greater the signal strength of a neighboring access point must be in order for the client to roam to it. This parameter is intended to reduce the amount of roaming between access points if the client is physically located on or near the border between two access points.

Range: 2 to 4 dB

Default: 2 dB

Step 5 In the Scan Threshold field, enter the minimum RSSI that is allowed before the client should roam to a better access point. When the RSSI drops below the specified value, the client must be able to roam to a better access point within the specified transition time. This parameter also provides a power-save method to minimize the time that the client spends in active or passive scanning. For example, the client can scan slowly when the RSSI is above the threshold and scan more rapidly when below the threshold.

Range: –70 to –77 dBm

Default: –72 dBm

Step 6 In the Transition Time field, enter the maximum time allowed for the client to detect a suitable neighboring access point to roam to and to complete the roam, whenever the RSSI from the client's associated access point is below the scan threshold.

The Scan Threshold and Transition Time parameters guarantee a minimum level of client roaming performance. Together with the highest expected client speed and roaming hysteresis, these parameters make it possible to design a wireless LAN network that supports roaming simply by ensuring a certain minimum overlap distance between access points.

Range: 1 to 10 seconds

Default: 5 seconds

Step 7 Click **Apply** to commit your changes.

Step 8 Click **Save Configuration** to save your changes.

Step 9 Repeat this procedure if you want to configure client roaming for another radio band (802.11a or 802.11b/g).

Using the CLI to Configure CCX Client Roaming Parameters

To configure CCX Layer 2 client roaming parameters, enter this command:

config {**802.11a** | **802.11b**} **l2roam rf-params** {**default** | **custom** *min_rssi roam_hyst scan_thresh trans_time*}

Note See the description, range, and default value of each RF parameter in the "Using the GUI to Configure CCX Client Roaming Parameters" section on page 63.

Using the CLI to Obtain CCX Client Roaming Information

Use these commands to view information about CCX Layer 2 client roaming.

1. To view the current RF parameters configured for client roaming for the 802.11a or 802.11b/g network, enter this command:

   show {**802.11a** | **802.11b**} **l2roam rf-param**

2. To view the CCX Layer 2 client roaming statistics for a particular access point, enter this command:

   show {**802.11a** | **802.11b**} **l2roam statistics** *ap_mac*

   This command provides the following information:

   – The number of roam reason reports received

   – The number of neighbor list requests received

   – The number of neighbor list reports sent

   – The number of broadcast neighbor updates sent

3. To view the roaming history for a particular client, enter this command:

   show client roam-history *client_mac*

   This command provides the following information:

   – The time when the report was received

   – The MAC address of the access point to which the client is currently associated

   – The MAC address of the access point to which the client was previously associated

   – The channel of the access point to which the client was previously associated

   – The SSID of the access point to which the client was previously associated

   – The time when the client disassociated from the previous access point

   – The reason for the client roam

Using the CLI to Debug CCX Client Roaming Issues

If you experience any problems with CCX Layer 2 client roaming, enter this command:

debug l2roam [**detail** | **error** | **packet** | **all]** {**enable** | **disable**}

Configuring IP-MAC Address Binding

In controller software release 5.2 or later, the controller enforces strict IP address-to-MAC address binding in client packets. The controller checks the IP address and MAC address in a packet, compares them to the addresses that are registered with the controller, and forwards the packet only if they both match. In previous releases, the controller checks only the MAC address of the client and ignores the IP address.

Note If the IP address or MAC address of the packet has been spoofed, the check does not pass, and the controller discards the packet. Spoofed packets can pass through the controller only if both the IP and MAC addresses are spoofed together and changed to that of another valid client on the same controller.

Using the controller CLI, follow these steps to configure IP-MAC address binding.

Step 1 To enable or disable IP-MAC address binding, enter this command:

config network ip-mac-binding {**enable** | **disable**}

The default value is enabled.

Note You might want to disable this binding check if you have a routed network behind a workgroup bridge (WGB).

Note You must disable this binding check in order to use an access point in sniffer mode if the access point is joined to a 5500 series controller, a 2100 series controller, or a controller network module running software release 6.0.

Step 2 To save your changes, enter this command:

save config

Step 3 To view the status of IP-MAC address binding, enter this command:

show network summary

Information similar to the following appears:

```
RF-Network Name............................ ctrl4404
Web Mode................................... Disable
Secure Web Mode............................ Enable
Secure Web Mode Cipher-Option High.......... Disable
Secure Web Mode Cipher-Option SSLv2......... Enable
...
IP/MAC Addr Binding Check ............... Enabled
...
```

Configuring Quality of Service

Quality of service (QoS) refers to the capability of a network to provide better service to selected network traffic over various technologies. The primary goal of QoS is to provide priority including dedicated bandwidth, controlled jitter and latency (required by some real-time and interactive traffic), and improved loss characteristics.

The controller supports four QoS levels:

- Platinum/Voice—Ensures a high quality of service for voice over wireless.
- Gold/Video—Supports high-quality video applications.
- Silver/Best Effort—Supports normal bandwidth for clients. This is the default setting.
- Bronze/Background—Provides the lowest bandwidth for guest services.

Note VoIP clients should be set to Platinum.

You can configure the bandwidth of each QoS level using QoS profiles and then apply the profiles to WLANs. The profile settings are pushed to the clients associated to that WLAN. In addition, you can create QoS roles to specify different bandwidth levels for regular and guest users. Follow the instructions in this section to configure QoS profiles and QoS roles.

Configuring Quality of Service Profiles

You can use the controller GUI or CLI to configure the Platinum, Gold, Silver, and Bronze QoS profiles.

Using the GUI to Configure QoS Profiles

Follow these steps to configure QoS profiles using the controller GUI.

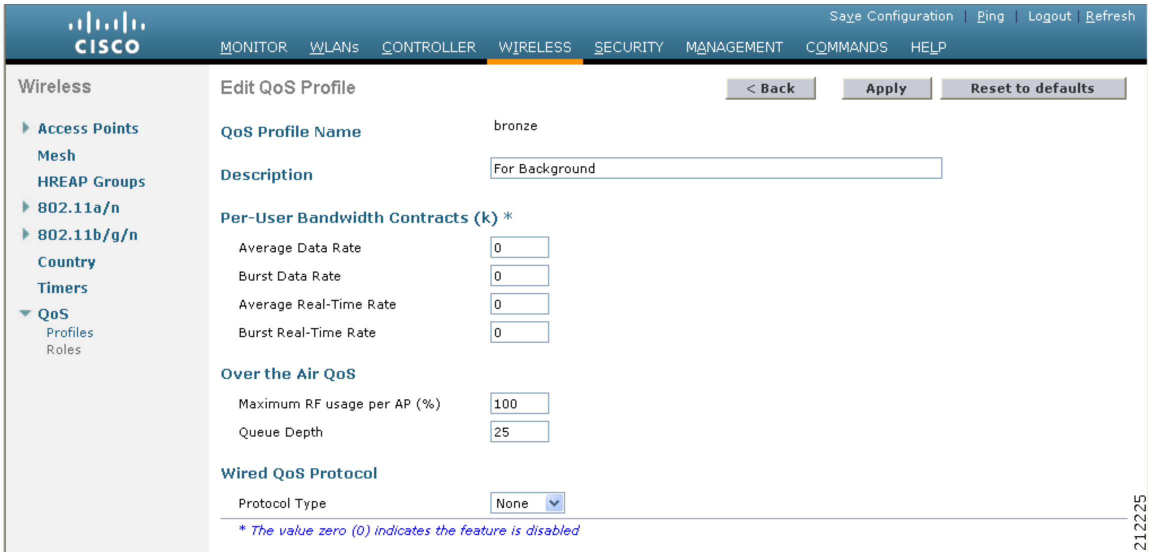
Step 1 Disable the 802.11a and 802.11b/g networks so that you can configure the QoS profiles.

To disable the radio networks, choose **Wireless > 802.11a/n** or **802.11b/g/n > Network**, uncheck the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 2 Choose **Wireless** > **QoS > Profiles** to open the QoS Profiles page.

Step 3 Click the name of the profile that you want to configure to open the Edit QoS Profile page (see Figure 25).

Figure 25 Edit QoS Profile Page



Step 4 To change the description of the profile, modify the contents of the Description field.

Step 5 To define the average data rate for TCP traffic per user, enter the rate in Kbps in the Average Data Rate field. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the profile.

Step 6 To define the peak data rate for TCP traffic per user, enter the rate in Kbps in the Burst Data Rate field. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the profile.

Note The Burst Data Rate should be greater than or equal to the Average Data Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Step 7 To define the average real-time rate for UDP traffic on a per user basis, enter the rate in Kbps in the Average Real-Time Rate field. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the profile.

Step 8 To define the peak real-time rate for UDP traffic on a per user basis, enter the rate in Kbps in the Burst Real-Time Rate field. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the profile.

Note The Burst Real-Time Rate should be greater than or equal to the Average Real-Time Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Step 9 In the Maximum RF Usage Per AP field, enter the maximum percentage of bandwidth given to a user class.

For example, if you set 50% for Bronze QoS, all the Bronze WLAN users combined will not get more than 50% of the available RF bandwidth. Actual throughput could be less than 50%, but it will never be more than 50%.

Step 10 In the Queue Depth field, enter the maximum number of packets that access points keep in their queues. Any additional packets are dropped.

Step 11 To define the maximum value (0–7) for the priority tag associated with packets that fall within the profile, choose **802.1p** from the Protocol Type drop-down box and enter the maximum priority value in the 802.1p Tag field.

The tagged packets include CAPWAP data packets (between access points and the controller) and packets sent toward the core network.

Note If a QoS profile has 802.1p tagging configured and if this QoS profile is assigned to a WLAN that uses an untagged interface on the controller, the client traffic will be blocked.

Step 12 Click **Apply** to commit your changes.

Step 13 Click **Save Configuration** to save your changes.

Step 14 Re-enable the 802.11a and 802.11b/g networks.

To enable the radio networks, choose **Wireless > 802.11a/n** or **802.11b/g/n > Network**, check the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 15 Follow the instructions in the "Assigning a QoS Profile to a WLAN" section on page 35 to assign a QoS profile to a WLAN.

Using the CLI to Configure QoS Profiles

Follow these steps to configure the Platinum, Gold, Silver, and Bronze QoS profiles using the CLI.

Step 1 To disable the 802.11a and 802.11b/g networks so that you can configure the QoS profiles, enter these commands:

config 802.11a disable network

config 802.11b disable network

Step 2 To change the profile description, enter this command:

config qos description {bronze | silver | gold | platinum} *description*

Step 3 To define the average data rate in Kbps for TCP traffic per user, enter this command:

config qos average-data-rate {bronze | silver | gold | platinum} *rate*

Note For the *rate* parameter, you can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS profile.

Step 4 To define the peak data rate in Kbps for TCP traffic per user, enter this command:

config qos burst-data-rate {bronze | silver | gold | platinum} *rate*

Step 5 To define the average real-time rate in Kbps for UDP traffic per user, enter this command:

config qos average-realtime-rate {bronze | silver | gold | platinum} *rate*

Step 6 To define the peak real-time rate in Kbps for UDP traffic per user, enter this command:

config qos burst-realtime-rate {bronze | silver | gold | platinum} *rate*

Step 7 To specify the maximum percentage of RF usage per access point, enter this command:

config qos max-rf-usage {bronze | silver | gold | platinum} *usage_percentage*

Step 8 To specify the maximum number of packets that access points keep in their queues, enter this command:

config qos queue_length {bronze | silver | gold | platinum} *queue_length*

> **Note** If a QoS profile has 802.1p tagging configured and if this QoS profile is assigned to a WLAN that uses an untagged interface on the controller, the client traffic will be blocked.

Step 9 To define the maximum value (0–7) for the priority tag associated with packets that fall within the profile, enter these commands:

config qos protocol-type {bronze | silver | gold | platinum} dot1p

config qos dot1p-tag {bronze | silver | gold | platinum} *tag*

The tagged packets include CAPWAP data packets (between access points and the controller) and packets sent toward the core network.

Step 10 To re-enable the 802.11a and 802.11b/g networks so that you can configure the QoS profiles, enter these commands:

config 802.11a enable network

config 802.11b enable network

Step 11 Follow the instructions in the "Assigning a QoS Profile to a WLAN" section on page 35 to assign a QoS profile to a WLAN.

Configuring Quality of Service Roles

After you configure a QoS profile and apply it to a WLAN, it limits the bandwidth level of clients associated to that WLAN. Multiple WLANs can be mapped to the same QoS profile, which can result in bandwidth contention between regular users (such as employees) and guest users. In order to prevent guest users from using the same level of bandwidth as regular users, you can create QoS roles with different (and presumably lower) bandwidth contracts and assign them to guest users.

You can use the controller GUI or CLI to configure up to ten QoS roles for guest users.

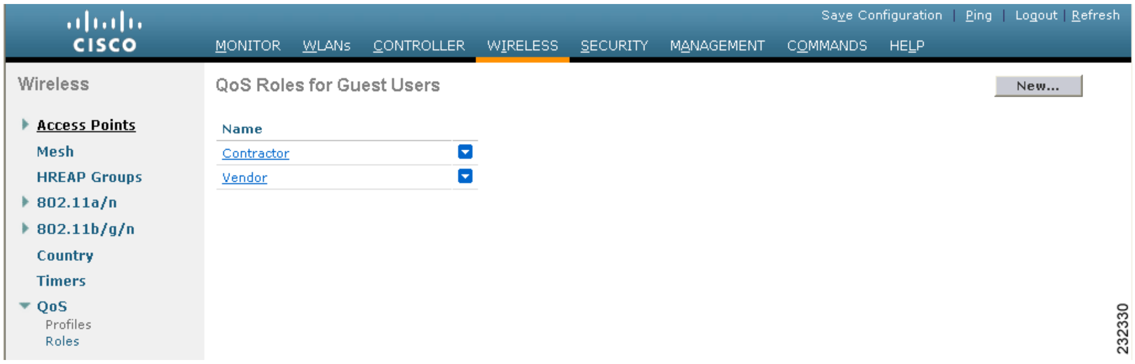
> **Note** If you choose to create an entry on the RADIUS server for a guest user and enable RADIUS authentication for the WLAN on which web authentication is performed rather than adding a guest user to the local user database from the controller, you need to assign the QoS role on the RADIUS server itself. To do so, a "guest-role" Airespace attribute needs to be added on the RADIUS server with a datatype of "string" and a return value of "11." This attribute is sent to the controller when authentication occurs. If a role with the name returned from the RADIUS server is found configured on the controller, the bandwidth associated to that role is enforced for the guest user after authentication completes successfully.

Using the GUI to Configure QoS Roles

Follow these steps to configure QoS roles using the controller GUI.

Step 1 Choose **Wireless > QoS > Roles** to open the QoS Roles for Guest Users page (see Figure 26).

Figure 26 QoS Roles for Guest Users Page



This page shows any existing QoS roles for guest users.

Note If you want to delete a QoS role, hover your cursor over the blue drop-down arrow for that role and choose **Remove**.

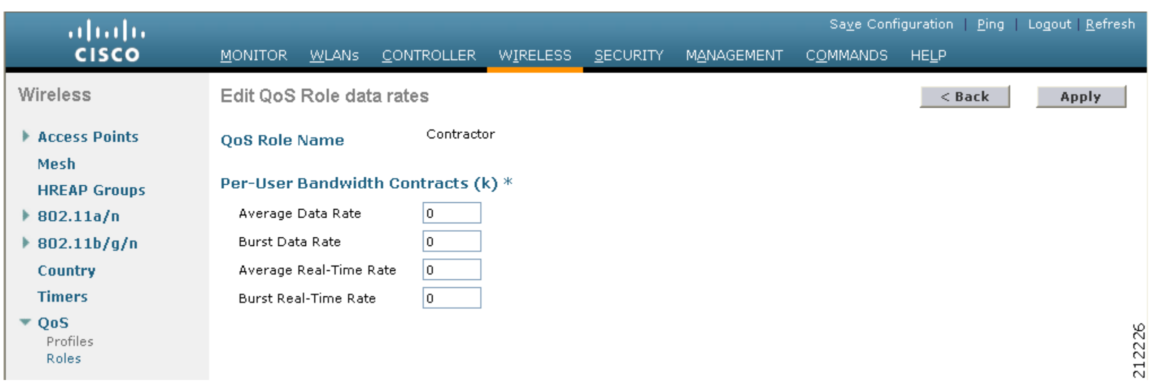
Step 2 To create a new QoS role, click **New**. The QoS Role Name > New page appears.

Step 3 In the Role Name field, enter a name for the new QoS role. The name should uniquely identify the role of the QoS user (such as Contractor, Vendor, and so on).

Step 4 Click **Apply** to commit your changes.

Step 5 To edit the bandwidth of a QoS role, click the name of the QoS role. The Edit QoS Role Data Rates page appears (see Figure 27).

Figure 27 Edit QoS Role Data Rates Page



Note The values that you configure for the per-user bandwidth contracts affect only the amount of bandwidth going downstream (from the access point to the wireless client). They do not affect the bandwidth for upstream traffic (from the client to the access point).

Step 6 To define the average data rate for TCP traffic on a per user basis, enter the rate in Kbps in the Average Data Rate field. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Step 7 To define the peak data rate for TCP traffic on a per user basis, enter the rate in Kbps in the Burst Data Rate field. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Note The Burst Data Rate should be greater than or equal to the Average Data Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Step 8 To define the average real-time rate for UDP traffic on a per user basis, enter the rate in Kbps in the Average Real-Time Rate field. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Step 9 To define the peak real-time rate for UDP traffic on a per user basis, enter the rate in Kbps in the Burst Real-Time Rate field. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Note The Burst Real-Time Rate should be greater than or equal to the Average Real-Time Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Step 12 To apply a QoS role to a guest user, follow the steps in the "Using the GUI to Configure Local Network Users" section on page 32.

Using the CLI to Configure QoS Roles

Follow these steps to configure QoS roles using the controller CLI.

Step 1 To create a QoS role for a guest user, enter this command:

config netuser guest-role create *role_name*

Note If you want to delete a QoS role, enter this command:
config netuser guest-role delete *role_name*

Step 2 To configure the bandwidth contracts for a QoS role, enter these commands:

- **config netuser guest-role qos data-rate average-data-rate** *role_name rate*—Configures the average data rate for TCP traffic on a per user basis.
- **config netuser guest-role qos data-rate burst-data-rate** *role_name rate*—Configures the peak data rate for TCP traffic on a per user basis.

  Note The Burst Data Rate should be greater than or equal to the Average Data Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

- **config netuser guest-role qos data-rate average-realtime-rate** *role_name rate*—Configures the average real-time rate for UDP traffic on a per user basis.

- **config netuser guest-role qos data-rate burst-realtime-rate** *role_name rate*—Configures the peak real-time rate for UDP traffic on a per user basis.

  Note The Burst Real-Time Rate should be greater than or equal to the Average Real-Time Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Note For the *role_name* parameter in each of these commands, enter a name for the new QoS role. The name should uniquely identify the role of the QoS user (such as Contractor, Vendor, and so on). For the *rate* parameter, you can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Step 3 To apply a QoS role to a guest user, enter this command:

config netuser guest-role apply *username role_name*

For example, the role of *Contractor* could be applied to guest user *jsmith*.

Note If you do not assign a QoS role to a guest user, the Role field in the User Details shows the role as “default.” The bandwidth contracts for this user are defined in the QoS profile for the WLAN.

Note If you want to unassign a QoS role from a guest user, enter this command: **config netuser guest-role apply** *username* **default**. This user now uses the bandwidth contracts defined in the QoS profile for the WLAN.

Step 4 To save your changes, enter this command:

save config

Step 5 To see a list of the current QoS roles and their bandwidth parameters, enter this command:

show netuser guest-roles

Information similar to the following appears:

```
Role Name....................................... Contractor
     Average Data Rate.......................... 10
     Burst Data Rate............................ 10
     Average Realtime Rate...................... 100
     Burst Realtime Rate........................ 100

Role Name....................................... Vendor
     Average Data Rate.......................... unconfigured
     Burst Data Rate............................ unconfigured
     Average Realtime Rate...................... unconfigured
     Burst Realtime Rate..................... unconfigured
```

Configuring Voice and Video Parameters

Three parameters on the controller affect voice and/or video quality:

- Call admission control
- Expedited bandwidth requests
- Unscheduled automatic power save delivery

Each of these parameters is supported in Cisco Compatible Extensions (CCX) v4 and v5. See the "Configuring Cisco Client Extensions" section on page 49 for more information on CCX.

Note CCX is not supported on the AP1030.

Traffic stream metrics (TSM) can be used to monitor and report issues with voice quality.

Call Admission Control

Call admission control (CAC) enables an access point to maintain controlled quality of service (QoS) when the wireless LAN is experiencing congestion. The Wi-Fi Multimedia (WMM) protocol deployed in CCXv3 ensures sufficient QoS as long as the wireless LAN is not congested. However, in order to maintain QoS under differing network loads, CAC in CCXv4 is required. Two types of CAC are available: bandwidth-based CAC and load-based CAC.

Bandwidth-Based CAC

Bandwidth-based, or static, CAC enables the client to specify how much bandwidth or shared medium time is required to accept a new call and in turn enables the access point to determine whether it is capable of accommodating this particular call. The access point rejects the call if necessary in order to maintain the maximum allowed number of calls with acceptable quality.

The QoS setting for a WLAN determines the level of bandwidth-based CAC support. To use bandwidth-based CAC with voice applications, the WLAN must be configured for Platinum QoS. To use bandwidth-based CAC with video applications, the WLAN must be configured for Gold QoS. Also, make sure that WMM is enabled for the WLAN. See the "Configuring 802.3 Bridging" section on page 54 for QoS and WMM configuration instructions.

Note You must enable admission control (ACM) for CCXv4 clients that have WMM enabled. Otherwise, bandwidth-based CAC does not operate properly.

Load-Based CAC

Load-based CAC incorporates a measurement scheme that takes into account the bandwidth consumed by all traffic types (including that from clients), co-channel access point loads, and co-located channel interference, for voice applications. Load-based CAC also covers the additional bandwidth consumption resulting from PHY and channel impairment.

In load-based CAC, the access point continuously measures and updates the utilization of the RF channel (that is, the percentage of bandwidth that has been exhausted), channel interference, and the additional calls that the access point can admit. The access point admits a new call only if the channel has enough unused bandwidth to support that call. By doing so, load-based CAC prevents over-subscription of the channel and maintains QoS under all conditions of WLAN loading and interference.

Note Load-based CAC is supported only on lightweight access points. If you disable load-based CAC, the access points start using bandwidth-based CAC.

Expedited Bandwidth Requests

The expedited bandwidth request feature enables CCXv5 clients to indicate the urgency of a WMM traffic specifications (TSPEC) request (for example, an e911 call) to the WLAN. When the controller receives this request, it attempts to facilitate the urgency of the call in any way possible without potentially altering the quality of other TSPEC calls that are in progress.

You can apply expedited bandwidth requests to both bandwidth-based and load-based CAC. Expedited bandwidth requests are disabled by default. When this feature is disabled, the controller ignores all expedited requests and processes TSPEC requests as normal TSPEC requests.

See Table 2 for examples of TSPEC request handling for normal TSPEC requests and expedited bandwidth requests.

Table 2 TSPEC Request Handling Examples

CAC Mode	Reserved bandwidth for voice calls[1]	Usage[2]	Normal TSPEC Request	TSPEC with Expedited Bandwidth Request
Bandwidth-based CAC	75% (default setting)	Less than 75%	Admitted	Admitted
		Between 75% and 90% (reserved bandwidth for voice calls exhausted)	Rejected	Admitted
		More than 90%	Rejected	Rejected
Load-based CAC		Less than 75%	Admitted	Admitted
		Between 75% and 85% (reserved bandwidth for voice calls exhausted)	Rejected	Admitted
		More than 85%	Rejected	Rejected

1. For bandwidth-based CAC, the voice call bandwidth usage is per access point and does not take into account co-channel access points. For load-based CAC, the voice call bandwidth usage is measured for the entire channel.
2. Bandwidth-based CAC (consumed voice and video bandwidth) or load-based CAC (channel utilization [Pb]).

Note Controller software release 6.0 supports admission control for TSPEC g711-40ms codec type.

Note When video ACM is enabled, the controller rejects a video TSPEC if the Nom-MSDU size in the TSPEC is greater than 149 or the mean data rate is greater than 1 Kb/s.

U-APSD

Unscheduled automatic power save delivery (U-APSD) is a QoS facility defined in IEEE 802.11e that extends the battery life of mobile clients. In addition to extending battery life, this feature reduces the latency of traffic flow delivered over the wireless media. Because U-APSD does not require the client to poll each individual packet buffered at the access point, it allows delivery of multiple downlink packets by sending a single uplink trigger packet. U-APSD is enabled automatically when WMM is enabled.

Traffic Stream Metrics

In a voice-over-wireless LAN (VoWLAN) deployment, traffic stream metrics (TSM) can be used to monitor voice-related metrics on the client-access point air interface. It reports both packet latency and packet loss. An administrator can isolate poor voice quality issues by studying these reports.

The metrics consist of a collection of uplink (client side) and downlink (access point side) statistics between an access point and a client device that supports CCX v4 or later. If the client is not CCX v4 or CCXv5 compliant, only downlink statistics are captured. The client and access point measure these metrics. The access point also collects the measurements every 5 seconds, prepares 90-second reports, and then sends the reports to the controller. The controller organizes the uplink measurements on a client basis and the downlink measurements on an access point basis and maintains an hour's worth of historical data. To store this data, the controller requires 32 MB of additional memory for uplink metrics and 4.8 MB for downlink metrics.

TSM can be configured through either the GUI or the CLI on a per radio-band basis (for example, all 802.11a radios). The controller saves the configuration in flash memory so that it persists across reboots. After an access point receives the configuration from the controller, it enables TSM on the specified radio band.

Note Access points support TSM in both local and hybrid-REAP modes.

Using the GUI to Configure Voice Parameters

Follow these steps to configure voice parameters using the GUI.

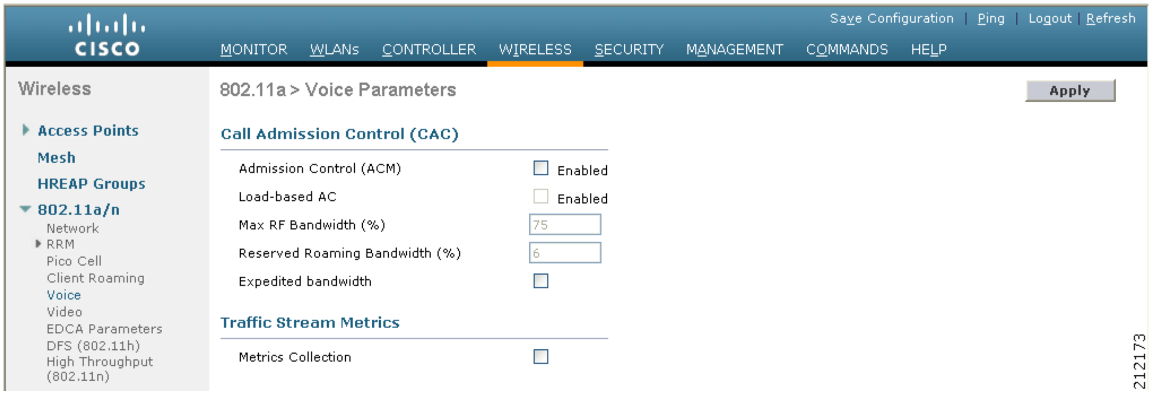
Step 1 Make sure that the WLAN is configured for WMM and the Platinum QoS level.

Step 2 Disable all WLANs with WMM enabled and click **Apply**.

Step 3 To disable the radio network, choose **Wireless** and then **Network** under 802.11a/n or 802.11b/g/n, uncheck the 802.11a (or 802.11b/g) Network Status check box, and click **Apply**.

Step 4 Choose **Voice** under 802.11a/n or 802.11b/g/n. The 802.11a (or 802.11b) > Voice Parameters page appears (see Figure 28).

Figure 28 802.11a > Voice Parameters Page



Step 5 To enable bandwidth-based CAC for this radio band, check the **Admission Control (ACM)** check box. The default value is disabled.

Step 6 To enable load-based CAC for this radio band, check both the **Admission Control (ACM)** check box and the **Load-based AC** check box. The default value for both check boxes is disabled.

Step 7 In the Max RF Bandwidth field, enter the percentage of the maximum bandwidth allocated to clients for voice applications on this radio band. Once the client reaches the value specified, the access point rejects new calls on this radio band.

Range: 40 to 85%

Default: 75%

Step 8 In the Reserved Roaming Bandwidth field, enter the percentage of maximum allocated bandwidth reserved for roaming voice clients. The controller reserves this much bandwidth from the maximum allocated bandwidth for roaming voice clients.

Range: 0 to 25%

Default: 6%

Step 9 To enable expedited bandwidth requests, check the **Expedited Bandwidth** check box. The default value is disabled.

Step 10 To enable TSM, check the **Metrics Collection** check box. The default value is disabled.

Step 11 Click **Apply** to commit your changes.

Step 12 Re-enable all WMM WLANs and click **Apply**.

Step 13 To re-enable the radio network, choose **Network** under 802.11a/n or 802.11b/g/n, check the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 14 Click **Save Configuration** to save your changes.

Step 15 Repeat this procedure if you want to configure voice parameters for another radio band (802.11a or 802.11b/g).

Using the GUI to Configure Video Parameters

Follow these steps to configure video parameters using the GUI.

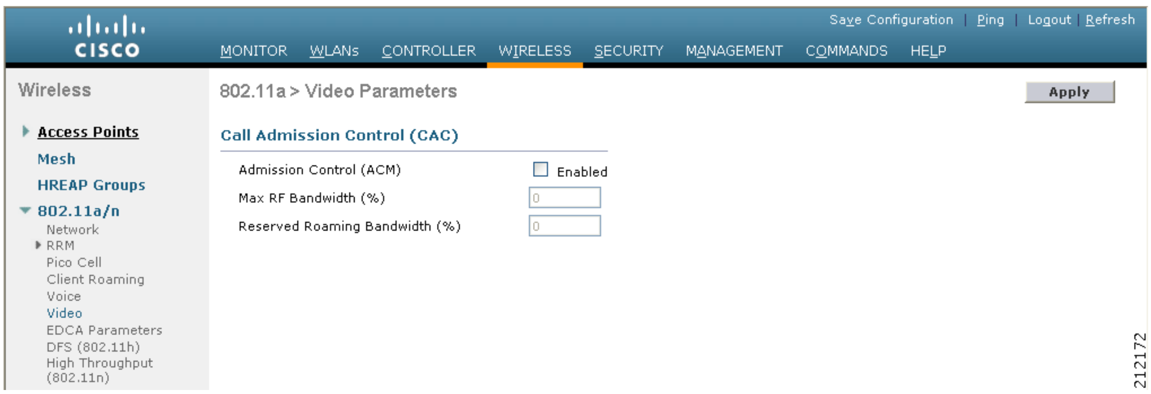
Step 1 Make sure that the WLAN is configured for WMM and the Gold QoS level.

Step 2 Disable all WLANs with WMM enabled and click **Apply**.

Step 3 To disable the radio network, choose **Wireless** and then **Network** under 802.11a/n or 802.11b/g/n, uncheck the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 4 Choose **Video** under 802.11a/n or 802.11b/g/n. The 802.11a (or 802.11b) > Video Parameters page appears (see Figure 28).

Figure 29 802.11a > Video Parameters Page



Step 5 To enable video CAC for this radio band, check the **Admission Control (ACM)** check box. The default value is disabled.

Step 6 In the Max RF Bandwidth field, enter the percentage of the maximum bandwidth allocated to clients for video applications on this radio band. Once the client reaches the value specified, the access point rejects new requests on this radio band.

Range: 0 to 100% (However, the maximum RF bandwidth cannot exceed 100% for voice + video.)

Default: 0%

Note If this parameter is set to zero (0), the controller assumes that the operator does not want to do any bandwidth allocation and, therefore, allows all bandwidth requests.

Step 7 In the Reserved Roaming Bandwidth field, enter the percentage of maximum allocated bandwidth reserved for roaming video clients. The controller reserves this much bandwidth from the maximum allocated bandwidth for roaming video clients.

Range: 0 to 25%

Default: 0%

Step 8 Click **Apply** to commit your changes.

Step 9 Re-enable all WMM WLANs and click **Apply**.

Step 10 To re-enable the radio network, choose **Network** under 802.11a/n or 802.11b/g/n, check the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 11 Click **Save Configuration** to save your changes.

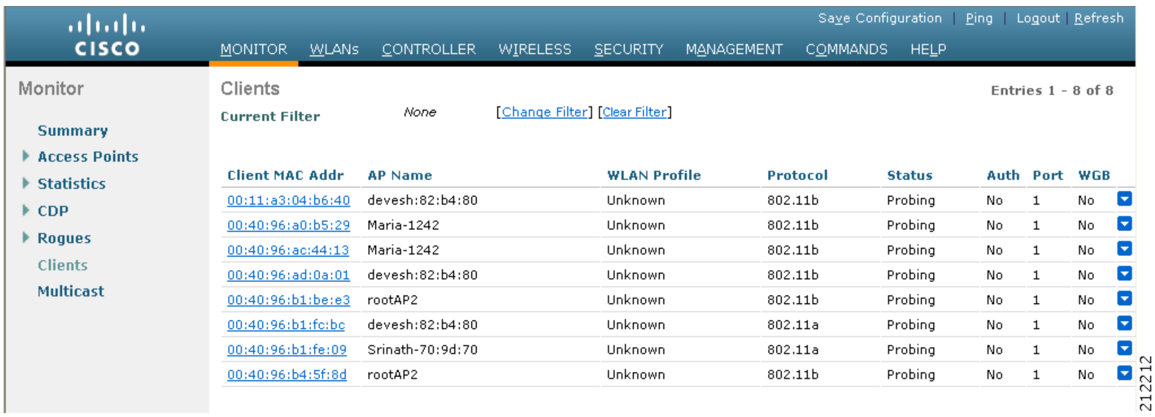
Step 12 Repeat this procedure if you want to configure video parameters for another radio band (802.11a or 802.11b/g).

Using the GUI to View Voice and Video Settings

Follow these steps to view voice and video settings using the GUI.

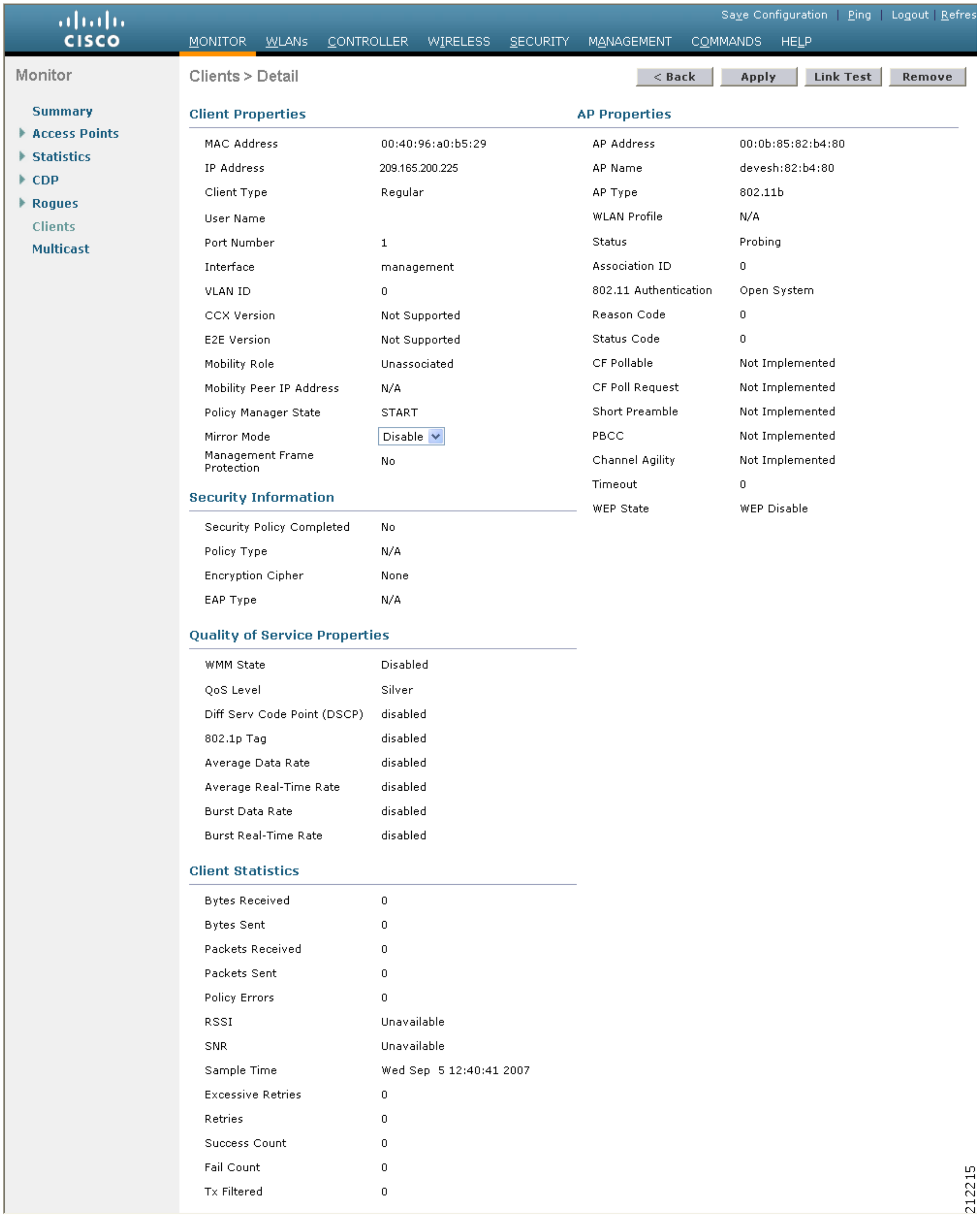
Step 1 Choose **Monitor** > **Clients** to open the Clients page (see Figure 30).

Figure 30 Clients Page



Step 2 Click the MAC address of the desired client to open the Clients > Detail page (see Figure 31).

Figure 31 Clients > Detail Page



This page shows the U-APSD status (if enabled) for this client under Quality of Service Properties.

Step 3 Click **Back** to return to the Clients page.

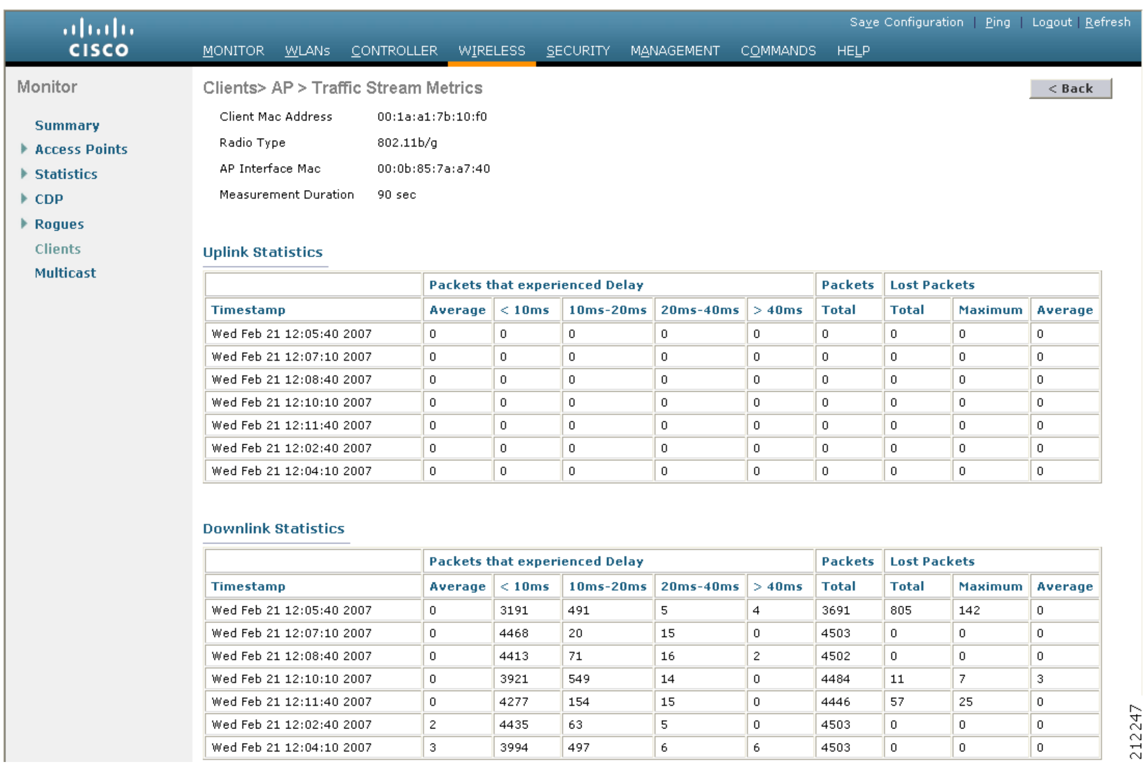
Step 4 Follow these steps to see the TSM statistics for a particular client and the access point to which this client is associated.

a. Hover your cursor over the blue drop-down arrow for the desired client and choose **802.11aTSM** or **802.11b/gTSM**. The Clients > AP page appears (see Figure 32).

Figure 32 Clients > AP Page

b. Click the **Detail** link for the desired access point to open the Clients > AP > Traffic Stream Metrics page (see Figure 33).

Figure 33 Clients > AP > Traffic Stream Metrics Page



Uplink Statistics

	Packets that experienced Delay					Packets	Lost Packets		
Timestamp	Average	< 10ms	10ms-20ms	20ms-40ms	> 40ms	Total	Total	Maximum	Average
Wed Feb 21 12:05:40 2007	0	0	0	0	0	0	0	0	0
Wed Feb 21 12:07:10 2007	0	0	0	0	0	0	0	0	0
Wed Feb 21 12:08:40 2007	0	0	0	0	0	0	0	0	0
Wed Feb 21 12:10:10 2007	0	0	0	0	0	0	0	0	0
Wed Feb 21 12:11:40 2007	0	0	0	0	0	0	0	0	0
Wed Feb 21 12:02:40 2007	0	0	0	0	0	0	0	0	0
Wed Feb 21 12:04:10 2007	0	0	0	0	0	0	0	0	0

Downlink Statistics

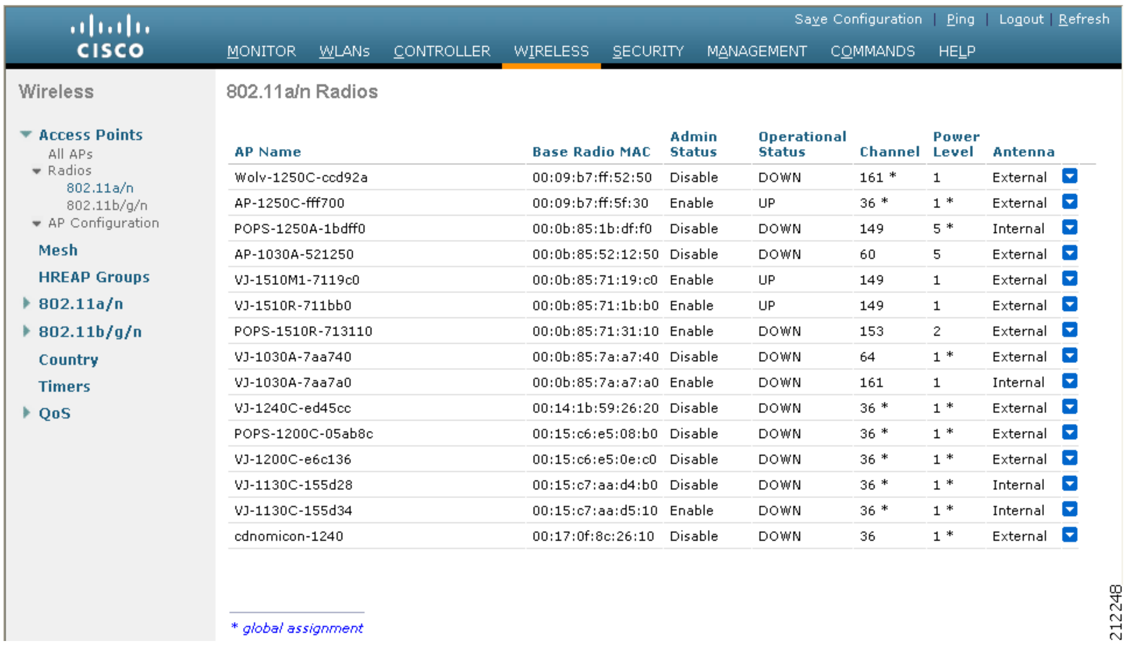
	Packets that experienced Delay					Packets	Lost Packets		
Timestamp	Average	< 10ms	10ms-20ms	20ms-40ms	> 40ms	Total	Total	Maximum	Average
Wed Feb 21 12:05:40 2007	0	3191	491	5	4	3691	805	142	0
Wed Feb 21 12:07:10 2007	0	4468	20	15	0	4503	0	0	0
Wed Feb 21 12:08:40 2007	0	4413	71	16	2	4502	0	0	0
Wed Feb 21 12:10:10 2007	0	3921	549	14	0	4484	11	7	3
Wed Feb 21 12:11:40 2007	0	4277	154	15	0	4446	57	25	0
Wed Feb 21 12:02:40 2007	2	4435	63	5	0	4503	0	0	0
Wed Feb 21 12:04:10 2007	3	3994	497	6	6	4503	0	0	0

This page shows the TSM statistics for this client and the access point to which it is associated. The statistics are shown in 90-second intervals. The timestamp field shows the specific interval when the statistics were collected.

Step 5 Follow these steps to see the TSM statistics for a particular access point and a particular client associated to this access point.

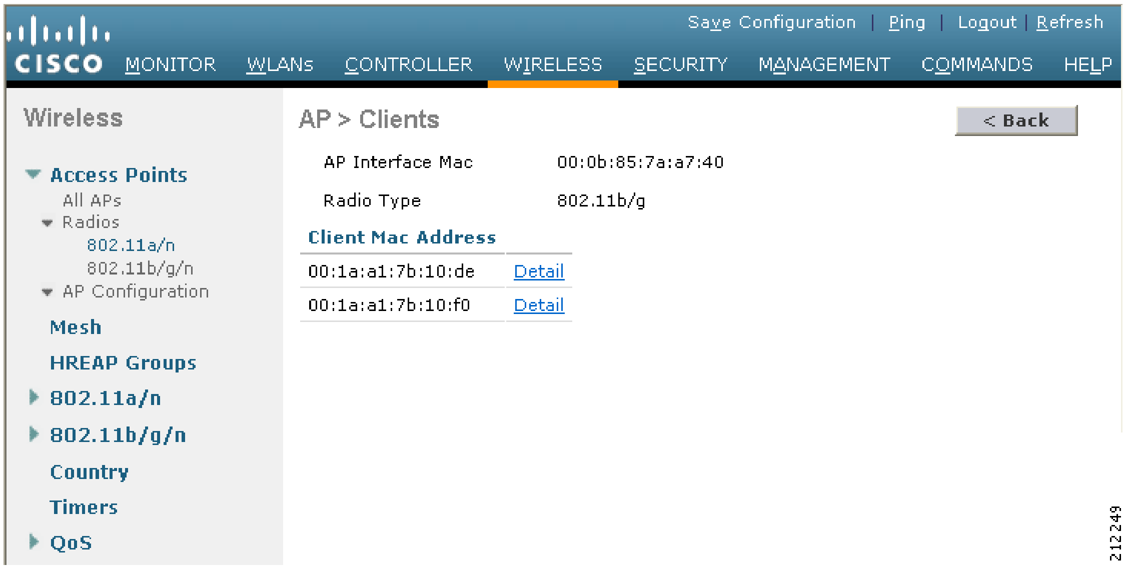
a. Choose **Wireless** > **Access Points** > **Radios** > **802.11a/n** or **802.11b/g/n**. The 802.11a/n Radios or 802.11b/g/n Radios page appears (see Figure 34).

Figure 34 802.11a/n Radios Page



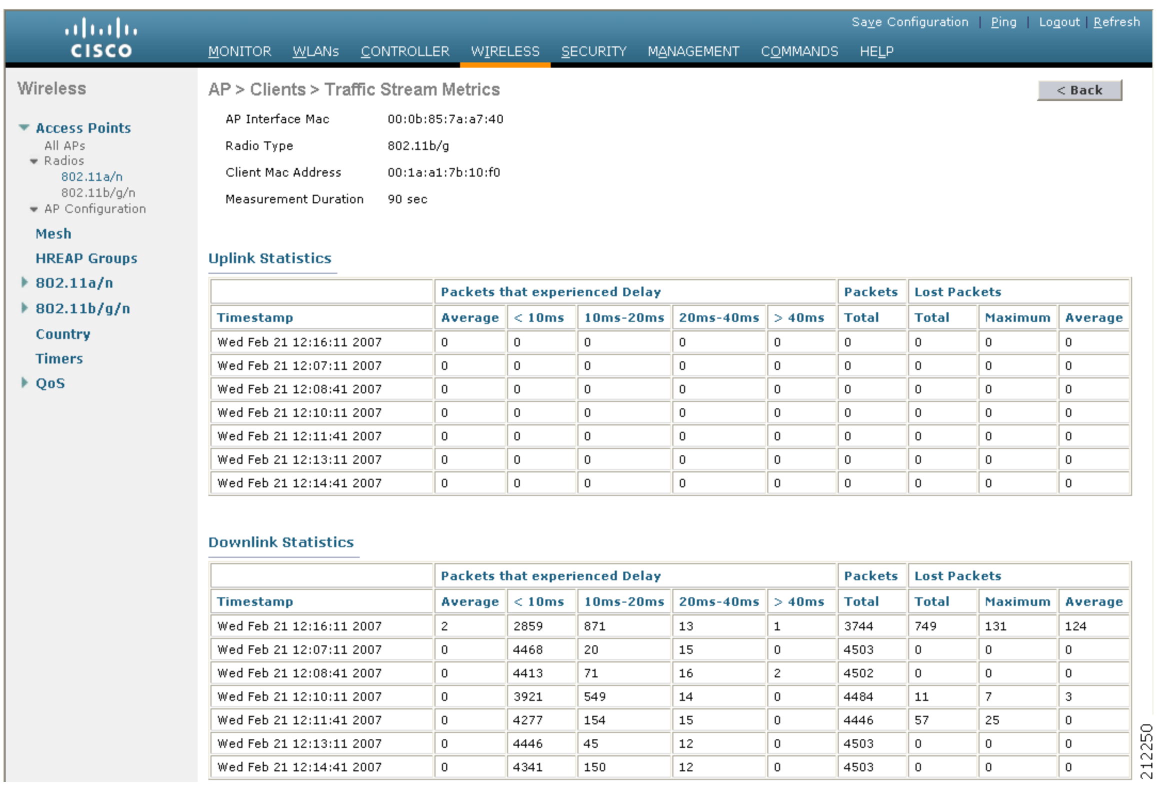
b. Hover your cursor over the blue drop-down arrow for the desired access point and choose **802.11aTSM** or **802.11b/gTSM**. The AP > Clients page appears (see Figure 35).

Figure 35 AP > Clients Page



c. Click the **Detail** link for the desired client to open the AP > Clients > Traffic Stream Metrics page (see Figure 36).

Figure 36 AP > Clients > Traffic Stream Metrics Page



This page shows the TSM statistics for this access point and a client associated to it. The statistics are shown in 90-second intervals. The timestamp field shows the specific interval when the statistics were collected.

Using the CLI to Configure Voice Parameters

Follow these steps to configure voice parameters using the CLI.

Step 1 To see all of the WLANs configured on the controller, enter this command:

show wlan summary

Step 2 To make sure that the WLAN you are planning to modify is configured for WMM and the QoS level is set to Platinum, enter this command:

show wlan *wlan_id*

Step 3 To disable all WLANs with WMM enabled prior to changing the voice parameters, enter this command:

config wlan disable *wlan_id*

Step 4 To disable the radio network, enter this command:

config {**802.11a** | **802.11b**} **disable network**

Step 5 To save your settings, enter this command:

save config

Step 6 To enable or disable bandwidth-based voice CAC for the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **cac voice acm** {**enable** | **disable**}

Step 7 To set the percentage of maximum bandwidth allocated to clients for voice applications on the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **cac voice max-bandwidth** *bandwidth*

The *bandwidth* range is 40 to 85%, and the default value is 75%. Once the client reaches the value specified, the access point rejects new calls on this network.

Step 8 To set the percentage of maximum allocated bandwidth reserved for roaming voice clients, enter this command:

config {**802.11a** | **802.11b**} **cac voice roam-bandwidth** *bandwidth*

The *bandwidth* range is 0 to 25%, and the default value is 6%. The controller reserves this much bandwidth from the maximum allocated bandwidth for roaming voice clients.

Step 9 To process or ignore the TSPEC inactivity timeout received from an access point, enter this command:

config {**802.11a** | **802.11b**} **cac voice tspec-inactivity-timeout** {**enable** | **ignore**}

Step 10 To enable or disable load-based CAC for the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **cac voice load-based** {**enable** | **disable**}

Step 11 To configure the number of aggregated voice WMM traffic specification (TSPEC) streams at a specified data rate for the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **cac voice stream-size** *number* **max-streams** *mean_datarate*

The *number* range is 1 to 5 voice streams, and the default value is 2. The *mean_datarate* range is 84 to 91.2 Kbps, and the default value is 84 Kbps.

Step 12 To enable or disable expedited bandwidth requests for the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **exp-bwreq** {**enable** | **disable**}

Step 13 To enable or disable TSM for the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **tsm** {**enable** | **disable**}

Step 14 To re-enable all WLANs with WMM enabled, enter this command:

config wlan enable *wlan_id*

Step 15 To re-enable the radio network, enter this command:

config {**802.11a** | **802.11b**} **enable network**

Step 16 To save your settings, enter this command:

save config

Using the CLI to Configure Video Parameters

Follow these steps to configure video parameters using the CLI.

Step 1 To see all of the WLANs configured on the controller, enter this command:

show wlan summary

Step 2 To make sure that the WLAN you are planning to modify is configured for WMM and the QoS level is set to Gold, enter this command:

show wlan *wlan_id*

Step 3 To disable all WLANs with WMM enabled prior to changing the video parameters, enter this command:

config wlan disable *wlan_id*

Step 4 To disable the radio network, enter this command:

config {**802.11a** | **802.11b**} **disable network**

Step 5 To save your settings, enter this command:

save config

Step 6 To enable or disable video CAC for the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **cac video acm** {**enable** | **disable**}

Step 7 To set the percentage of maximum bandwidth allocated to clients for video applications on the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **cac video max-bandwidth** *bandwidth*

The *bandwidth* range is 0 to 100%, and the default value is 0%. However, the maximum RF bandwidth cannot exceed 100% for voice + video. Once the client reaches the value specified, the access point rejects new calls on this network.

Note If this parameter is set to zero (0), the controller assumes that the operator does not want to do any bandwidth allocation and, therefore, allows all bandwidth requests.

Step 8 To set the percentage of maximum allocated bandwidth reserved for roaming video clients, enter this command:

config {**802.11a** | **802.11b**} **cac video roam-bandwidth** *bandwidth*

The *bandwidth* range is 0 to 25%, and the default value is 0%. The controller reserves this much bandwidth from the maximum allocated bandwidth for roaming video clients.

Step 9 To process or ignore the TSPEC inactivity timeout received from an access point, enter this command:

config {**802.11a** | **802.11b**} **cac video tspec-inactivity-timeout** {**enable** | **ignore**}

Step 10 To re-enable all WLANs with WMM enabled, enter this command:

config wlan enable *wlan_id*

Step 11 To re-enable the radio network, enter this command:

config {**802.11a** | **802.11b**} **enable network**

Step 12 To save your settings, enter this command:

save config

Using the CLI to View Voice and Video Settings

Use these commands to view voice and video settings using the CLI.

1. To see the CAC configuration for the 802.11a or 802.11b/g network, enter this command:

   show {**802.11a** | **show 802.11b**}

2. To see the CAC statistics for a particular access point, enter this command:

   show ap stats {**802.11a** | **802.11b**} *ap_name*

   Information similar to the following appears:

```
Call Admission Control (CAC) Stats
  Voice Bandwidth in use(% of config bw)......... 0
    Total channel MT free........................ 0
    Total voice MT free.......................... 0
    Na Direct.................................... 0
    Na Roam...................................... 0
  Video Bandwidth in use(% of config bw)......... 0
  Total num of voice calls in progress........... 0
  Num of roaming voice calls in progress......... 0
  Total Num of voice calls since AP joined....... 0
  Total Num of roaming calls since AP joined..... 0
```

```
  Total Num of exp bw requests received.......... 5
  Total Num of exp bw requests admitted.......... 2

Num of voice calls rejected since AP joined...... 0
  Num of roam calls rejected since AP joined..... 0
  Num of calls rejected due to insufficient bw....0
  Num of calls rejected due to invalid params.... 0
  Num of calls rejected due to PHY rate.......... 0
  Num of calls rejected due to QoS policy..... 0
```

In the example above, "MT" is medium time, "Na" is the number of additional calls, and "exp bw" is expedited bandwidth.

3. To see the U-APSD status for a particular client, enter this command:

   show client detail *client_mac*

4. To see the TSM statistics for a particular client and the access point to which this client is associated, enter this command:

   show client tsm {**802.11a** | **802.11b**} *client_mac* {*ap_mac* | **all**}

   The optional **all** command shows all access points to which this client has associated. Information similar to the following appears:

```
AP Interface Mac:                    00:0b:85:01:02:03
Client Interface Mac:                00:01:02:03:04:05
Measurement Duration:                90 seconds

  Timestamp                            1st Jan 2006, 06:35:80
    UpLink Stats
    ================
       Average Delay (5sec intervals)...........................35
       Delay less than 10 ms....................................20
       Delay bet 10 - 20 ms.....................................20
       Delay bet 20 - 40 ms.....................................20
       Delay greater than 40 ms.................................20
      Total packet Count.........................................80
      Total packet lost count (5sec)............................10
      Maximum Lost Packet count(5sec)...........................5
      Average Lost Packet count(5secs)..........................2
    DownLink Stats
    ================
       Average Delay (5sec intervals)...........................35
       Delay less than 10 ms....................................20
       Delay bet 10 - 20 ms.....................................20
       Delay bet 20 - 40 ms.....................................20
       Delay greater than 40 ms.................................20
      Total packet Count.........................................80
      Total packet lost count (5sec)............................10
      Maximum Lost Packet count(5sec)...........................5
      Average Lost Packet count(5secs)..........................2
```

Note The statistics are shown in 90-second intervals. The timestamp field shows the specific interval when the statistics were collected.

Note To clear the TSM statistics for a particular access point or all the access points to which this client is associated, enter this command: **clear client tsm** {**802.11a** | **802.11b**} *client_mac* {*ap_mac* | **all**}.

5. To see the TSM statistics for a particular access point and a particular client associated to this access point, enter this command:

   show ap stats {**802.11a** | **802.11b**} *ap_name* **tsm** {*client_mac* | **all**}

   The optional **all** command shows all clients associated to this access point. Information similar to the following appears:

```
AP Interface Mac:                  00:0b:85:01:02:03
Client Interface Mac:              00:01:02:03:04:05
Measurement Duration:              90 seconds

  Timestamp                          1st Jan 2006, 06:35:80
    UpLink Stats
    ================
       Average Delay (5sec intervals)...........................35
       Delay less than 10 ms....................................20
       Delay bet 10 - 20 ms.....................................20
       Delay bet 20 - 40 ms.....................................20
       Delay greater than 40 ms.................................20
      Total packet Count........................................80
      Total packet lost count (5sec)............................10
      Maximum Lost Packet count(5sec)...........................5
      Average Lost Packet count(5secs)..........................2
    DownLink Stats
    ================
       Average Delay (5sec intervals)...........................35
       Delay less than 10 ms....................................20
       Delay bet 10 - 20 ms.....................................20
       Delay bet 20 - 40 ms.....................................20
       Delay greater than 40 ms.................................20
      Total packet Count........................................80
      Total packet lost count (5sec)............................10
      Maximum Lost Packet count(5sec)...........................5
      Average Lost Packet count(5secs)..........................2
```

Note The statistics are shown in 90-second intervals. The timestamp field shows the specific interval when the statistics were collected.

6. To enable or disable debugging for call admission control (CAC) messages, events, or packets, enter this command:

   debug cac {**all** | **event** | **packet**}{**enable** | **disable**}

   where **all** configures debugging for all CAC messages, **event** configures debugging for all CAC events, and **packet** configures debugging for all CAC packets.

Configuring EDCA Parameters

Enhanced distributed channel access (EDCA) parameters are designed to provide preferential wireless channel access for voice, video, and other quality-of-service (QoS) traffic. Follow the instructions in this section to configure EDCA parameters using the controller GUI or CLI.

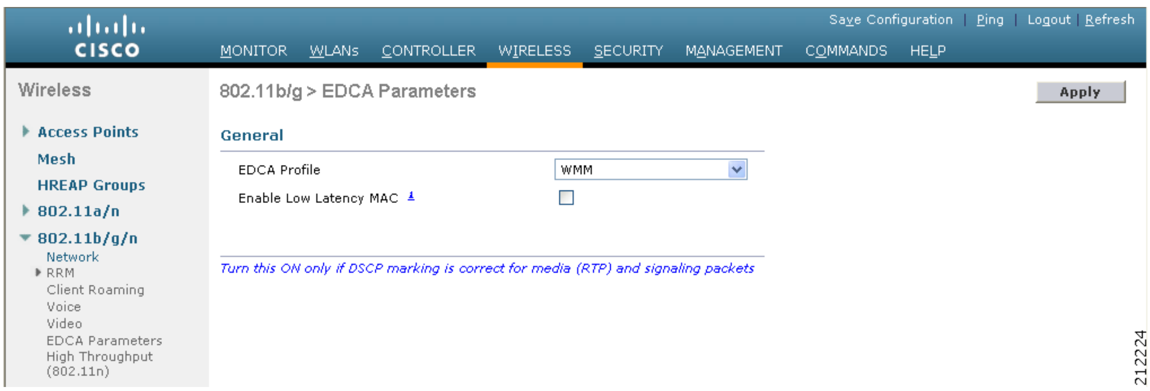
Using the GUI to Configure EDCA Parameters

Follow these steps to configure EDCA parameters using the controller GUI.

Step 1 To disable the radio network, choose **Wireless** and then **Network** under 802.11a/n or 802.11b/g/n, uncheck the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 2 Choose **EDCA Parameters** under 802.11a/n or 802.11b/g/n. The 802.11a (or 802.11b/g) > EDCA Parameters page appears (see Figure 37).

Figure 37 802.11a > EDCA Parameters Page



Step 3 Choose one of the following options from the EDCA Profile drop-down box:

- **WMM**—Enables the Wi-Fi Multimedia (WMM) default parameters. This is the default value. Choose this option when voice or video services are not deployed on your network.
- **Spectralink Voice Priority**—Enables SpectraLink voice priority parameters. Choose this option if SpectraLink phones are deployed on your network to improve the quality of calls.
- **Voice Optimized**—Enables EDCA voice-optimized profile parameters. Choose this option when voice services other than SpectraLink are deployed on your network.
- **Voice & Video Optimized**—Enables EDCA voice- and video-optimized profile parameters. Choose this option when both voice and video services are deployed on your network.

> **Note** If you deploy video services, admission control (ACM) must be disabled.

Step 4 If you want to enable MAC optimization for voice, check the **Enable Low Latency MAC** check box. Otherwise, leave this check box unchecked, which is the default value. This feature enhances voice performance by controlling packet retransmits and appropriately aging out voice packets on lightweight access points, thereby improving the number of voice calls serviced per access point.

Note You should enable low latency MAC only if the WLAN allows WMM clients. If WMM is enabled, then low latency MAC can be used with any of the EDCA profiles. Refer to the "Configuring QoS Enhanced BSS" section on page 37 for instructions on enabling WMM.

Caution We recommend that you not use the low latency MAC feature if you are using the 1140, 1250, 1260, and 3500 series access points that are based on the Marvell platform. If used, the data packets are retried at the data rate specified multiple times without downshifting the rates.
We also recommend that you not use the low latency MAC feature if you are using the 1120, 1130, 1230, and 1240 series access points (not based on the Marvell platform). If used, the number of retries is reduced to 3 with the first retry at the initial rate.

Step 5 Click **Apply** to commit your changes.

Step 6 To re-enable the radio network, choose **Network** under 802.11a/n or 802.11b/g/n, check the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure EDCA Parameters

Follow these steps to configure EDCA parameters using the CLI.

Step 1 To disable the radio network, enter this command:

config {**802.11a** | **802.11b**} **disable network**

Step 2 To save your settings, enter this command:

save config

Step 3 To enable a specific EDCA profile, enter this command:

config advanced {**802.11a** | **802.11b**} **edca-parameters** *?*

where *?* is one of the following:

- **wmm-default**—Enables the Wi-Fi Multimedia (WMM) default parameters. This is the default value. Choose this option when voice or video services are not deployed on your network.
- **svp-voice**—Enables SpectraLink voice priority parameters. Choose this option if SpectraLink phones are deployed on your network to improve the quality of calls.
- **optimized-voice**—Enables EDCA voice-optimized profile parameters. Choose this option when voice services other than SpectraLink are deployed on your network.
- **optimized-video-voice**—Enables EDCA voice- and video-optimized profile parameters. Choose this option when both voice and video services are deployed on your network.

> **Note** If you deploy video services, admission control (ACM) must be disabled.

Step 4 To view the current status of MAC optimization for voice, enter this command:

show {**802.11a** | **802.11b**}

Information similar to the following appears:

```
Voice-mac-optimization...................Disabled
```

Step 5 To enable or disable MAC optimization for voice, enter this command:

config advanced {**802.11a** | **802.11b**} **voice-mac-optimization** {**enable** | **disable**}

This feature enhances voice performance by controlling packet retransmits and appropriately aging out voice packets on lightweight access points, thereby improving the number of voice calls serviced per access point. The default value is disabled.

Step 6 To re-enable the radio network, enter this command:

config {**802.11a** | **802.11b**} **enable network**

Step 7 To save your settings, enter this command:

save config

Configuring Cisco Discovery Protocol

Cisco Discovery Protocol (CDP) is a device discovery protocol that runs on all Cisco-manufactured equipment. A device enabled with CDP sends out periodic interface updates to a multicast address in order to make itself known to neighboring devices.

The default value for the frequency of periodic transmissions is 60 seconds, and the default advertised time-to-live value is 180 seconds. The second and latest version of the protocol, CDPv2, introduces new time-length-values (TLVs) and provides a reporting mechanism that allows for more rapid error tracking, thereby reducing down time.

CDPv1 and CDPv2 are supported on the following devices:

- 5500, 4400, and 2100 series controllers

> **Note** CDP is not supported on the controllers that are integrated into Cisco switches and routers, including those in the Catalyst 3750G Integrated Wireless LAN Controller Switch, the Cisco WiSM, and the Cisco 28/37/38xx Series Integrated Services Router. However, you can use the **show ap cdp neighbors detail** {*Cisco_AP* | **all**} command on these controllers in order to see the list of CDP neighbors for the access points that are connected to the controller.

- CAPWAP- enabled access points
- An access point connected directly to a 5500, 4400, or 2100 series controller

This support enables network management applications to discover Cisco devices.

These TLVs are supported by both the controller and the access point:

- **Device-ID TLV: 0x0001**—The host name of the controller, the access point, or the CDP neighbor.

- **Address TLV: 0x0002**—The IP address of the controller, the access point, or the CDP neighbor.
- **Port-ID TLV: 0x0003**—The name of the interface on which CDP packets are sent out.
- **Capabilities TLV: 0x0004**—The capabilities of the device. The controller sends out this TLV with a value of Host: 0x10, and the access point sends out this TLV with a value of Transparent Bridge: 0x02.

- **Version TLV: 0x0005**—The software version of the controller, the access point, or the CDP neighbor.
- **Platform TLV: 0x0006**—The hardware platform of the controller, the access point, or the CDP neighbor.

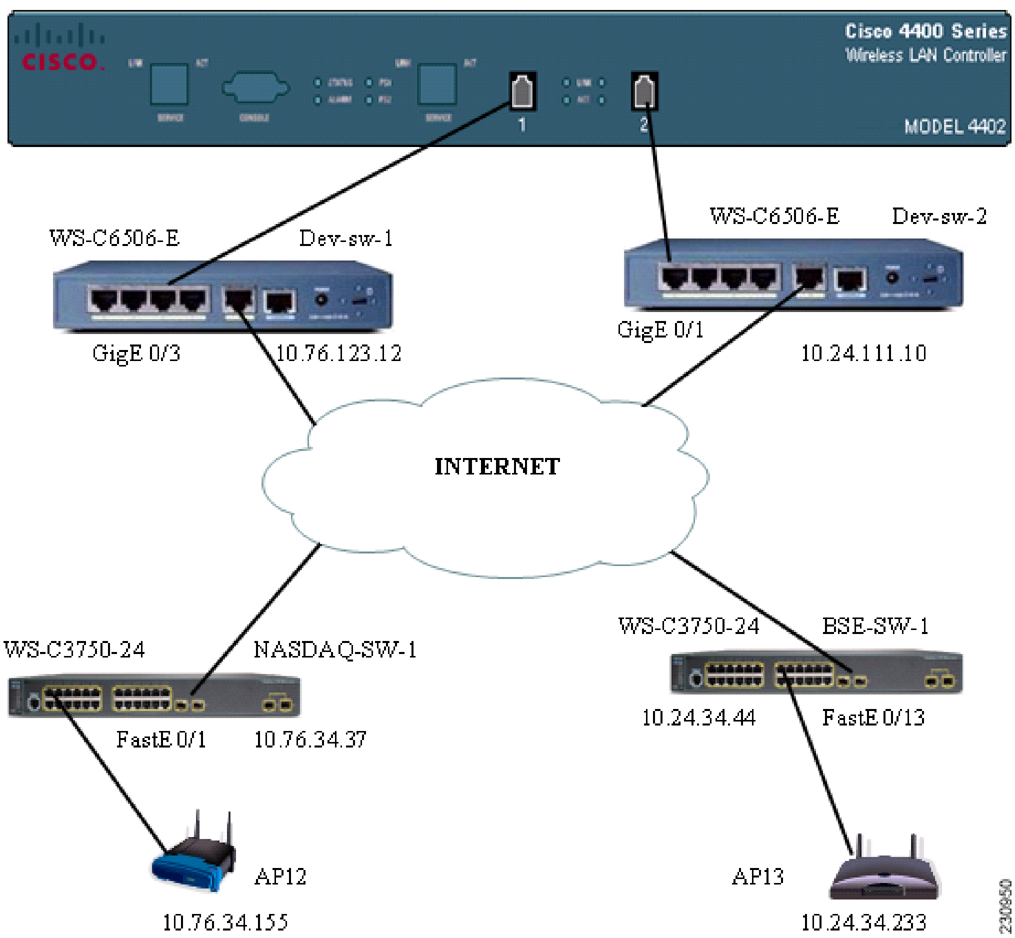
These TLVs are supported only by the access point:

- **Full/Half Duplex TLV: 0x000b**—The full- or half-duplex mode of the Ethernet link on which CDP packets are sent out. This TLV is not supported on access points that are connected directly to a 5500, 4400, or 2100 series controller.
- **Power Consumption TLV: 0x0010**—The maximum amount of power consumed by the access point. This TLV is not supported on access points that are connected directly to a 5500, 4400, or 2100 series controller.

You can configure CDP and view CDP information using the GUI in controller software release 4.1 or later or the CLI in controller software release 4.0 or later. Figure 38 shows a sample network that you can use as a reference when performing the procedures in this section.

Note Changing the CDP configuration on the controller does not change the CDP configuration on the access points connected to the controller. You must enable and disable CDP separately for each access point.

Figure 38 Sample Network Illustrating CDP

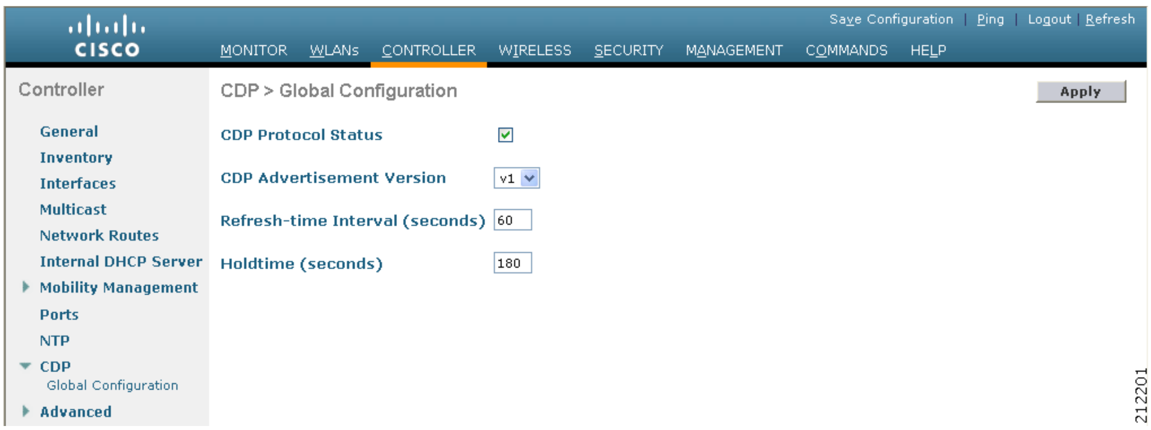


Using the GUI to Configure Cisco Discovery Protocol

Follow these steps to configure CDP using the controller GUI.

Step 1 Choose **Controller** > **CDP** > **Global Configuration** to open the CDP > Global Configuration page (see Figure 39).

Figure 39 CDP > Global Configuration Page



Step 2 Check the **CDP Protocol Status** check box to enable CDP on the controller or uncheck it to disable this feature. The default value is checked.

Step 3 From the CDP Advertisement Version drop-down box, choose **v1** or **v2** to specify the highest CDP version supported on the controller. The default value is v1.

Step 4 In the Refresh-time Interval field, enter the interval at which CDP messages are to be generated. The range is 5 to 254 seconds, and the default value is 60 seconds.

Step 5 In the Holdtime field, enter the amount of time to be advertised as the time-to-live value in generated CDP packets. The range is 10 to 255 seconds, and the default value is 180 seconds.

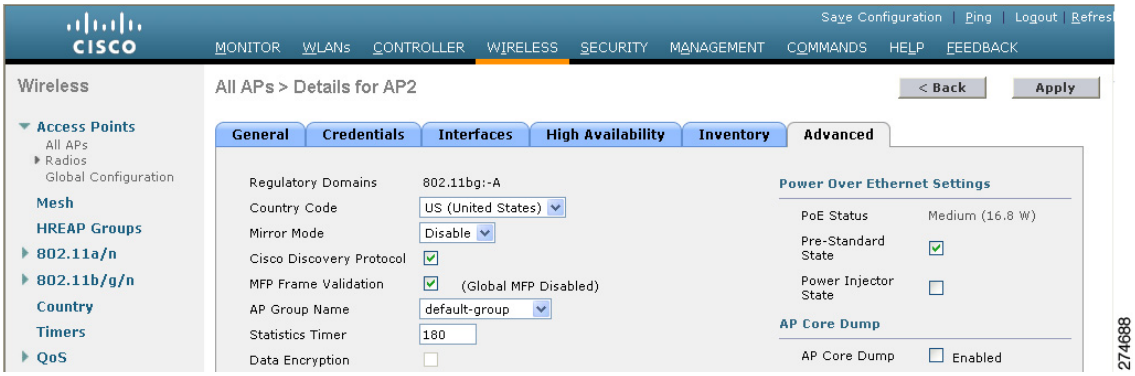
Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Step 8 Perform one of the following:

- To enable or disable CDP on a specific access point, follow these steps:
  - **a.** Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.
  - **b.** Click the link for the desired access point.
  - **c.** Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 40).

Figure 40 All APs > Details for (Advanced) Page



d. Check the **Cisco Discovery Protocol** check box to enable CDP on this access point or uncheck it to disable this feature. The default value is enabled.

e. Click **Apply** to commit your changes.

- To enable or disable CDP on all access points currently associated to the controller, follow these steps:

  a. Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page.

  b. Check the **CDP State** check box to enable CDP on all access points associated to the controller or uncheck it to disable CDP on all access points. The default value is checked.

  c. Click **Apply** to commit your changes.

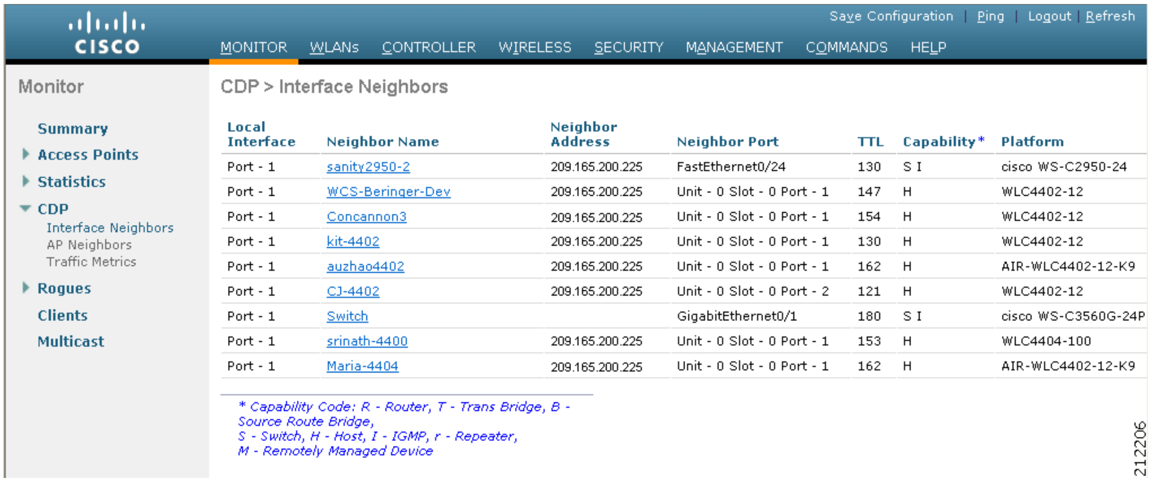
Step 9 Click **Save Configuration** to save your changes.

Using the GUI to View Cisco Discovery Protocol Information

Follow these steps to view CDP information using the controller GUI.

Step 1 To see a list of all CDP neighbors on all interfaces, choose **Monitor > CDP > Interface Neighbors**. The CDP > Interface Neighbors page appears (see Figure 41).

Figure 41 CDP > Interface Neighbors Page

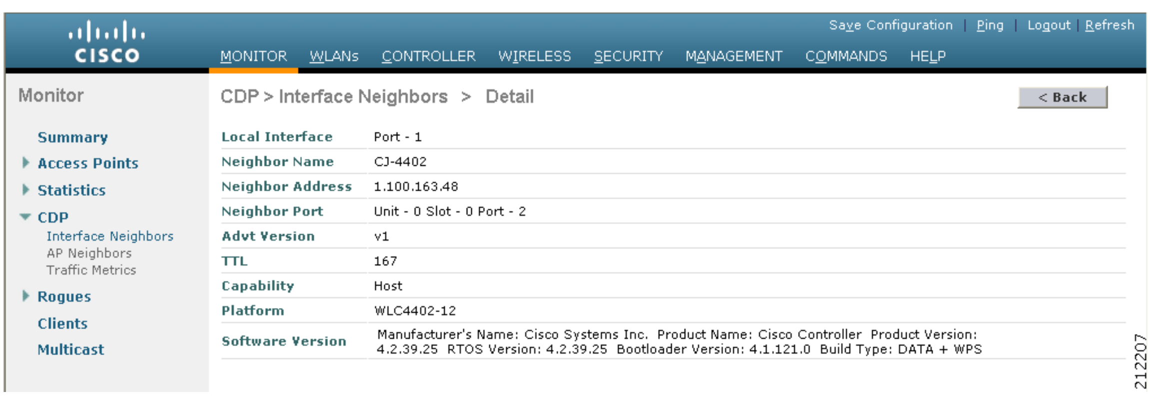


This page shows the following information:

- The controller port on which the CDP packets were received
- The name of each CDP neighbor
- The IP address of each CDP neighbor
- The port used by each CDP neighbor for transmitting CDP packets
- The time left (in seconds) before each CDP neighbor entry expires
- The functional capability of each CDP neighbor, defined as follows: R - Router, T - Trans Bridge, B - Source Route Bridge, S - Switch, H - Host, I - IGMP, r - Repeater, or M - Remotely Managed Device
- The hardware platform of each CDP neighbor device

Step 2 To see more detailed information about each interface's CDP neighbor, click the name of the desired interface neighbor. The CDP > Interface Neighbors > Detail page appears (see Figure 42).

Figure 42 CDP > Interface Neighbors > Detail Page



This page shows the following information:

- The controller port on which the CDP packets were received
- The name of the CDP neighbor
- The IP address of the CDP neighbor
- The port used by the CDP neighbor for transmitting CDP packets
- The CDP version being advertised (v1 or v2)
- The time left (in seconds) before the CDP neighbor entry expires
- The functional capability of the CDP neighbor, defined as follows: Router, Trans Bridge, Source Route Bridge, Switch, Host, IGMP, Repeater, or Remotely Managed Device
- The hardware platform of the CDP neighbor device
- The software running on the CDP neighbor

Step 3 To see a list of CDP neighbors for all access points connected to the controller, choose **AP Neighbors**. The CDP AP Neighbors page appears (see Figure 43).

Figure 43 CDP AP Neighbors Page

Step 4 To see a list of CDP neighbors for a specific access point, click the **CDP Neighbors** link for the desired access point. The CDP > AP Neighbors page appears (see Figure 45).

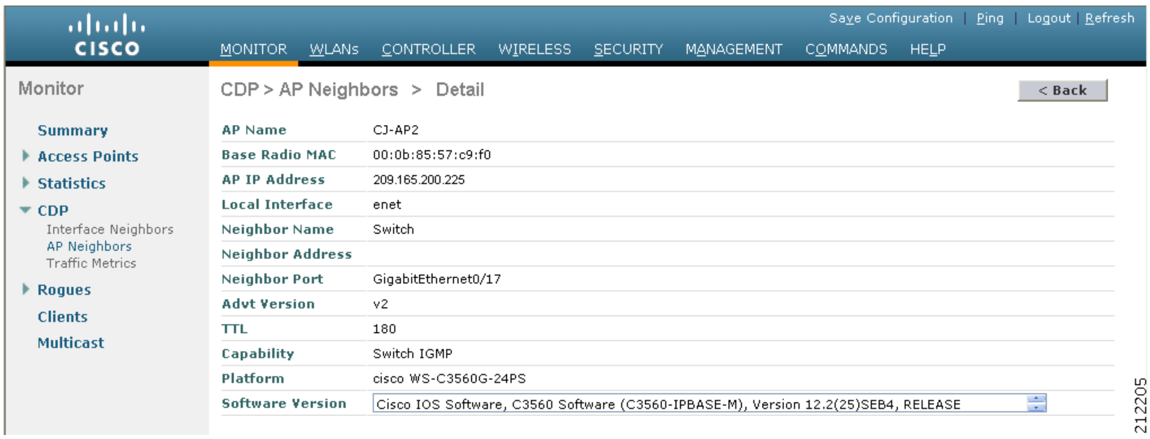
Figure 44 CDP > AP Neighbors Page

This page shows the following information:

- The name of each access point
- The IP address of each access point
- The name of each CDP neighbor
- The IP address of each CDP neighbor
- The port used by each CDP neighbor
- The CDP version being advertised (v1 or v2)

Step 5 To see detailed information about an access point's CDP neighbors, click the name of the desired access point. The CDP > AP Neighbors > Detail page appears (see Figure 45).

Figure 45 CDP > AP Neighbors > Detail Page

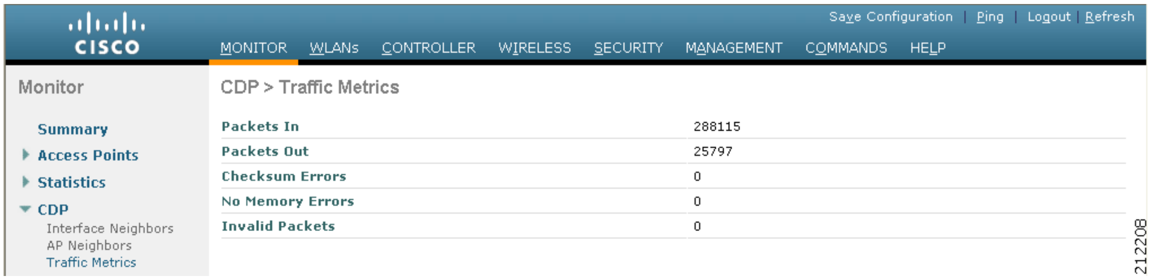


This page shows the following information:

- The name of the access point
- The MAC address of the access point's radio
- The IP address of the access point
- The interface on which the CDP packets were received
- The name of the CDP neighbor
- The IP address of the CDP neighbor
- The port used by the CDP neighbor
- The CDP version being advertised (v1 or v2)
- The time left (in seconds) before the CDP neighbor entry expires
- The functional capability of the CDP neighbor, defined as follows: R - Router, T - Trans Bridge, B - Source Route Bridge, S - Switch, H - Host, I - IGMP, r - Repeater, or M - Remotely Managed Device
- The hardware platform of the CDP neighbor device
- The software running on the CDP neighbor

Step 6 To see CDP traffic information, choose **Traffic Metrics**. The CDP > Traffic Metrics page appears (see Figure 46).

Figure 46 CDP > Traffic Metrics Page



This page shows the following information:

- The number of CDP packets received by the controller
- The number of CDP packets sent from the controller
- The number of packets that experienced a checksum error
- The number of packets dropped due to insufficient memory
- The number of invalid packets

Using the CLI to Configure Cisco Discovery Protocol

Use these commands to configure CDP using the controller CLI.

1. To enable or disable CDP on the controller, enter this command:

   config cdp {**enable** | **disable**}

   CDP is enabled by default.

2. To specify the interval at which CDP messages are to be generated, enter this command:

   config cdp timer *seconds*

   The range is 5 to 254 seconds, and the default value is 60 seconds.

3. To specify the amount of time to be advertised as the time-to-live value in generated CDP packets, enter this command:

   config cdp holdtime *seconds*

   The range is 10 to 255 seconds, and the default value is 180 seconds.

4. To specify the highest CDP version supported on the controller, enter this command:

   config cdp advertise {**v1** | **v2**}

   The default value is v1.

5. To enable or disable CDP on all access points that are joined to the controller, enter this command:

   config ap cdp {**enable** | **disable**} **all**

   The **config ap cdp disable all** command disables CDP on all access points that are joined to the controller and all access points that join in the future. CDP remains disabled on both current and future access points even after the controller or access point reboots. To enable CDP, enter **config ap cdp enable all**.

> **Note** After you enable CDP on all access points joined to the controller, you may disable and then re-enable CDP on individual access points using the command in #6 below. After you disable CDP on all access points joined to the controller, you may not enable and then disable CDP on individual access points.

6. To enable or disable CDP on a specific access point, enter this command:

   config ap cdp {**enable** | **disable**} *Cisco_AP*

7. To save your settings, enter this command:

   save config

Using the CLI to View Cisco Discovery Protocol Information

Use these commands to obtain information about CDP neighbors on the controller.

1. To see the status of CDP and to view CDP protocol information, enter this command:

   show cdp

2. To see a list of all CDP neighbors on all interfaces, enter this command:

   show cdp neighbors [**detail**]

   The optional **detail** command provides detailed information for the controller's CDP neighbors.

   > **Note** This command shows only the CDP neighbors of the controller. It does not show the CDP neighbors of the controller's associated access points. Additional commands are provided below to show the list of CDP neighbors per access point.

3. To see all CDP entries in the database, enter this command:

   show cdp entry all

4. To see CDP traffic information on a given port (for example, packets sent and received, CRC errors, and so on), enter this command:

   show cdp traffic

5. To see the CDP status for a specific access point, enter this command:

   show ap cdp ap-name *Cisco_AP*

6. To see the CDP status for all access points that are connected to the controller, enter this command:

   show ap cdp all

7. To see a list of all CDP neighbors for a specific access point, enter these commands:

   show ap cdp neighbors ap-name *Cisco_AP*

   show ap cdp neighbors detail *Cisco_AP*

   > **Note** The access point sends CDP neighbor information to the controller only when the information changes.

8. To see a list of all CDP neighbors for all access points connected to the controller, enter these commands:

   show ap cdp neighbors all

   show ap cdp neighbors detail all

   Information similar to the following appears when you enter **show ap cdp neighbors all**:

```
AP Name            AP IP          Neighbor Name  Neighbor IP    Neighbor Port
--------           --------       -------------  -----------    -------------
AP0013.601c.0a0     10.76.108.123        6500-1   10.76.108.207  GigabitEthernet1/26
AP0013.601c.0b0     10.76.108.111        6500-1   10.76.108.207  GigabitEthernet1/27
AP0013.601c.0c0    10.76.108.125        6500-1    10.76.108.207  GigabitEthernet1/28
```

   Information similar to the following appears when you enter **show ap cdp neighbors detail all**:

```
AP Name: AP0013.601c.0a0
AP IP Address: 10.76.108.125
----------------------------------
Device ID: 6500-1
Entry address(es): 10.76.108.207
Platform: cisco WS-C6506-E,  Capabilities: Router Switch IGMP
Interface: Port - 1,  Port ID (outgoing port): GigabitEthernet1/26
Holdtime: 157 sec

Version:
Cisco Internetwork Operating System Software  IOS (tm) s72033_rp Software
(s72033_rp-PSV-M), Version 12.2(18)SXD5, RELEASE SOFTWARE (fc3) Technical Support:
http://www.cisco.com/techsupport Copyright (c) 1986-2005 by cisco Systems, Inc.
Compiled Fri 13-Ma
```

Note The access point sends CDP neighbor information to the controller only when the information changes.

Use these commands to obtain CDP debug information for the controller.

1. To obtain debug information related to CDP packets, enter this command:

   debug cdp packets

2. To obtain debug information related to CDP events, enter this command:

   debug cdp events

Configuring RFID Tag Tracking

The controller enables you to configure radio-frequency identification (RFID) tag tracking. RFID tags are small wireless devices that are affixed to assets for real-time location tracking. They operate by advertising their location using special 802.11 packets, which are processed by access points, the controller, and the location appliance.

The controller supports tags from AeroScout, WhereNet, and Pango (an InnerWireless company). Some of the tags from these vendors comply with Cisco Compatible Extensions for RFID Tags. See Table 3 for details. The location appliance receives telemetry and chokepoint information from tags that are compliant with this CCX specification.

Table 3 Cisco Compatible Extensions for RFID Tags Summary

Partners	AeroScout		WhereNet	Pango (InnerWireless)
Product Name	T2	T3	Wheretag IV	V3
Telemetry				
Temperature	X	X		X
Pressure				
Humidity				
Status				
Fuel				
Quantity				
Distance				
Motion Detection	X	X		X
Number of Panic Buttons	1	2	0	1
Tampering		X	X	X
Battery Information	X	X	X	X
Multiple-Frequency Tags[1]	X	X	X	

1. For chokepoint systems, note that the tag can work only with chokepoints coming from the same vendor.

Note Network Mobility Services Protocol (NMSP) runs on location appliance software release 3.0 or later. In order for NMSP to function properly, the TCP port (16113) over which the controller and location appliance communicate must be open (not blocked) on any firewall that exists between these two devices. Refer to the *Cisco Location Appliance Configuration Guide* for additional information on NMSP and RFID tags.

The Cisco-approved tags support these capabilities:

- **Information notifications**—Enable you to view vendor-specific and emergency information.
- **Information polling**—Enables you to monitor battery status and telemetry data. Many telemetry data types provide support for sensory networks and a large range of applications for RFID tags.
- **Measurement notifications**—Enable you to deploy chokepoints at strategic points within your buildings or campuses. Whenever an RFID tag moves to within a defined proximity of a chokepoint, the tag begins transmitting packets that advertise its location in relation to the chokepoint.

The number of tags supported varies depending on controller platform. Table 4 lists the number of tags supported per controller.

Table 4 RFID Tags Supported per Controller

Controller	Number of RFID Tags Supported
5508	2500
Cisco WiSM	5000
4404	2500
4402	1250
Catalyst 3750G Integrated Wireless LAN Controller Switch	1250
2106	500
Controller Network Module within the Cisco 28/37/38xx Series Integrated Services Routers	500

You can configure and view RFID tag tracking information through the controller CLI.

Using the CLI to Configure RFID Tag Tracking

Follow these steps to configure RFID tag tracking parameters using the CLI.

Step 1 To enable or disable RFID tag tracking, enter this command:

config rfid status {**enable** | **disable**}

The default value is enabled.

Step 2 To specify a static timeout value (between 60 and 7200 seconds), enter this command:

config rfid timeout *seconds*

The static timeout value is the amount of time that the controller maintains tags before expiring them. For example, if a tag is configured to beacon every 30 seconds, Cisco recommends that you set the timeout value to 90 seconds (approximately three times the beacon value). The default value is 1200 seconds.

Step 3 To enable or disable RFID tag mobility for specific tags, enter these commands:

- **config rfid mobility** *vendor_name* **enable**—Enables client mobility for a specific vendor's tags. When you enter this command, tags are unable to obtain a DHCP address for client mode when attempting to check and/or download a configuration.
- **config rfid mobility** *vendor_name* **disable**—Disables client mobility for a specific vendor's tags. When you enter this command, tags can obtain a DHCP address. If a tag roams from one subnet to another, it obtains a new address rather than retaining the anchor state.

Note These commands can be used only for Pango tags. Therefore, the only valid entry for *vendor_name* is "pango" in all lowercase letters.

Using the CLI to View RFID Tag Tracking Information

Use these commands to view RFID tag tracking information using the controller CLI.

1. To see the current configuration for RFID tag tracking, enter this command:

   show rfid config

   Information similar to the following appears:

```
RFID Tag data Collection......................... Enabled
RFID timeout..................................... 1200 seconds
RFID mobility................................. Oui:00:14:7e : Vendor:pango
                                                 State:Disabled
```

2. To see detailed information for a specific RFID tag, enter this command:

   show rfid detail *mac_address*

   where *mac_address* is the tag's MAC address.

   Information similar to the following appears:

```
RFID address..................................... 00:12:b8:00:20:52
Vendor........................................... G2
Last Heard....................................... 51 seconds ago
Packets Received................................. 2
Bytes Received................................... 324
Cisco Type.......................................

Content Header
=================
Version.......................................... 1
Tx Power......................................... 12 dBm
Channel.......................................... 1
Reg Class........................................ 12
Burst Length..................................... 1

CCX Payload
===========
Last Sequence Control............................ 0
Payload length................................... 127
Payload Data Hex Dump

01 09 00 00 00 00 0b 85 52 52 52 02 07 4b ff ff
7f ff ff ff 03 14 00 12 7b 10 48 53 c1 f7 51 4b
50 ba 5b 97 27 80 00 67 00 01 03 05 01 42 34 00
00 03 05 02 42 5c 00 00 03 05 03 42 82 00 00 03
05 04 42 96 00 00 03 05 05 00 00 00 55 03 05 06
42 be 00 00 03 02 07 05 03 12 08 10 00 01 02 03
04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 03 0d 09 03
08 05 07 a8 02 00 10 00 23 b2 4e 03 02 0a 03

Nearby AP Statistics:
      lap1242-2(slot 0, chan 1) 50 seconds ag.... -76 dBm
      lap1242(slot 0, chan 1) 50 seconds ago..... -65 dBm
```

3. To see a list of all RFID tags currently connected to the controller, enter this command:

   show rfid summary

   Information similar to the following appears:

```
Total Number of RFID   : 24
----------------- -------- ------------------ ------ ---------------------
     RFID ID      VENDOR       Closest AP      RSSI  Time Since Last Heard
----------------- -------- ------------------ ------ ---------------------
00:04:f1:00:00:03 Wherenet HReap               -70      151 seconds ago
00:04:f1:00:00:05 Wherenet HReap               -66      251 seconds ago
00:0c:cc:5b:f8:1e Aerosct  HReap               -40        5 seconds ago
00:0c:cc:5c:05:10 Aerosct  HReap               -68       25 seconds ago
00:0c:cc:5c:06:69 Aerosct  HReap               -54        7 seconds ago
00:0c:cc:5c:06:6b Aerosct  HReap               -68      245 seconds ago
00:0c:cc:5c:06:b5 Aerosct  cisco1242           -67       70 seconds ago
00:0c:cc:5c:5a:2b Aerosct  cisco1242           -68       31 seconds ago
00:0c:cc:5c:87:34 Aerosct  HReap               -40        5 seconds ago
00:14:7e:00:05:4d Pango    cisco1242           -66      298 seconds ago
```

4. To see a list of RFID tags that are associated to the controller as clients, enter this command:

   show rfid client

   When the RFID tag is in client mode, information similar to the following appears:

```
------------------ -------- --------- ----------------- ------ ----------------
                              Heard
   RFID Mac         VENDOR   Sec Ago    Associated AP    Chnl    Client State
------------------ -------- --------- ----------------- ------ ----------------

00:14:7e:00:0b:b1   Pango      35    AP0019.e75c.fef4   1      Probing
```

   When the RFID tag is not in client mode, the above fields are blank.

Using the CLI to Debug RFID Tag Tracking Issues

If you experience any problems with RFID tag tracking, use these debug commands.

- To configure MAC address debugging, enter this command:

  debug mac addr *mac_address*

  Note Cisco recommends that you perform the debugging on a per-tag basis. If you enable debugging for all of the tags, the console or Telnet screen is inundated with messages.

- To enable or disable RFID debug options, enter this command:

  debug rfid {**all** | **detail** | **error** | **nmsp** | **receive**} {**enable** | **disable**}

  where

  – **all** configures debugging of all RFID messages,

  – **detail** configures debugging of RFID detailed messages,

  – **error** configures debugging of RFID error messages,

  – **nmsp** configures debugging of RFID NMSP messages, and

  – **receive** configures debugging of incoming RFID tag messages.

Configuring and Viewing Location Settings

This section provides instructions for configuring and viewing location settings from the controller CLI.

Note Access points in monitor mode should not be used for location purposes.

Installing the Location Appliance Certificate

A self-signed certificate (SSC) is required on the location appliance. This certificate, which is comprised of the location appliance MAC address and a 20-byte key hash, must be present on the controller. Otherwise, the controller cannot authenticate the location appliance, and they can never establish a connection. WCS usually pushes the certificate to the controller automatically, but you can install the certificate on the controller using the controller CLI if necessary (for example, if the controller is not connected to WCS or if an error or certificate mismatch occurs on WCS).

Note If an error occurs on WCS and prevents the location appliance certificate from being pushed to the controller, make sure that the time zone has been synchronized on the controller and the location appliance before following this procedure. Follow the instructions in the "Viewing Location Settings" section on page 109 to do so.

Follow these steps to install the location appliance certificate on the controller.

Step 1 To obtain the key hash value of the location appliance certificate, enter this command:

debug pm pki enable

Information similar to the following appears:

```
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Calculate SHA1 hash on Public Key Data
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  30820122 300d0609 2a864886
f70d0101
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  01050003 82010f00 3082010a
02820101
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  009a98b5 d2b7c77b 036cdb87
5bd20e5a
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  894c66f4 df1cbcfb fe2fcf01
09b723aa
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  5c0917f1 ec1d5061 2d386351
573f2c5e
Thu Oct 11 08:52:30 2007: sshpmGetIssuerHandles: Key Data  b9020301 0001
Thu Oct 11 08:52:30 2007: sshpmGetIssuerHandles: SSC Key Hash is
4869b32638c00ffca88abe9b1a8e0525b9344b8b
```

Step 2 To install the location appliance certificate on the controller, enter this command:

config auth-list add lbs-ssc *lbs_mac lbs_key*

where

- *lbs_mac* is the MAC address of the location appliance, and
- *lbs_key* is the 20-byte key hash value of the certificate.

Step 3 To save your changes, enter this command:

save config

Step 4 To verify that the location appliance certificate is installed on the controller, enter this command:

show auth-list

Information similar to the following appears:

```
Authorize APs against AAA ....................... disabled
Allow APs with Self-Signed Certificate (SSC) .... disabled

Mac Addr                  Cert Type    Key Hash
-----------------------   ----------   ---------------------------------------------
00:16:36:91:9a:27         LBS-SSC     593f34e7cb151997a28cc7da2a6cac040b329636
```

Synchronizing the Controller and Location Appliance

For controller software release 4.2 or later, if a location appliance (release 3.1 or later) is installed on your network, the time zone must be set on the controller to ensure proper synchronization between the two systems. Also, the times must be in sync on the two devices. Cisco highly recommends that the time be set even for networks that do not have location appliances. Refer to the "Configuring 802.11 Bands" section on page 30 for instructions on setting the time and date on the controller.

Note The time zone can be different for the controller and the location appliance, but the time zone delta must be configured accordingly, based on GMT.

Configuring Location Settings

The controller determines the location of client devices by gathering received signal strength indication (RSSI) measurements from access points all around the client of interest. The controller can obtain location reports from up to 16 access points for clients, RFID tags, and rogue access points.

To improve location accuracy by configuring the path loss measurement (S60) request for normal clients or calibrating clients, enter this command:

config location plm *?*

where *?* is one of the following:

- **client** {**enable** | **disable**} *burst_interval*—Enables or disables the path loss measurement request for normal, non-calibrating clients. The valid range for the *burst_interval* parameter is 1 to 3600 seconds, and the default value is 60 seconds.

- **calibrating** {**enable** | **disable**} {**uniband** | **multiband**}—Enables or disables the path loss measurement request for calibrating clients on the associated 802.11a or 802.11b/g radio or on the associated 802.11a/b/g radio.

If a client does not send probes often or sends them only on a few channels, its location cannot be updated or cannot be updated accurately. The **config location plm** command forces clients to send more packets on all channels. When a CCXv4 (or higher) client associates, the controller sends it a path loss measurement request, which instructs the client to transmit on the bands and channels that the access points are on (typically channels 1, 6, and 11 for 2.4-GHz-only access points) at a configurable interval (such as 60 seconds) indefinitely.

These four additional location CLI commands are available; however, they are set to optimal default values, so Cisco does not recommend that you use or modify them.

1. To configure the RSSI timeout value for various devices, enter this command:

   config location expiry *?*

   where *?* is one of the following:

   - **client** *timeout*—Configures the RSSI timeout value for clients. The valid range for the *timeout* parameter is 5 to 3600 seconds, and the default value is 5 seconds.
   - **calibrating-client** *timeout*—Configures the RSSI timeout value for calibrating clients. The valid range for the *timeout* parameter is 0 to 3600 seconds, and the default value is 5 seconds.
   - **tags** *timeout*—Configures the RSSI timeout value for RFID tags. The valid range for the *timeout* parameter is 5 to 300 seconds, and the default value is 5 seconds.
   - **rogue-aps** *timeout*—Configures the RSSI timeout value for rogue access points. The valid range for the *timeout* parameter is 5 to 3600 seconds, and the default value is 5 seconds.

   Ensuring that recent, strong RSSIs are retained by the CPU is critical to location accuracy. The **config location expiry** command enables you to specify the length of time after which old RSSI averages expire.

   Note Cisco recommends that you do not use or modify the **config location expiry** command.

2. To configure the RSSI half life for various devices, enter this command:

   config location rssi-half-life *?*

   where *?* is one of the following:

   - **client** *half_life*—Configures the RSSI half life for clients. The valid range for the *half_life* parameter is 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.
   - **calibrating-client** *half_life*—Configures the RSSI half life for calibrating clients. The valid range for the *half_life* parameter is 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.
   - **tags** *half_life*—Configures the RSSI half life for RFID tags. The valid range for the *half_life* parameter is 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.
   - **rogue-aps** *half_life*—Configures the RSSI half life for rogue access points. The valid range for the *half_life* parameter is 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.

Some client devices transmit at reduced power immediately after changing channels, and RF is variable, so RSSI values might vary considerably from packet to packet. The **config location rssi-half-life** command increases accuracy by averaging non-uniformly arriving data using a configurable forget period (or half life).

> **Note** Cisco recommends that you do not use or modify the **config location rssi-half-life** command.

3. To configure the NMSP notification threshold for RSSI measurements, enter this command:

   config location notify-threshold *?*

   where *?* is one of the following:

   - **client** *threshold*—Configures the NMSP notification threshold (in dB) for clients and rogue clients. The valid range for the *threshold* parameter is 0 to 10 dB, and the default value is 0 dB.
   - **tags** *threshold*—Configures the NMSP notification threshold (in dB) for RFID tags. The valid range for the *threshold* parameter is 0 to 10 dB, and the default value is 0 dB.
   - **rogue-aps** *threshold*—Configures the NMSP notification threshold (in dB) for rogue access points. The valid range for the *threshold* parameter is 0 to 10 dB, and the default value is 0 dB.

   > **Note** Cisco recommends that you do not use or modify the **config location notify-threshold** command.

4. To configure the algorithm used to average RSSI and signal-to-noise ratio (SNR) values, enter this command:

   config location algorithm *?*

   where *?* is one of the following:

   - **simple**—Specifies a faster algorithm that requires low CPU overhead but provides less accuracy.
   - **rssi-average**—Specifies a more accurate algorithm but requires more CPU overhead.

   > **Note** Cisco recommends that you do not use or modify the **config location algorithm** command.

Viewing Location Settings

Use these CLI commands to view location information.

1. To view the current location configuration values, enter this command:

   show location summary

Information similar to the following appears:

```
Location Summary

Algorithm used:                         Average
Client
       RSSI expiry timeout:              5 sec
       Half life:                        0 sec
       Notify Threshold:                 0 db
Calibrating Client
       RSSI expiry timeout:              5 sec
       Half life:                        0 sec
Rogue AP
       RSSI expiry timeout:              5 sec
       Half life:                        0 sec
       Notify Threshold:                 0 db
RFID Tag
       RSSI expiry timeout:              5 sec
       Half life:                        0 sec
       Notify Threshold:                 0 db
```

2. To see the RSSI table for a particular client, enter this command:

   show location detail *client_mac_addr*

   Information similar to the following appears:

```
...
[11] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A 0) (antenna-B 0), snr 0, acceptable 0
[12] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A 0) (antenna-B 0), snr 0, acceptable 0
[13] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A -1) (antenna-B 0), snr 0, acceptable 0
[14] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A 0) (antenna-B 0), snr 0, acceptable 0
[15] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A 0) (antenna-B 0), snr 0, acceptable 0
```

3. To see the location-based RFID statistics, enter this command:

   show location statistics rfid

   Information similar to the following appears:

```
RFID Statistics

Database Full :        0        Failed Delete:         0
Null Bufhandle:        0        Bad Packet:            0
Bad LWAPP Data:        0        Bad LWAPP Encap:       0
Off Channel:           0        Bad CCX Version:       0
Bad AP Info :          0
Above Max RSSI:        0        Below Max RSSI:        0
Invalid RSSI:          0        Add RSSI Failed:       0
Oldest Expired RSSI:  0        Smallest Overwrite:  0
```

4. To clear the location-based RFID statistics, enter this command:

   clear location statistics rfid

5. To clear a specific RFID tag or all of the RFID tags in the entire database, enter this command:

   clear location rfid {*mac_address* | **all**}

6. To see whether location presence (S69) is supported on a client, enter this command:

   show client detail *client_mac*

   When location presence is supported by a client and enabled on a location appliance, the location appliance can provide the client with its location upon request. Location presence is enabled automatically on CCXv5 clients.

   Information similar to the following appears:

```
Client MAC Address.............................. 00:40:96:b2:a3:44
Client Username ................................ N/A
AP MAC Address.................................. 00:18:74:c7:c0:90
Client State.................................... Associated
Wireless LAN Id................................. 1
BSSID........................................... 00:18:74:c7:c0:9f
Channel......................................... 56
IP Address...................................... 192.168.10.28
Association Id.................................. 1
Authentication Algorithm........................ Open System
Reason Code..................................... 0
Status Code..................................... 0
Session Timeout................................. 0
Client CCX version.............................. 5
Client E2E version.............................. No E2E support
Diagnostics Capability.......................... Supported
S69 Capability.................................. Supported
Mirroring....................................... Disabled
QoS Level....................................... Silver
...
```

Note See the *Cisco Wireless Control System Configuration Guide* or the *Cisco Location Appliance Configuration Guide* for instructions on enabling location presence on a location appliance.

Modifying the NMSP Notification Interval for Clients, RFID Tags, and Rogues

The Network Mobility Services Protocol (NMSP) manages communication between the location appliance and the controller for incoming and outgoing traffic. If your application requires more frequent location updates, you can modify the NMSP notification interval (to a value between 1 and 180 seconds) for clients, active RFID tags, and rogue access points and clients.

Note The TCP port (16113) that the controller and location appliance communicate over must be open (not blocked) on any firewall that exists between the controller and the location appliance for NMSP to function.

Using the controller CLI, follow these steps to modify the NMSP notification interval value on the controller.

Step 1 To set the NMSP notification interval value for clients, RFID tags, and rogue clients and access points, enter these commands, where *interval* is a value between 1 and 180 seconds:

- **config nmsp notification interval rssi clients** *interval*
- **config nmsp notification interval rssi rfid** *interval*
- **config nmsp notification interval rssi rogues** *interval*

Step 2 To see the NMSP notification intervals, enter this command:

show nmsp notification interval

Information similar to the following appears:

```
NMSP Notification Interval Summary

RSSI Interval:
 Client....................................... 2 sec
 RFID......................................... 0 sec
 Rogue AP..................................... 2 sec
 Rogue Client................................. 2 sec
```

Viewing NMSP Settings

Use these CLI commands to view NMSP information.

1. To see the status of active NMSP connections, enter this command:

   show nmsp status

   Information similar to the following appears:

```
MSE IP Address    Tx Echo Resp    Rx Echo Req    Tx Data    Rx Data
--------------    ------------    -----------    -------    -------
171.71.132.107      39046           39046        103742         1
```

2. To see the NMSP capabilities, enter this command:

   show nmsp capability

   Information similar to the following appears:

```
Service                  Subservice
-------                  ----------
RSSI                     Mobile Station, Tags, Rogue,
Info                     Mobile Station, Rogue,
Statistics               Mobile Station, Tags,
IDS Services            WIPS
```

3. To see the NMSP counters, enter this command:

   show nmsp statistics {**summary** | **connection**}

   where

   – **summary** shows the common NMSP counters, and

   – **connection** shows the connection-specific NMSP counters.

   Information similar to the following appears for the **show nmsp statistics summary** command:

```
NMSP Global Counters

Client Measure Send Fail......................... 0
Send RSSI with no entry.......................... 0
APP msg too big.................................. 0
Failed Select on Accept Socket................... 0
Failed SSL write................................. 0
Partial SSL write................................ 0
SSL write returned zero.......................... 0
SSL write attempts to want read.................. 0
SSL write attempts to want write................. 0
SSL write got default error...................... 0
SSL write max data length sent................... 0
```

```
SSL write max attempts to write in loop.......... 0
SSL read returned zero........................... 0
SSL read attempts to want read................... 0
SSL read attempts to want write.................. 0
SSL read got default error....................... 0
Failed SSL read - Con Rx buf freed............... 0
Failed SSL read - Con/SSL freed.................. 0
Max records read before exiting SSL read......... 0
Normal Prio Tx Q full............................ 0
Highest Prio Tx Q count.......................... 0
Normal Prio Tx Q count........................... 0
Messages sent by APPs to Highest Prio TxQ........ 0
Max Measure Notify Msg........................... 0
Max Info Notify Msg.............................. 0
Max Highest Prio Tx Q Size....................... 0
Max Normal Prio Tx Q Size........................ 0
Max Rx Size...................................... 1
Max Info Notify Q Size........................... 0
Max Client Info Notify Delay..................... 0
Max Rogue AP Info Notify Delay................... 0
Max Rogue Client Info Notify Delay............... 0
Max Client Measure Notify Delay.................. 0
Max Tag Measure Notify Delay..................... 0
Max Rogue AP Measure Notify Delay................ 0
Max Rogue Client Measure Notify Delay............ 0
Max Client Stats Notify Delay.................... 0
Max Client Stats Notify Delay.................... 0
RFID Measurement Periodic........................ 0
RFID Measurement Immediate....................... 0
SSL Handshake failed............................. 0
NMSP Rx detected con failure..................... 0
NMSP Tx detected con failure..................... 0
NMSP Tx buf size exceeded........................ 0
Reconnect Before Conn Timeout................. 0
```

Information similar to the following appears for each active connection when you enter the **show nmsp statistics connection** command:

```
NMSP Connection Counters

MSE IP: 171.71.132.107
 Connection status:     UP
 Tx message count                       Rx message count
 ----------------                       ----------------
 WLC Capability:        1               MSE Capability:         0
 Service Subscr Rsp:    1               Service Subscr Req:     1
 Measure Rsp:           0               Measure Req:            0
 Measure Notify:        0
 Info Rsp:              0               Info Req:               0
 Info Notify:           0
 Stats Rsp:             0               Stats Req:              0
 Stats Notify:          0
 Loc Req:               0               Loc Rsp:                0
 Loc Subscr Req:        0               Loc Subscr Rsp:         0
                                        Loc Notify:             0
 Loc Unsubscr Req:      0               Loc Unsubscr Rsp:       0
 AP Monitor Rsp:        0               AP Monitor Req:         0
 AP Monitor Notify:     64677
 IDS Get Rsp:           0               IDS Get Req:            0
IDS Notif:             0
 IDS Set Rsp:           0               IDS Set Req:            0
```

4. To see the mobility services that are active on the controller, enter this command:

   show nmsp subscription {**summary** | **detail** | **detail** *ip_addr*}

   where

   – **summary** shows all of the mobility services to which the controller is subscribed,

   – **detail** shows details for all of the mobility services to which the controller is subscribed, and

   – **detail** *ip_addr* shows details only for the mobility services subscribed to by a specific IP address.

   Information similar to the following appears for the **show nmsp subscription summary** command:

```
Mobility Services Subscribed:

 Server IP                Services
 ---------                --------
 1.4.93.31                RSSI, Info, Statistics
```

   Information similar to the following appears for the **show nmsp subscription detail** *ip_addr* command:

```
Mobility Services Subscribed by 1.4.93.31

Services                 Sub-services
--------                 ------------
RSSI                     Mobile Station, Tags,
Info                     Mobile Station,
Statistics             Mobile Station, Tags,
```

5. To clear all NMSP statistics, enter this command:

   clear nmsp statistics

Debugging NMSP Issues

Use these CLI commands if you experience any problems with NMSP.

- To configure NMSP debug options, enter this command:

  debug nmsp *?*

  where *?* is one of the following:

  – **all** {**enable** | **disable**}—Enables or disables debugging for all NMSP messages.

  – **connection** {**enable** | **disable**}—Enables or disables debugging for NMSP connection events.

  – **detail** {**enable** | **disable**}—Enables or disables debugging for NMSP detailed events.

  – **error** {**enable** | **disable**}—Enables or disables debugging for NMSP error messages.

  – **event** {**enable** | **disable**}—Enables or disables debugging for NMSP events.

  – **message** {**tx** | **rx**} {**enable** | **disable**}—Enables or disables debugging for NMSP transmit or receive messages.

  – **packet** {**enable** | **disable**}—Enables or disables debugging for NMSP packet events.

- To enable or disable debugging for IAPP NMSP events, enter this command:

  debug iapp nmsp {**enable** | **disable**}
- To enable or disable debugging for RFID NMSP messages, enter this command:

  debug rfid nmsp {**enable** | **disable**}
- To enable or disable debugging for access point monitor NMSP events, enter this command:

  debug service ap-monitor nmsp {**enable** | **disable**}
- To enable or disable debugging for wIPS NMSP events, enter this command:

  debug wips nmsp {**enable** | **disable**}

Configuring the Supervisor 720 to Support the WiSM

When you install a WiSM in a Cisco Catalyst 6500 switch or a Cisco 7600 series router, you must configure the Supervisor 720 to support the WiSM. When the supervisor detects the WiSM, the supervisor creates ten Gigabit Ethernet interfaces, ranging from Gig*slot*/1 to Gig*slot*/8. For example, if the WiSM is in slot 9, the supervisor creates interfaces Gig9/1 through Gig9/8. The first eight Gigabit Ethernet interfaces must be organized into two Etherchannel bundles of four interfaces each. The remaining two Gigabit Ethernet interfaces are used as service-port interfaces, one for each controller on the WiSM. You must manually create VLANs to communicate with the ports on the WiSM.

Note The WiSM is supported on Cisco 7600 series routers running only Cisco IOS Release 12.2(18)SXF5.

General WiSM Guidelines

Keep these general guidelines in mind when you add a WiSM to your network:

- The switch or router ports leading to the controller service port are automatically configured and cannot be manually configured.
- The switch or router ports leading to the controller data ports should be configured as edge ports to avoid sending unnecessary BPDUs.
- The switch or router ports leading to the controller data ports should not be configured with any additional settings (such as port channel or SPAN destination) other than settings necessary for carrying data traffic to and from the controllers.

Note Refer to the *Configuring Ports and Interfaces* chapter for information on configuring the WiSM's ports and interfaces.

Configuring the Supervisor

Log into the switch or router CLI and, beginning in Privileged Exec mode, follow these steps to configure the supervisor to support the WiSM:

	Command	Purpose
Step 1	**configure terminal**	Enter global configuration mode.
Step 2	**interface** *vlan*	Create a VLAN to communicate with the data ports on the WiSM and enter interface config mode.
Step 3	**ip address** *ip-address gateway*	Assign an IP address and gateway to the VLAN.
Step 4	**ip helper-address** *ip-address*	Assign a helper address to the VLAN.
Step 5	**end**	Return to global config mode.
Step 6	**wism module** *module_number* **controller** { **1** | **2**} **allowed-vlan** *vlan_number*	Create Gigabit port-channel interfaces automatically for the specified WiSM controller and configure the port-channel interfaces as trunk ports. Also, specify the VLAN you created earlier as the allowed VLAN on the port-channel trunk. VLAN traffic is carried on the trunk between the WiSM controller and the supervisor. **Note** Services might be temporarily interrupted (for approximately two pings) after you enter this command.
Step 7	**wism module** *module_number* **controller** { **1** | **2**} **native-vlan** *vlan_number*	For the native VLAN on the ports, specify the VLAN that you created earlier to communicate with the WiSM data ports.
Step 8	**interface** *vlan*	Create a VLAN to communicate with the service ports on the WiSM.
Step 9	**ip address** *ip_address gateway*	Assign an IP address and gateway to the VLAN.
Step 10	**end**	Return to global config mode.
Step 11	**wism service-vlan** *vlan*	Configure the VLAN that you created in steps 8 through 10 to communicate with the WiSM service ports.
Step 12	**end**	Return to global config mode.
Step 13	**show wism status**	Verify that the WiSM is operational.

Note The commands used for communication between the Cisco WiSM, the Supervisor 720, and the 4404 controllers are documented in *Configuring a Cisco Wireless Services Module and Wireless Control System* at this URL:

http://www.cisco.com/c/en/us/td/docs/wireless/technology/wism/technical/reference/appnote.html#wp39498

Using the Wireless LAN Controller Network Module

Keep these guidelines in mind when using a wireless LAN controller network module (CNM) installed in a Cisco Integrated Services Router:

- The CNM does not support IPSec. To use IPSec with the CNM, configure IPSec on the router in which the CNM is installed. Click this link to browse to IPSec configuration instructions for routers:

  http://www.cisco.com/c/en/us/tech/security-vpn/ipsec-negotiation-ike-protocols/tech-configuration-guides-list.html

- The CNM does not have a battery and cannot save a time setting. It must receive a time setting from an external NTP server when it powers up. When you install the module, the configuration wizard prompts you for NTP server information.

- To access the CNM bootloader, Cisco recommends that you reset the CNM from the router. If you reset the CNM from a CNM user interface, the router might reset the CNM while you are using the bootloader.

  When you reset the CNM from a CNM interface, you have 17 minutes to use the bootloader before the router automatically resets the CNM. The CNM bootloader does not run the Router Blade Configuration Protocol (RBCP), so the RBCP heartbeat running on the router times out after 17 minutes, triggering a reset of the CNM.

  If you reset the CNM from the router, the router stops the RBCP heartbeat exchange and does not restart it until the CNM boots up. To reset the CNM from the router, enter one of these commands on the router CLI:

  service-module wlan-controller 1/0 reset (for Fast Ethernet CNM versions)

  service-module integrated-service-engine 1/0 reset (for Gigabit Ethernet CNM versions)

- Gigabit Ethernet versions of the Controller Network Module are supported on Cisco 28/37/38xx Series Integrated Services Routers running Cisco IOS Release 12.4(11)T2 or later.

Resetting the Controller to Default Settings

If you want to return the controller to its original configuration, you can use the controller GUI or CLI to reset the controller to factory default settings.

Using the GUI to Reset the Controller to Default Settings

Using the GUI, follow these steps to return the controller to factory default settings.

Step 1 Open your Internet browser.

Step 2 Enter the controller IP address in the browser address line and press **Enter**. An Enter Network Password window appears.

Step 3 Enter your username in the User Name field. The default username is *admin*.

Step 4 Enter the wireless device password in the Password field and press **Enter**. The default password is *admin*.

Step 5 Choose **Commands** > **Reset to Factory Default**.

Step 6 Click **Reset**.

Step 7 When prompted, confirm the reset.

Step 8 Reboot the controller without saving the configuration.

Step 9 Use the configuration wizard to enter configuration settings. Refer to the "Using the Configuration Wizard" section on page 2 for instructions.

Using the CLI to Reset the Controller to Default Settings

Using the CLI, follow these steps to return the controller to factory default settings.

Step 1 Enter **reset system**. At the prompt that asks whether you need to save changes to the configuration, enter **N**. The unit reboots.

Step 2 When you are prompted for a username, enter **recover-config** to restore the factory default configuration. The controller reboots and displays this message:

```
Welcome to the Cisco WLAN Solution Wizard Configuration Tool
```

Step 3 Use the configuration wizard to enter configuration settings. Refer to the "Using the Configuration Wizard" section on page 2 for instructions.

Configuring Security Solutions

This chapter describes security solutions for wireless LANs. It contains these sections:

Cisco UWN Solution Security

Cisco UWN Solution security includes the following sections:

Security Overview

The Cisco UWN security solution bundles potentially complicated Layer 1, Layer 2, and Layer 3 802.11 Access Point security components into a simple policy manager that customizes system-wide security policies on a per-WLAN basis. The Cisco UWN security solution provides simple, unified, and systematic security management tools.

One of the biggest hurdles to WLAN deployment in the enterprise is WEP encryption, which is a weak standalone encryption method. A newer problem is the availability of low-cost access points, which can be connected to the enterprise network and used to mount man-in-the-middle and denial-of-service attacks. Also, the complexity of add-on security solutions has prevented many IT managers from embracing the benefits of the latest advances in WLAN security.

Layer 1 Solutions

The Cisco UWN security solution ensures that all clients gain access within an operator-set number of attempts. Should a client fail to gain access within that limit, it is automatically excluded (blocked from access) until the operator-set timer expires. The operating system can also disable SSID broadcasts on a per-WLAN basis.

Layer 2 Solutions

If a higher level of security and encryption is required, the network administrator can also implement industry-standard security solutions such as Extensible Authentication Protocol (EAP), Wi-Fi protected access (WPA), and WPA2. The Cisco UWN Solution WPA implementation includes AES (advanced encryption standard), TKIP + Michael (temporal key integrity protocol + message integrity code checksum) dynamic keys, or WEP (Wired Equivalent Privacy) static keys. Disabling is also used to automatically block Layer 2 access after an operator-set number of failed authentication attempts.

Regardless of the wireless security solution selected, all Layer 2 wired communications between controllers and lightweight access points are secured by passing data through CAPWAP tunnels.

Layer 3 Solutions

The WEP problem can be further solved using industry-standard Layer 3 security solutions such as passthrough VPNs (virtual private networks).

The Cisco UWN Solution supports local and RADIUS MAC (media access control) filtering. This filtering is best suited to smaller client groups with a known list of 802.11 access card MAC addresses.

Finally, the Cisco UWN Solution supports local and RADIUS user/password authentication. This authentication is best suited to small to medium client groups.

Integrated Security Solutions

- Cisco UWN Solution operating system security is built around a robust 802.1X AAA (authorization, authentication and accounting) engine, which allows operators to rapidly configure and enforce a variety of security policies across the Cisco UWN Solution.
- The controllers and lightweight access points are equipped with system-wide authentication and authorization protocols across all ports and interfaces, maximizing system security.
- Operating system security policies are assigned to individual WLANs, and lightweight access points simultaneously broadcast all (up to 16) configured WLANs. This can eliminate the need for additional access points, which can increase interference and degrade system throughput.
- Operating system security uses the RRM function to continually monitor the air space for interference and security breaches, and notify the operator when they are detected.
- Operating system security works with industry-standard authorization, authentication, and accounting (AAA) servers, making system integration simple and easy.

Configuring RADIUS

Remote Authentication Dial-In User Service (RADIUS) is a client/server protocol that provides centralized security for users attempting to gain management access to a network. It serves as a backend database similar to local and TACACS+ and provides authentication and accounting services:

- **Authentication—**The process of verifying users when they attempt to log into the controller.

  Users must enter a valid username and password in order for the controller to authenticate users to the RADIUS server.

  Note When multiple databases are configured, you can use the controller GUI or CLI to specify the sequence in which the backend databases should be tried.

- **Accounting—**The process of recording user actions and changes.

  Whenever a user successfully executes an action, the RADIUS accounting server logs the changed attributes, the user ID of the person who made the change, the remote host where the user is logged in, the date and time when the command was executed, the authorization level of the user, and a description of the action performed and the values provided. If the RADIUS accounting server becomes unreachable, users are able to continue their sessions uninterrupted.

RADIUS uses User Datagram Protocol (UDP) for its transport. It maintains a database and listens on UDP port 1812 for incoming authentication requests and UDP port 1813 for incoming accounting requests. The controller, which requires access control, acts as the client and requests AAA services from the server. The traffic between the controller and the server is encrypted by an algorithm defined in the protocol and a shared secret key configured on both devices.

You can configure up to 17 RADIUS authentication and accounting servers each. For example, you may want to have one central RADIUS authentication server but several RADIUS accounting servers in different regions. If you configure multiple servers of the same type and the first one fails or becomes unreachable, the controller automatically tries the second one, then the third one if necessary, and so on.

Note If multiple RADIUS servers are configured for redundancy, the user database must be identical in all the servers for the backup to work properly.

The primary RADIUS server (the server with lowest server index) is assumed to be the most preferable server for the controller. If the primary server becomes unresponsive, the controller switches to the next active backup server (the server with the next lowest server index). The controller continues to use this backup server forever, unless you configure the controller to fall back to the primary RADIUS server when it recovers and becomes responsive or to a more preferable server from the available backup servers.

You must configure RADIUS on both your CiscoSecure Access Control Server (ACS) and your controller. You can configure the controller through either the GUI or the CLI.

Configuring RADIUS on the ACS

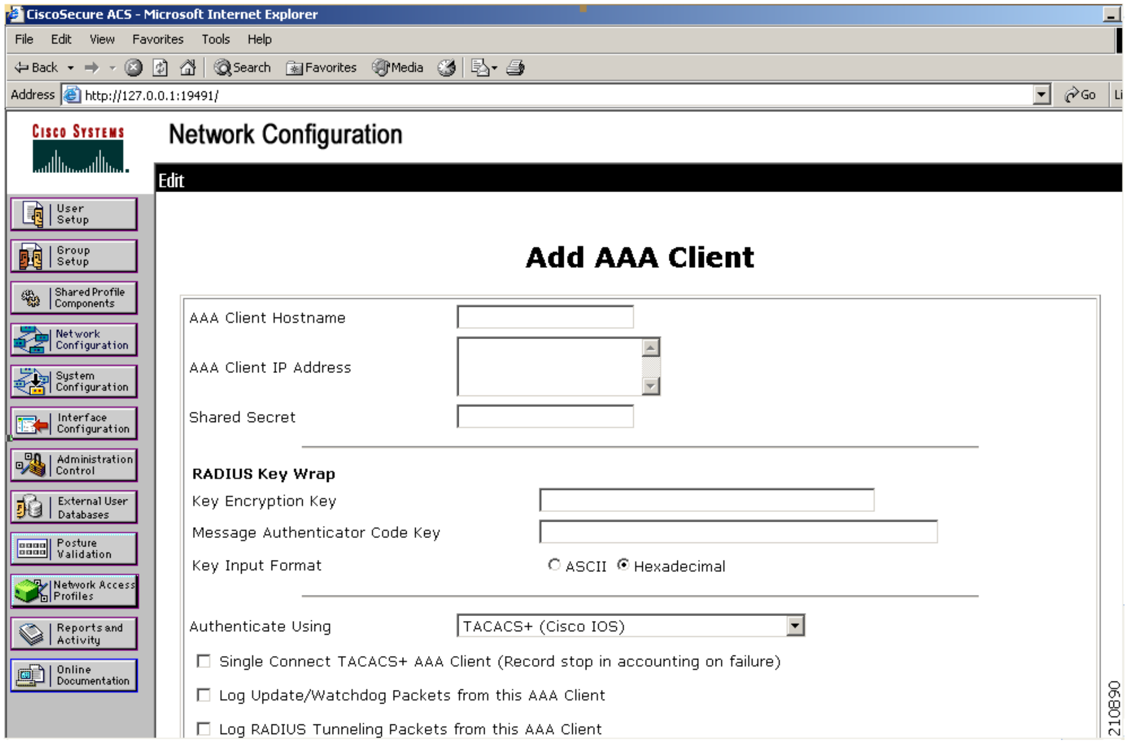
Follow these steps to configure RADIUS on the ACS.

Note RADIUS is supported on CiscoSecure ACS version 3.2 and greater. The instructions and illustrations in this section pertain to ACS version 4.1 and may vary for other versions. Refer to the CiscoSecure ACS documentation for the version you are running.

Step 1 Choose **Network Configuration** on the ACS main page.

Step 2 Choose **Add Entry** under AAA Clients to add your controller to the server. The Add AAA Client page appears (see Figure 5-1).

Figure 5-1 Add AAA Client Page on CiscoSecure ACS



Step 3 In the AAA Client Hostname field, enter the name of your controller.

Step 4 In the AAA Client IP Address field, enter the IP address of your controller.

Step 5 In the Shared Secret field, enter the shared secret key to be used for authentication between the server and the controller.

> **Note** The shared secret key must be the same on both the server and the controller.

Step 6 Choose **RADIUS (Cisco Aironet)** from the Authenticate Using drop-down box.

Step 7 Click **Submit + Apply** to save your changes.

Step 8 Choose **Interface Configuration** on the ACS main page.

Step 9 Choose **RADIUS (Cisco Aironet)**. The RADIUS (Cisco Aironet) page appears.

Step 10 Under User Group, check the **Cisco-Aironet-Session-Timeout** check box.

Step 11 Click **Submit** to save your changes.

Step 12 Choose **System Configuration** on the ACS main page.

Step 13 Choose **Logging**.

Step 14 When the Logging Configuration page appears, enable all of the events that you want to be logged and save your changes.

Step 15 Choose **Group Setup** on the ACS main page.

Step 16 Choose a previously created group from the Group drop-down box.

> **Note** This step assumes that you have already assigned users to groups on the ACS according to the roles to which they will be assigned.

Step 17 Click **Edit Settings**. The Group Setup page appears.

Step 18 Under **Cisco Aironet Attributes**, check the **Cisco-Aironet-Session-Timeout** check box and enter a session timeout value in the edit box.

Step 19 To specify read-only or read-write access to controllers through RADIUS authentication, set the Service-Type attribute (006) to **Callback NAS Prompt** for read-only access or to **Administrative** for read-write privileges. If you do not set this attribute, the authentication process completes successfully (without an authorization error on the controller), but you might be prompted to authenticate again.

> **Note** If you set the Service-Type attribute on the ACS, make sure to check the **Management** check box on the RADIUS Authentication Servers page of the controller GUI. See Step 17 in the next section for more information.

> **Note** The "RADIUS Authentication Attributes Sent by the Access Point" section on page 5-16 lists the RADIUS attributes that are sent by a lightweight access point to a client in access-request and access-accept packets.

Step 20 Click **Submit** to save your changes.

Using the GUI to Configure RADIUS

Using the controller GUI, follow these steps to configure RADIUS.

Step 1 Choose **Security** > **AAA** > **RADIUS**.

Step 2 Perform one of the following:

- If you want to configure a RADIUS server for authentication, choose **Authentication**.
- If you want to configure a RADIUS server for accounting, choose **Accounting**.

> **Note** The GUI pages used to configure authentication and accounting contain mostly the same fields. Therefore, these instructions walk through the configuration only once, using the Authentication pages as examples. You would follow the same steps to configure multiple services and/or multiple servers.

The RADIUS Authentication (or Accounting) Servers page appears (see Figure 5-2).

Figure 5-2 RADIUS Authentication Servers Page

This page lists any RADIUS servers that have already been configured.

- If you want to delete an existing server, hover your cursor over the blue drop-down arrow for that server and choose **Remove**.
- If you want to make sure that the controller can reach a particular server, hover your cursor over the blue drop-down arrow for that server and choose **Ping**.

Step 3 From the Call Station ID Type drop-down box, choose **IP Address**, **System MAC Address**, or **AP MAC Address** to specify whether the IP address, system MAC address, or AP MAC address of the originator will be sent to the RADIUS server in the Access-Request message.

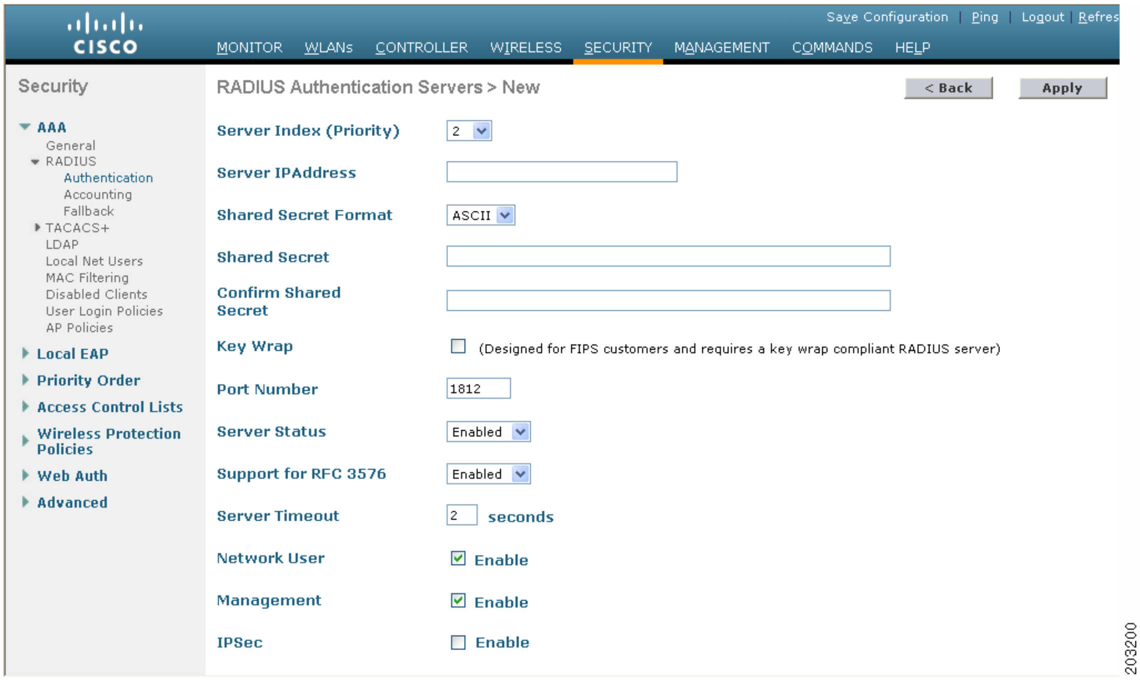
Step 4 To enable RADIUS-to-controller key transport using AES key wrap protection, check the **Use AES Key Wrap** check box. The default value is unchecked. This feature is required for FIPS customers.

Step 5 Click **Apply** to commit your changes.

Step 6 Perform one of the following:

- To edit an existing RADIUS server, click the server index number for that server. The RADIUS Authentication (or Accounting) Servers > Edit page appears.
- To add a RADIUS server, click **New**. The RADIUS Authentication (or Accounting) Servers > New page appears (see Figure 5-3).

Figure 5-3 RADIUS Authentication Servers > New Page



Step 7 If you are adding a new server, choose a number from the Server Index (Priority) drop-down box to specify the priority order of this server in relation to any other configured RADIUS servers providing the same service. You can configure up to 17 servers. If the controller cannot reach the first server, it tries the second one in the list, then the third one if necessary, and so on.

Step 8 If you are adding a new server, enter the IP address of the RADIUS server in the Server IP Address field.

Step 9 From the Shared Secret Format drop-down box, choose **ASCII** or **Hex** to specify the format of the shared secret key to be used between the controller and the RADIUS server. The default value is ASCII.

Step 10 In the Shared Secret and Confirm Shared Secret fields, enter the shared secret key to be used for authentication between the controller and the server.

Note The shared secret key must be the same on both the server and the controller.

Step 11 If you are configuring a new RADIUS authentication server and want to enable AES key wrap, which makes the shared secret between the controller and the RADIUS server more secure, follow these steps. AES key wrap is designed for Federal Information Processing Standards (FIPS) customers and requires a key-wrap compliant RADIUS authentication server.

a. Check the **Key Wrap** check box.Choose **ASCII** or **Hex** from the Key Wrap Format drop-down box to specify the format of the AES key wrap keys: Key Encryption Key (KEK) and Message Authentication Code Key (MACK).

b. In the Key Encryption Key (KEK) field, enter the 16-byte KEK.

c. In the Message Authentication Code Key (MACK) field, enter the 20-byte KEK.

Step 12 If you are adding a new server, enter the RADIUS server's UDP port number for the interface protocols in the Port Number field. The valid range is 1 to 65535, and the default value is 1812 for authentication and 1813 for accounting.

Step 13 From the Server Status field, choose **Enabled** to enable this RADIUS server or choose **Disabled** to disable it. The default value is Enabled.

Step 14 If you are configuring a new RADIUS authentication server, choose **Enabled** from the Support for RFC 3576 drop-down box to enable RFC 3576, which is an extension to the RADIUS protocol that allows dynamic changes to a user session, or choose **Disabled** to disable this feature. The default value is Enabled. RFC 3576 includes support for disconnecting users and changing authorizations applicable to a user session and supports disconnect and change-of-authorization (CoA) messages). Disconnect messages cause a user session to be terminated immediately whereas CoA messages modify session authorization attributes such as data filters.

Step 15 In the Server Timeout field, enter the number of seconds between retransmissions. The valid range is 2 to 30 seconds, and the default value is 2 seconds.

> **Note** Cisco recommends that you increase the timeout value if you experience repeated reauthentication attempts or the controller falls back to the backup server when the primary server is active and reachable.

Step 16 Check the **Network User** check box to enable network user authentication (or accounting), or uncheck it to disable this feature. The default value is checked. If you enable this feature, this entry is considered the RADIUS authentication (or accounting) server for network users. If you did not configure a RADIUS server entry on the WLAN, you must enable this option for network users.

Step 17 If you are configuring a RADIUS authentication server, check the **Management** check box to enable management authentication, or uncheck it to disable this feature. The default value is checked. If you enable this feature, this entry is considered the RADIUS authentication server for management users, and authentication requests go to the RADIUS server.

Step 18 Check the **IPSec** check box to enable the IP security mechanism, or uncheck it to disable this feature. The default value is unchecked.

> **Note** The IPSec option appears only if a crypto card is installed in the controller.

Step 19 If you enabled IPSec in Step 18, follow these steps to configure additional IPSec parameters:

a. From the IPSec drop-down box, choose one of the following options as the authentication protocol to be used for IP security: **HMAC MD5** or **HMAC SHA1**. The default value is HMAC SHA1.

A message authentication code (MAC) is used between two parties that share a secret key to validate information transmitted between them. HMAC (Hash MAC) is a mechanism based on cryptographic hash functions. It can be used in combination with any iterated cryptographic hash function. HMAC MD5 and HMAC SHA1 are two constructs of the HMAC using the MD5 hash function and the SHA1 hash function. HMAC also uses a secret key for calculation and verification of the message authentication values.

b. From the IPSec Encryption drop-down box, choose one of the following options to specify the IP security encryption mechanism:

- **DES**—Data Encryption Standard is a method of data encryption using a private (secret) key. DES applies a 56-bit key to each 64-bit block of data.
- **3DES**—Data Encryption Standard that applies three keys in succession. This is the default value.
- **AES CBS—**Advanced Encryption Standard uses keys with a length of 128, 192, or 256 bits to encrypt data blocks with a length of 128, 192, or 256 bits. AES 128 CBC uses a 128-bit data path in Cipher Clock Chaining (CBC) mode.

c. From the IKE Phase 1 drop-down box, choose one of the following options to specify the Internet Key Exchange (IKE) protocol: **Aggressive** or **Main**. The default value is Aggressive.

IKE Phase 1 is used to negotiate how IKE should be protected. Aggressive mode passes more information in fewer packets with the benefit of slightly faster connection establishment at the cost of transmitting the identities of the security gateways in the clear.

d. In the Lifetime field, enter a value (in seconds) to specify the timeout interval for the session. The valid range is 1800 to 57600 seconds, and the default value is 1800 seconds.

e. From the IKE Diffie Hellman Group drop-down box, choose one of the following options to specify the IKE Diffie Hellman group: **Group 1 (768 bits)**, **Group 2 (1024 bits)**, or **Group 5 (1536 bits)**. The default value is Group 1 (768 bits).

Diffie-Hellman techniques are used by two devices to generate a symmetric key through which they can publicly exchange values and generate the same symmetric key. Although all three groups provide security from conventional attacks, Group 5 is considered more secure because of its larger key size. However, computations involving Group 1 and Group 2 based keys might occur slightly faster because of their smaller prime number size.

Step 20 Click **Apply** to commit your changes.

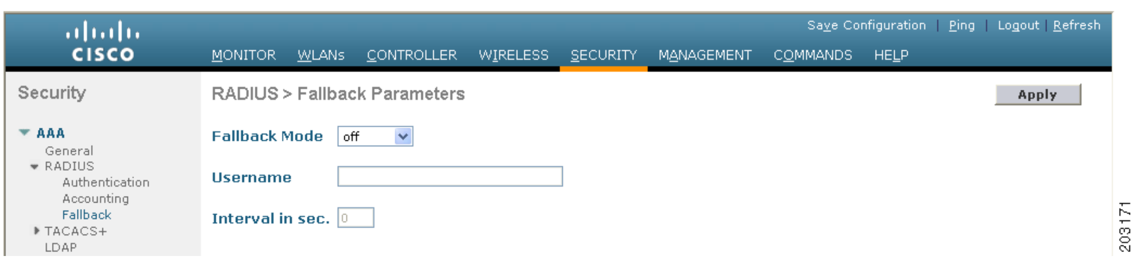
Step 21 Click **Save Configuration** to save your changes.

Step 22 Repeat the previous steps if you want to configure any additional services on the same server or any additional RADIUS servers.

Step 23 To specify the RADIUS server fallback behavior, follow these steps:

a. Choose **Security** > **AAA** > **RADIUS** > **Fallback** to open the RADIUS > Fallback Parameters page (see Figure 5-4).

Figure 5-4 RADIUS > Fallback Parameters Page



b. From the Fallback Mode drop-down box, choose one of the following options:

- **Off**—Disables RADIUS server fallback. This is the default value.
- **Passive**—Causes the controller to revert to a server with a lower priority from the available backup servers without using extraneous probe messages. The controller simply ignores all inactive servers for a time period and retries later when a RADIUS message needs to be sent.
- **Active**—Causes the controller to revert to a server with a lower priority from the available backup servers by using RADIUS probe messages to proactively determine whether a server that has been marked inactive is back online. The controller simply ignores all inactive servers for all active RADIUS requests. Once the primary server receives a response from the recovered ACS server, the active fallback RADIUS server no longer sends probe messages to the server requesting the active probe authentication.

c. If you enabled Active fallback mode in Step b, enter the name to be sent in the inactive server probes in the Username field. You can enter up to 16 alphanumeric characters. The default value is "cisco-probe."

d. If you enabled Active fallback mode in Step b, enter the probe interval value (in seconds) in the Interval in Sec field. The interval serves as inactive time in passive mode and probe interval in active mode. The valid range is 180 to 3600 seconds, and the default value is 300 seconds.

Step 24 To specify the order of authentication when multiple databases are configured, choose **Security** > **Priority Order** > **Management User**. The Priority Order > Management User page appears (see Figure 5-5).

Figure 5-5 Priority Order > Management User Page

Step 25 In the Order Used for Authentication field, specify which servers have priority when the controller attempts to authenticate management users. Use the **>** and **<** buttons to move servers between the Not Used and Order Used for Authentication fields. After the desired servers appear in the Order Used for Authentication field, use the **Up** and **Down** buttons to move the priority server to the top of the list.

By default, the local database is always queried first. If the username is not found, the controller switches to the RADIUS server if configured for RADIUS or to the TACACS+ server if configured for TACACS+. The default setting is local and then RADIUS.

Step 26 Click **Apply** to commit your changes.

Step 27 Click **Save Configuration** to save your changes.

Using the CLI to Configure RADIUS

Using the controller CLI, follow these steps to configure RADIUS.

Note Refer to the "Using the GUI to Configure RADIUS" section on page 5-6 for the valid ranges and default values of the parameters used in the CLI commands.

Step 1 To specify whether the IP address, system MAC address, or AP MAC address of the originator will be sent to the RADIUS server in the Access-Request message, enter this command:

config radius callStationIdType {*ip_address*, *mac_address*, *ap_mac_address*, *ap_macaddr_ssid*}

Step 2 To specify the delimiter to be used in the MAC addresses that are sent to the RADIUS authentication or accounting server in Access-Request messages, enter this command:

config radius {**auth** | **acct**} **mac-delimiter {colon** | **hyphen** | **single-hyphen** | **none**}

where

- **colon** sets the delimiter to a colon (the format is xx:xx:xx:xx:xx:xx).
- **hyphen** sets the delimiter to a hyphen (the format is xx-xx-xx-xx-xx-xx). This is the default value.
- **single-hyphen** sets the delimiter to a single hyphen (the format is xxxxxx-xxxxxx).
- **none** disables delimiters (the format is xxxxxxxxxxxx).

Step 3 Use these commands to configure a RADIUS authentication server:

- **config radius auth add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a RADIUS authentication server.
- **config radius auth keywrap {enable** | **disable**}—Enables AES key wrap, which makes the shared secret between the controller and the RADIUS server more secure. AES key wrap is designed for Federal Information Processing Standards (FIPS) customers and requires a key-wrap compliant RADIUS authentication server.
- **config radius auth keywrap add {ascii** | **hex**} *kek mack index*—Configures the AES key wrap attributes where
  - *kek* specifies the 16-byte Key Encryption Key (KEK).
  - *mack* specifies the 20-byte Message Authentication Code Key (MACK).
  - *index* specifies the index of the RADIUS authentication server on which to configure the AES key wrap.
- **config radius auth rfc3576 {enable** | **disable**} *index*—Enables or disables RFC 3576, which is an extension to the RADIUS protocol that allows dynamic changes to a user session. RFC 3576 includes support for disconnecting users and changing authorizations applicable to a user session and supports disconnect and change-of-authorization (CoA) messages). Disconnect messages cause a user session to be terminated immediately whereas CoA messages modify session authorization attributes such as data filters.
- **config radius auth retransmit-timeout** *index timeout*—Configures the retransmission timeout value for a RADIUS authentication server.
- **config radius auth network** *index* **{enable** | **disable**}—Enables or disables network user authentication. If you enable this feature, this entry is considered the RADIUS authentication server for network users. If you did not configure a RADIUS server entry on the WLAN, you must enable this option for network users.
- **config radius auth management** *index* **{enable** | **disable**}—Enables or disables management authentication. If you enable this feature, this entry is considered the RADIUS authentication server for management users, and authentication requests go to the RADIUS server.
- **config radius auth ipsec** {**enable** | **disable**} *index*—Enables or disables the IP security mechanism.
- **config radius auth ipsec authentication** {**hmac-md5** | **hmac-sha1**} *index*—Configures the authentication protocol to be used for IP security.
- **config radius auth ipsec encryption** {**3des** | **aes** | **des** | **none**} *index*—Configures the IP security encryption mechanism.
- **config radius auth ipsec ike dh-group** {**group-1** | **group-2** | **group-5**} *index*—Configures the IKE Diffie Hellman group.

- **config radius auth ipsec ike lifetime** *interval index*—Configures the timeout interval for the session.
- **config radius auth ipsec ike phase1**{**aggressive** | **main**} *index*—Configures the Internet Key Exchange (IKE) protocol.
- **config radius auth** {**enable** | **disable**} *index*—Enables or disables a RADIUS authentication server.
- **config radius auth delete** *index*—Deletes a previously added RADIUS authentication server.

Step 4 Use these commands to configure a RADIUS accounting server:

- **config radius acct add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a RADIUS accounting server.
- **config radius acct server-timeout** *index timeout*—Configures the retransmission timeout value for a RADIUS accounting server.
- **config radius acct network** *index* **{enable** | **disable**}—Enables or disables network user accounting. If you enable this feature, this entry is considered the RADIUS accounting server for network users. If you did not configure a RADIUS server entry on the WLAN, you must enable this option for network users.
- **config radius acct ipsec** {**enable** | **disable**} *index*—Enables or disables the IP security mechanism.
- **config radius acct ipsec authentication** {**hmac-md5** | **hmac-sha1**} *index*—Configures the authentication protocol to be used for IP security.
- **config radius acct ipsec encryption** {**3des** | **aes** | **des** | **none**} *index*—Configures the IP security encryption mechanism.
- **config radius acct ipsec ike dh-group** {**group-1** | **group-2** | **group-5**} *index*—Configures the IKE Diffie Hellman group.
- **config radius acct ipsec ike lifetime** *interval index*—Configures the timeout interval for the session.
- **config radius acct ipsec ike phase1**{**aggressive** | **main**} *index*—Configures the Internet Key Exchange (IKE) protocol.
- **config radius acct** {**enable** | **disable**} *index*—Enables or disables a RADIUS accounting server.
- **config radius acct delete** *index*—Deletes a previously added RADIUS accounting server.

Step 5 To configure the RADIUS server fallback behavior, enter this command:

config radius fallback-test mode {**off** | **passive** | **active**}

where

- **Off** disables RADIUS server fallback.
- **Passive** causes the controller to revert to a server with a lower priority from the available backup servers without using extraneous probe messages. The controller simply ignores all inactive servers for a time period and retries later when a RADIUS message needs to be sent.
- **Active** causes the controller to revert to a server with a lower priority from the available backup servers by using RADIUS probe messages to proactively determine whether a server that has been marked inactive is back online. The controller simply ignores all inactive servers for all active RADIUS requests. Once the primary server receives a response from the recovered ACS server, the active fallback RADIUS server no longer sends probe messages to the server requesting the active probe authentication.

Step 6 If you enabled Active mode in Step 5, enter these commands to configure additional fallback parameters:

- **config radius fallback-test username** *username*—Specifies the name to be sent in the inactive server probes. You can enter up to 16 alphanumeric characters for the *username* parameter.
- **config radius fallback-test interval** *interval*—Specifies the probe interval value (in seconds).

Step 7 To save your changes, enter this command:

save config

Step 8 To configure the order of authentication when multiple databases are configured, enter this command:

config aaa auth mgmt *AAA_server_type AAA_server_type*

where *AAA_server_type is* **local**, **radius**, or **tacacs**.

To see the current management authentication server order, enter this command:

show aaa auth

Information similar to the following appears:

```
Management authentication server order:
   1......................................... local
   2...................................... radius
```

Step 9 Use these commands to see RADIUS statistics:

- **show radius summary**—Shows a summary of RADIUS servers and statistics.
- **show radius auth statistics**—Shows the RADIUS authentication server statistics.
- **show radius acct statistics**—Shows the RADIUS accounting server statistics.
- **show radius rfc3576 statistics**—Shows a summary of the RADIUS RFC-3576 server.

Information similar to the following appears for the **show radius auth statistics** command:

```
Authentication Servers:

Server Index..................................... 1
Server Address................................... 10.91.104.76
Msg Round Trip Time.............................. 0 (msec)
First Requests................................... 1
Retry Requests................................... 0
Accept Responses................................. 0
Reject Responses................................. 0
Challenge Responses.............................. 0
Malformed Msgs................................... 0
Bad Authenticator Msgs........................... 0
Pending Requests................................. 0
Timeout Requests................................. 0
Unknowntype Msgs................................. 0
Other Drops.................................. 0
```

Information similar to the following appears for the **show radius acct statistics** command:

```
Accounting Servers:

Server Index..................................... 1
Server Address................................... 10.10.10.1
Msg Round Trip Time.............................. 0 (msec)
First Requests................................... 1
Retry Requests................................... 0
Accounting Responses............................. 0
Malformed Msgs................................... 0
Bad Authenticator Msgs........................... 0
Pending Requests................................. 0
```

```
Timeout Requests................................ 0
Unknowntype Msgs................................ 0
Other Drops..................................... 0
```

Information similar to the following appears for the **show radius rfc3576 statistics** command:

```
RFC-3576 Servers:

Server Index.................................... 1
Server Address.................................. 10.91.104.76
Disconnect-Requests............................. 0
COA-Requests.................................... 0
Retransmitted Requests.......................... 0
Malformed Requests.............................. 0
Bad Authenticator Requests...................... 0
Other Drops..................................... 0
Sent Disconnect-Ack............................. 0
Sent Disconnect-Nak............................. 0
Sent CoA-Ack.................................... 0
Sent CoA-Nak................................ 0
```

Step 10 Use these commands to see active security associations:

- **show ike** {**brief** | **detailed**} *ip_or_mac_addr*—Shows a brief or detailed summary of active Internet Key Exchange (IKE) security associations.
- **show ipsec** {**brief** | **detailed**} *ip_or_mac_addr*—Shows a brief or detailed summary of active Internet Protocol Security (IPSec) security associations.

Step 11 To clear the statistics for one or more RADIUS servers, enter this command:

clear stats radius {**auth** | **acct**} {*index* | **all**}

Step 12 To make sure the controller can reach the RADIUS server, enter this command:

ping *server_ip_address*

RADIUS Authentication Attributes Sent by the Access Point

The tables in this section identify the RADIUS authentication attributes sent by a lightweight access point to a client in access-request and access-accept packets.

Table 5-1 Authentication Attributes Sent in Access-Request Packets

Attribute ID	Description
1	User-Name
2	Password
3	CHAP-Password
4	NAS-IP-Address
5	NAS-Port
6	Service-Type[1]
12	Framed-MTU
30	Called-Station-ID (MAC address)
31	Calling-Station-ID (MAC address)
32	NAS-Identifier
33	Proxy-State
60	CHAP-Challenge
61	NAS-Port-Type
79	EAP-Message
243	TPLUS-Role

1. To specify read-only or read-write access to controllers through RADIUS authentication, you must set the Service-Type attribute (6) on the RADIUS server to **Callback NAS Prompt** for read-only access or to **Administrative** for read-write privileges. See Step 19 in the "Configuring RADIUS on the ACS" section for more information.

Table 5-2 Authentication Attributes Honored in Access-Accept Packets (Cisco)

Attribute ID	Description
1	Cisco-LEAP-Session-Key
2	Cisco-Keywrap-Msg-Auth-Code
3	Cisco-Keywrap-NonCE
4	Cisco-Keywrap-Key
5	Cisco-URL-Redirect
6	Cisco-URL-Redirect-ACL

Note These Cisco-specific attributes are not supported: Auth-Algo-Type and SSID.

Table 5-3 Authentication Attributes Honored in Access-Accept Packets (Standard)

Attribute ID	Description
6	Service-Type[1]
8	Framed-IP-Address
25	Class
26	Vendor-Specific
27	Timeout
29	Termination-Action
40	Acct-Status-Type
64	Tunnel-Type
79	EAP-Message
81	Tunnel-Group-ID

1. To specify read-only or read-write access to controllers through RADIUS authentication, you must set the Service-Type attribute (6) on the RADIUS server to **Callback NAS Prompt** for read-only access or to **Administrative** for read-write privileges. See Step 19 in the "Configuring RADIUS on the ACS" section for more information.

Note Message authenticator is not supported.

Table 5-4 Authentication Attributes Honored in Access-Accept Packets (Microsoft)

Attribute ID	Description
11	MS-CHAP-Challenge
16	MS-MPPE-Send-Key
17	MS-MPPE-Receive-Key
25	MS-MSCHAP2-Response
26	MS-MSCHAP2-Success

Table 5-5 Authentication Attributes Honored in Access-Accept Packets (Airespace)

Attribute ID	Description
1	VAP-ID
2	QoS-Level
3	DSCP
4	8021P-Type
5	VLAN-Interface-Name
6	ACL-Name
7	Data-Bandwidth-Average-Contract
8	Real-Time-Bandwidth-Average-Contract
9	Data-Bandwidth-Burst-Contract
10	Real-Time-Bandwidth-Burst-Contract
11	Guest-Role-Name

RADIUS Accounting Attributes

Table 5-6 identifies the RADIUS accounting attributes for accounting requests sent from a controller to the RADIUS server. Table 5-7 lists the different values for the Accounting-Status-Type attribute (40).

Table 5-6 Accounting Attributes for Accounting Requests

Attribute ID	Description
1	User-Name
4	NAS-IP-Address
5	NAS-Port
8	Framed-IP-Address
25	Class
30	Called-Station-ID (MAC address)
31	Calling-Station-ID (MAC address)
32	NAS-Identifier
40	Accounting-Status-Type
41	Accounting-Delay-Time (Stop and interim messages only)
42	Accounting-Input-Octets (Stop and interim messages only)
43	Accounting-Output-Octets (Stop and interim messages only)
44	Accounting-Session-ID
45	Accounting-Authentic
46	Accounting-Session-Time (Stop and interim messages only)
47	Accounting-Input-Packets (Stop and interim messages only)
48	Accounting-Output-Packets (Stop and interim messages only)
49	Accounting-Terminate-Cause (Stop messages only)

Table 5-6 Accounting Attributes for Accounting Requests (continued)

Attribute ID	Description
64	Tunnel-Type
65	Tunnel-Medium-Type
81	Tunnel-Group-ID

Table 5-7 Accounting-Status-Type Attribute Values

Attribute ID	Description
1	Start
2	Stop
3	Interim-Update
7	Accounting-On
8	Accounting-Off
9-14	Reserved for Tunneling Accounting
15	Reserved for Failed

Configuring TACACS+

Terminal Access Controller Access Control System Plus (TACACS+) is a client/server protocol that provides centralized security for users attempting to gain management access to a controller. It serves as a backend database similar to local and RADIUS. However, local and RADIUS provide only authentication support and limited authorization support while TACACS+ provides three services:

- **Authentication**—The process of verifying users when they attempt to log into the controller.

  Users must enter a valid username and password in order for the controller to authenticate users to the TACACS+ server. The authentication and authorization services are tied to one another. For example, if authentication is performed using the local or RADIUS database, then authorization would use the permissions associated with the user in the local or RADIUS database (which are read-only, read-write, and lobby-admin) and not use TACACS+. Similarly, when authentication is performed using TACACS+, authorization is tied to TACACS+.

  Note When multiple databases are configured, you can use the controller GUI or CLI to specify the sequence in which the backend databases should be tried.

- **Authorization**—The process of determining the actions that users are allowed to take on the controller based on their level of access.

  For TACACS+, authorization is based on privilege (or role) rather than specific actions. The available roles correspond to the seven menu options on the controller GUI: MONITOR, WLAN, CONTROLLER, WIRELESS, SECURITY, MANAGEMENT, and COMMANDS. An additional role, LOBBY, is available for users who require only lobby ambassador privileges. The roles to which users are assigned are configured on the TACACS+ server. Users can be authorized for one or more roles. The minimum authorization is MONITOR only, and the maximum is ALL, which authorizes the user to execute the functionality associated with all seven menu options. For example, a user who is assigned the role of SECURITY can make changes to any items appearing on the

Security menu (or designated as security commands in the case of the CLI). If users are not authorized for a particular role (such as WLAN), they can still access that menu option in read-only mode (or the associated CLI **show** commands). If the TACACS+ authorization server becomes unreachable or unable to authorize, users are unable to log into the controller.

Note If users attempt to make changes on a controller GUI page that are not permitted for their assigned role, a message appears indicating that they do not have sufficient privilege. If users enter a controller CLI command that is not permitted for their assigned role, a message may appear indicating that the command was successfully executed although it was not. In this case, the following additional message appears to inform users that they lack sufficient privileges to successfully execute the command: "Insufficient Privilege! Cannot execute command!"

- **Accounting**—The process of recording user actions and changes.

  Whenever a user successfully executes an action, the TACACS+ accounting server logs the changed attributes, the user ID of the person who made the change, the remote host where the user is logged in, the date and time when the command was executed, the authorization level of the user, and a description of the action performed and the values provided. If the TACACS+ accounting server becomes unreachable, users are able to continue their sessions uninterrupted.

TACACS+ uses Transmission Control Protocol (TCP) for its transport, unlike RADIUS which uses User Datagram Protocol (UDP). It maintains a database and listens on TCP port 49 for incoming requests. The controller, which requires access control, acts as the client and requests AAA services from the server. The traffic between the controller and the server is encrypted by an algorithm defined in the protocol and a shared secret key configured on both devices.

You can configure up to three TACACS+ authentication, authorization, and accounting servers each. For example, you may want to have one central TACACS+ authentication server but several TACACS+ authorization servers in different regions. If you configure multiple servers of the same type and the first one fails or becomes unreachable, the controller automatically tries the second one and then the third one if necessary.

Note If multiple TACACS+ servers are configured for redundancy, the user database must be identical in all the servers for the backup to work properly.

You must configure TACACS+ on both your CiscoSecure Access Control Server (ACS) and your controller. You can configure the controller through either the GUI or the CLI.

Configuring TACACS+ on the ACS

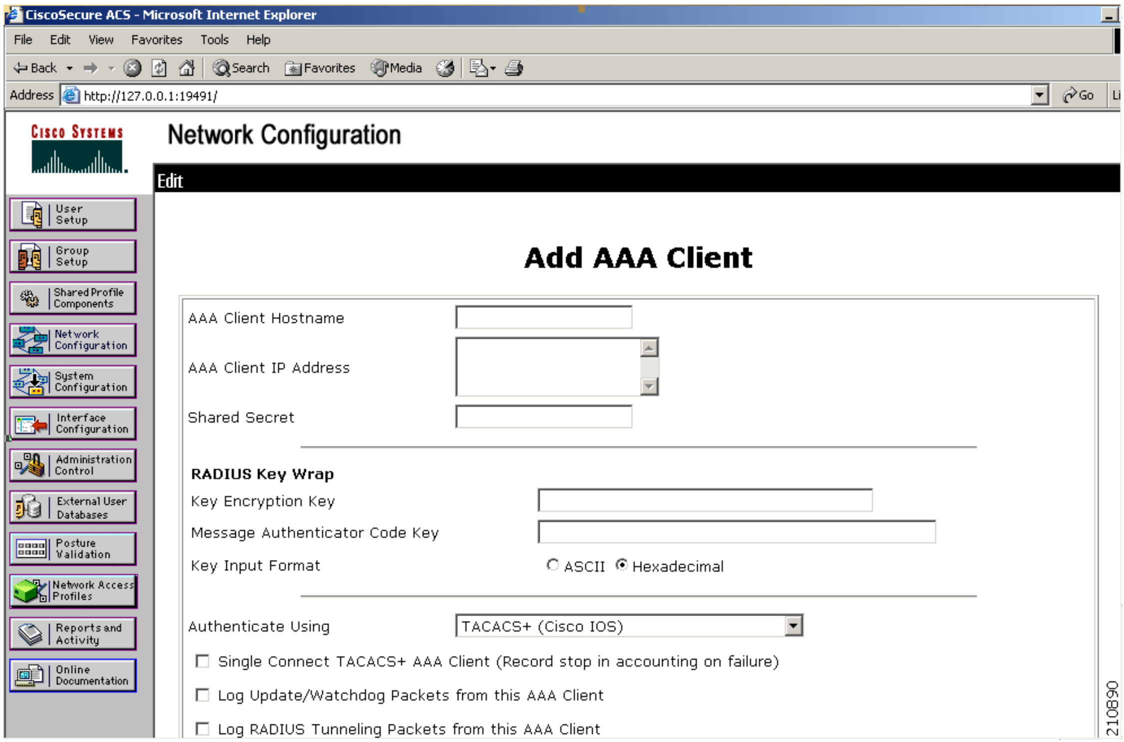
Follow these steps to configure TACACS+ on the ACS.

Note TACACS+ is supported on CiscoSecure ACS version 3.2 and greater. The instructions and illustrations in this section pertain to ACS version 4.1 and may vary for other versions. Refer to the CiscoSecure ACS documentation for the version you are running.

Step 1 Choose **Network Configuration** on the ACS main page.

Step 2 Choose **Add Entry** under AAA Clients to add your controller to the server. The Add AAA Client page appears (see Figure 5-6).

Figure 5-6 Add AAA Client Page on CiscoSecure ACS



Step 3 In the AAA Client Hostname field, enter the name of your controller.

Step 4 In the AAA Client IP Address field, enter the IP address of your controller.

Step 5 In the Shared Secret field, enter the shared secret key to be used for authentication between the server and the controller.

Note The shared secret key must be the same on both the server and the controller.

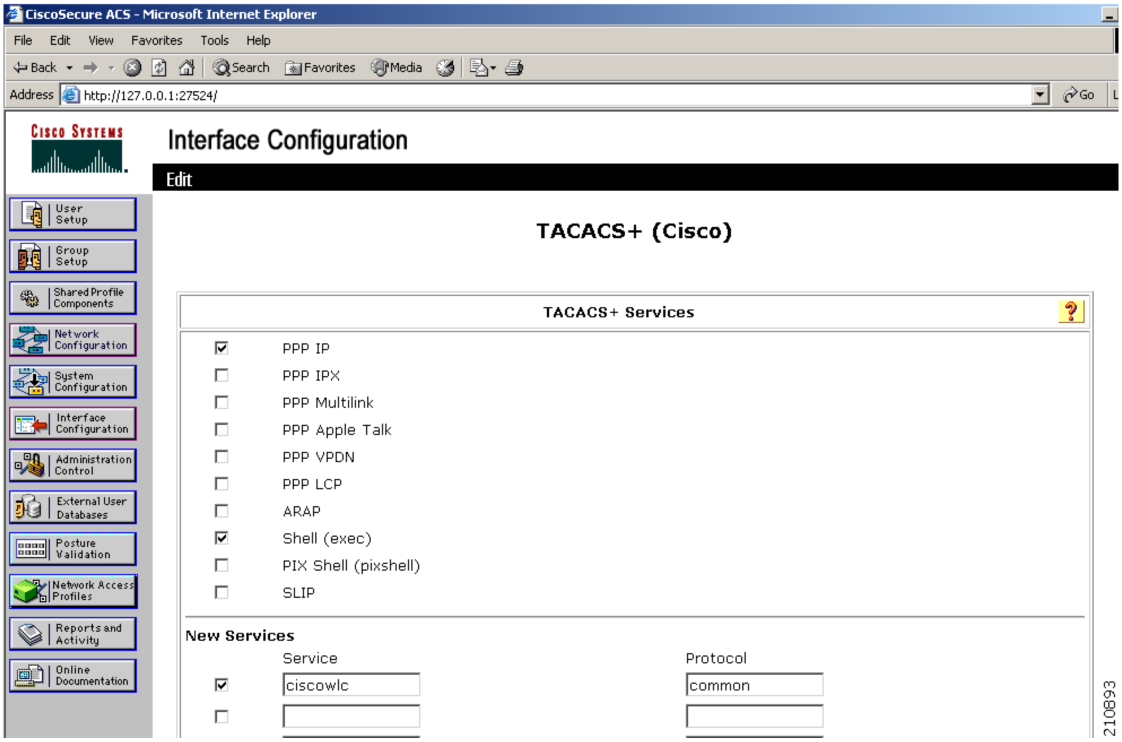
Step 6 Choose **TACACS+ (Cisco IOS)** from the Authenticate Using drop-down box.

Step 7 Click **Submit + Apply** to save your changes.

Step 8 Choose **Interface Configuration** on the ACS main page.

Step 9 Choose **TACACS+ (Cisco IOS)**. The TACACS+ (Cisco) page appears (see Figure 5-7).

Figure 5-7 TACACS+ (Cisco) Page on CiscoSecure ACS



Step 10 Under TACACS+ Services, check the **Shell (exec)** check box.

Step 11 Under New Services, check the first check box and enter **ciscowlc** in the Service field and **common** in the Protocol field.

Step 12 Under Advanced Configuration Options, check the **Advanced TACACS+ Features** check box.

Step 13 Click **Submit** to save your changes.

Step 14 Choose **System Configuration** on the ACS main page.

Step 15 Choose **Logging**.

Step 16 When the Logging Configuration page appears, enable all of the events that you want to be logged and save your changes.

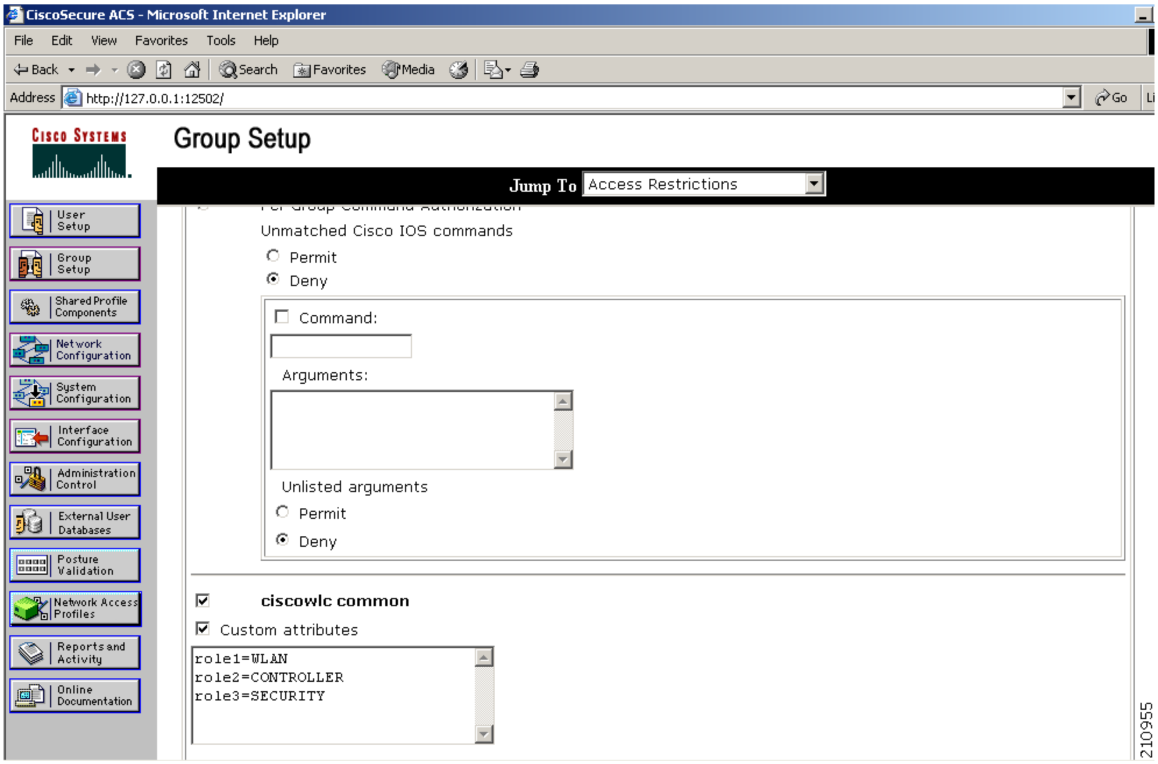
Step 17 Choose **Group Setup** on the ACS main page.

Step 18 Choose a previously created group from the Group drop-down box.

Note This step assumes that you have already assigned users to groups on the ACS according to the roles to which they will be assigned.

Step 19 Click **Edit Settings**. The Group Setup page appears (see Figure 5-8).

Figure 5-8 Group Setup Page on CiscoSecure ACS



Step 20 Under **TACACS+ Settings**, check the **ciscowlc common** check box.

Step 21 Check the **Custom Attributes** check box.

Step 22 In the text box below Custom Attributes, specify the roles that you want to assign to this group. The available roles are MONITOR, WLAN, CONTROLLER, WIRELESS, SECURITY, MANAGEMENT, COMMANDS, ALL, and LOBBY. As mentioned previously, the first seven correspond to the menu options on the controller GUI and allow access to those particular controller features. You can enter one or multiple roles, depending on the group's needs. Use ALL to specify all seven roles or LOBBY to specify the lobby ambassador role. Enter the roles using this format:

role*x*=*ROLE*

For example, to specify the WLAN, CONTROLLER, and SECURITY roles for a particular user group, you would enter the following text:

```
role1=WLAN
role2=CONTROLLER
role3=SECURITY
```

To give a user group access to all seven roles, you would enter the following text:

```
role1=ALL
```

Note Make sure to enter the roles using the format shown above. The roles must be in all uppercase letters, and there can be no spaces within the text.

> **Note** You should not combine the MONITOR role or the LOBBY role with any other roles. If you specify one of these two roles in the Custom Attributes text box, users will have MONITOR or LOBBY privileges only, even if additional roles are specified.

Step 23 Click **Submit** to save your changes.

Using the GUI to Configure TACACS+

Follow these steps to configure TACACS+ through the controller GUI.

Step 1 Choose **Security** > **AAA** > **TACACS+**.

Step 2 Perform one of the following:

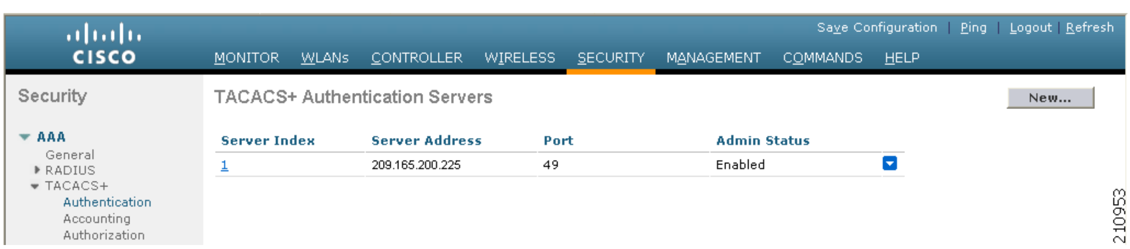
- If you want to configure a TACACS+ server for authentication, choose **Authentication**.
- If you want to configure a TACACS+ server for authorization, choose **Authorization**.
- If you want to configure a TACACS+ server for accounting, choose **Accounting**.

> **Note** The GUI pages used to configure authentication, authorization, and accounting all contain the same fields. Therefore, these instructions walk through the configuration only once, using the Authentication pages as examples. You would follow the same steps to configure multiple services and/or multiple servers.

> **Note** For basic management authentication via TACACS+ to succeed, it is required to configure authentication and authorization servers on the WLC. Accounting configuration is optional.

The TACACS+ (Authentication, Authorization, or Accounting) Servers page appears (see Figure 5-9).

Figure 5-9 TACACS+ Authentication Servers Page



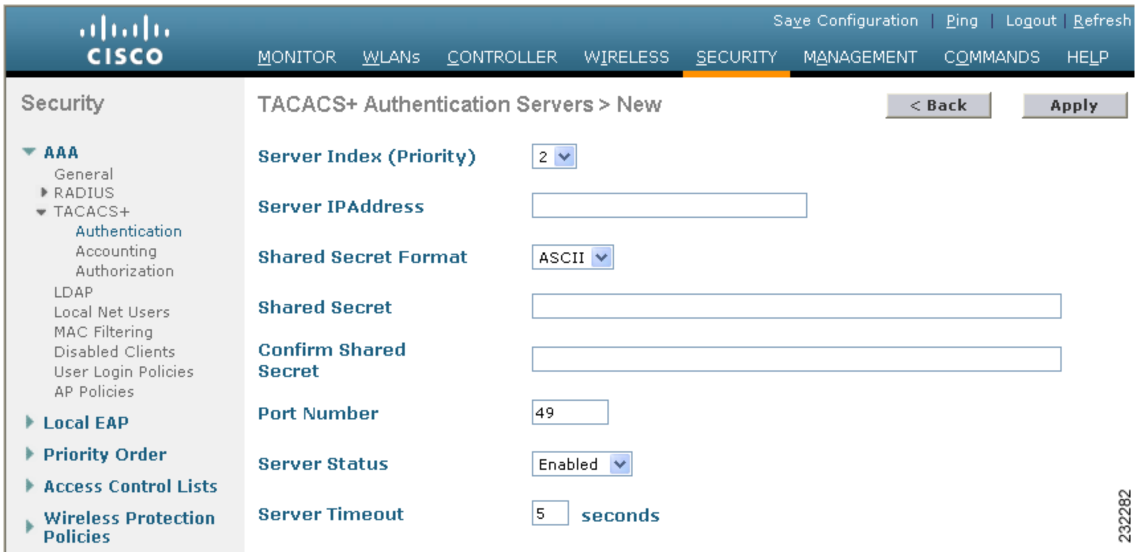
This page lists any TACACS+ servers that have already been configured.

- If you want to delete an existing server, hover your cursor over the blue drop-down arrow for that server and choose **Remove**.
- If you want to make sure that the controller can reach a particular server, hover your cursor over the blue drop-down arrow for that server and choose **Ping**.

Step 3 Perform one of the following:

- To edit an existing TACACS+ server, click the server index number for that server. The TACACS+ (Authentication, Authorization, or Accounting) Servers > Edit page appears.
- To add a TACACS+ server, click **New**. The TACACS+ (Authentication, Authorization, or Accounting) Servers > New page appears (see Figure 5-10).

Figure 5-10 TACACS+ Authentication Servers > New Page



Step 4 If you are adding a new server, choose a number from the Server Index (Priority) drop-down box to specify the priority order of this server in relation to any other configured TACACS+ servers providing the same service. You can configure up to three servers. If the controller cannot reach the first server, it tries the second one in the list and then the third if necessary.

Step 5 If you are adding a new server, enter the IP address of the TACACS+ server in the Server IP Address field.

Step 6 From the Shared Secret Format drop-down box, choose **ASCII** or **Hex** to specify the format of the shared secret key to be used between the controller and the TACACS+ server. The default value is ASCII.

Step 7 In the Shared Secret and Confirm Shared Secret fields, enter the shared secret key to be used for authentication between the controller and the server.

Note The shared secret key must be the same on both the server and the controller.

Step 8 If you are adding a new server, enter the TACACS+ server's TCP port number for the interface protocols in the Port Number field. The valid range is 1 to 65535, and the default value is 49.

Step 9 From the Server Status field, choose **Enabled** to enable this TACACS+ server or choose **Disabled** to disable it. The default value is Enabled.

Step 10 In the Server Timeout field, enter the number of seconds between retransmissions. The valid range is 5 to 30 seconds, and the default value is 5 seconds.

> **Note** Cisco recommends that you increase the timeout value if you experience repeated reauthentication attempts or the controller falls back to the backup server when the primary server is active and reachable.

Step 11 Click **Apply** to commit your changes.

Step 12 Click **Save Configuration** to save your changes.

Step 13 Repeat the previous steps if you want to configure any additional services on the same server or any additional TACACS+ servers.

Step 14 To specify the order of authentication when multiple databases are configured, choose **Security** > **Priority Order** > **Management User**. The Priority Order > Management User page appears (see Figure 5-11).

Figure 5-11 Priority Order > Management User Page

Step 15 In the Order Used for Authentication field, specify which servers have priority when the controller attempts to authenticate management users. Use the **>** and **<** buttons to move servers between the Not Used and Order Used for Authentication fields. After the desired servers appear in the Order Used for Authentication field, use the **Up** and **Down** buttons to move the priority server to the top of the list.

By default, the local database is always queried first. If the username is not found, the controller switches to the RADIUS server if configured for RADIUS or to the TACACS+ server if configured for TACACS+. The default setting is local and then RADIUS.

Step 16 Click **Apply** to commit your changes.

Step 17 Click **Save Configuration** to save your changes.

Using the CLI to Configure TACACS+

Use the commands in this section to configure TACACS+ through the controller CLI.

Note Refer to the "Using the GUI to Configure TACACS+" section on page 5-24 for the valid ranges and default values of the parameters used in the CLI commands.

1. Use these commands to configure a TACACS+ authentication server:
   - **config tacacs auth add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a TACACS+ authentication server.
   - **config tacacs auth delete** *index*—Deletes a previously added TACACS+ authentication server.
   - **config tacacs auth** (**enable** | **disable**} *index*—Enables or disables a TACACS+ authentication server.
   - **config tacacs auth server-timeout** *index timeout*—Configures the retransmission timeout value for a TACACS+ authentication server.
2. Use these commands to configure a TACACS+ authorization server:
   - **config tacacs athr add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a TACACS+ authorization server.
   - **config tacacs athr delete** *index*—Deletes a previously added TACACS+ authorization server.
   - **config tacacs athr** (**enable** | **disable**} *index*—Enables or disables a TACACS+ authorization server.
   - **config tacacs athr server-timeout** *index timeout*—Configures the retransmission timeout value for a TACACS+ authorization server.
3. Use these commands to configure a TACACS+ accounting server:
   - **config tacacs acct add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a TACACS+ accounting server.
   - **config tacacs acct delete** *index*—Deletes a previously added TACACS+ accounting server.
   - **config tacacs acct** (**enable** | **disable**} *index*—Enables or disables a TACACS+ accounting server.
   - **config tacacs acct server-timeout** *index timeout*—Configures the retransmission timeout value for a TACACS+ accounting server.
4. Use these commands to see TACACS+ statistics:
   - **show tacacs summary**—Shows a summary of TACACS+ servers and statistics.
   - **show tacacs auth stats**—Shows the TACACS+ authentication server statistics.
   - **show tacacs athr stats**—Shows the TACACS+ authorization server statistics.
   - **show tacacs acct stats**—Shows the TACACS+ accounting server statistics.

   For example, information similar to the following appears for the **show tacacs summary** command:

```
Authentication Servers

Idx  Server Address    Port    State     Tout
---  ----------------  ------  --------  ----
1    11.11.12.2        49      Enabled   5
2    11.11.13.2        49      Enabled   5
3    11.11.14.2        49      Enabled   5
```

```
Authorization Servers

Idx  Server Address    Port    State     Tout
---  ----------------  ------  --------  ----
1    11.11.12.2        49      Enabled   5
2    11.11.13.2        49      Enabled   5
3    11.11.14.2        49      Enabled   5

Accounting Servers

Idx  Server Address    Port    State     Tout
---  ----------------  ------  --------  ----
1    11.11.12.2        49      Enabled   5
2    11.11.13.2        49      Enabled   5
3    11.11.14.2        49      Enabled   5
```

Information similar to the following appears for the **show tacacs auth stats** command:

```
Server Index................................... 1
Server Address................................. 10.10.10.10
Msg Round Trip Time............................ 0 (msec)
First Requests................................. 0
Retry Requests................................. 0
Accept Responses............................... 0
Reject Responses............................... 0
Error Responses................................ 0
Restart Responses.............................. 0
Follow Responses............................... 0
GetData Responses.............................. 0
Encrypt no secret Responses.................... 0
Challenge Responses............................ 0
Malformed Msgs................................. 0
Bad Authenticator Msgs......................... 0
Pending Requests............................... 0
Timeout Requests............................... 0
Unknowntype Msgs............................... 0
Other Drops..................................0
```

5. To clear the statistics for one or more TACACS+ servers, enter this command:

   clear stats tacacs [**auth** | **athr** | **acct**] {*index* | **all**}

6. To configure the order of authentication when multiple databases are configured, enter this command. The default setting is local and then radius.

   config aaa auth mgmt [**radius** | **tacacs**]

   To see the current management authentication server order, enter this command:

   show aaa auth

   Information similar to the following appears:

   ```
   Management authentication server order:
      1............................................ local
      2......................................... tacacs
   ```

7. To make sure the controller can reach the TACACS+ server, enter this command:

   ping *server_ip_address*

8. To enable or disable TACACS+ debugging, enter this command:

   debug aaa tacacs {**enable** | **disable**}

9. To save your changes, enter this command:

   save config

Viewing the TACACS+ Administration Server Logs

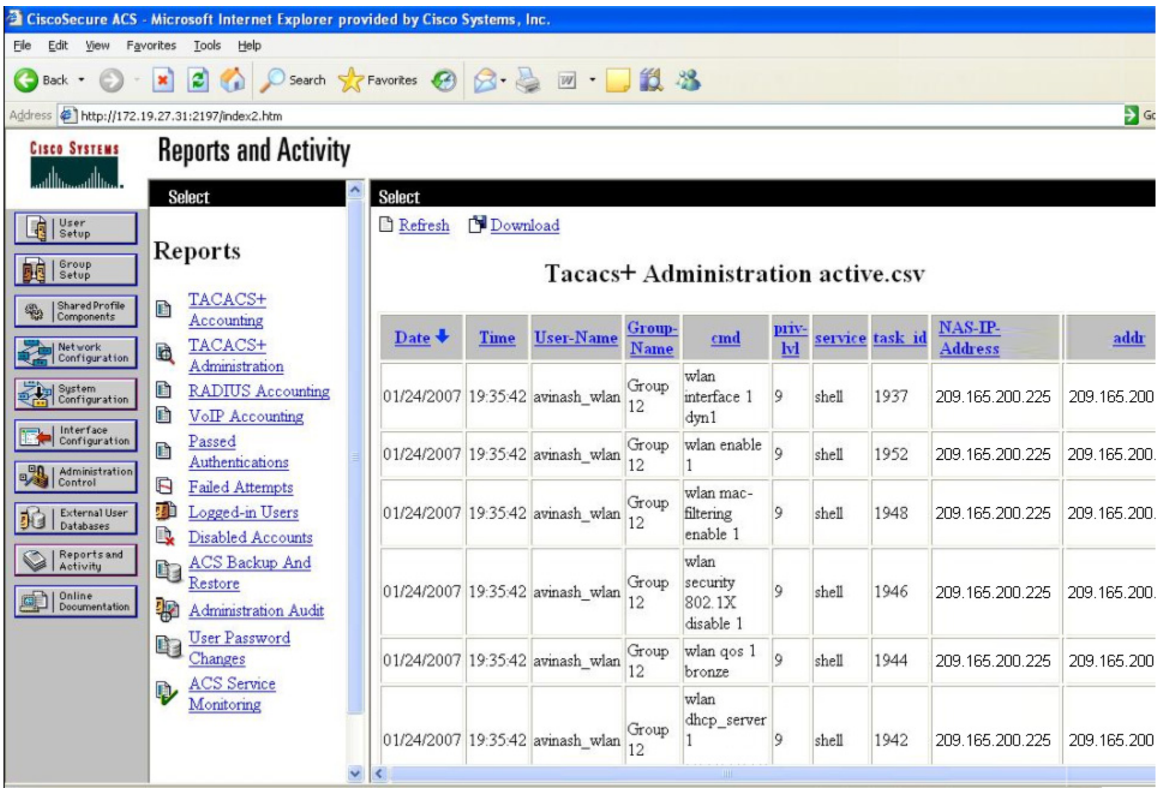
Follow these steps to view the TACACS+ administration server logs, if you have a TACACS+ accounting server configured on the controller.

Step 1 Choose **Reports and Activity** on the ACS main page.

Step 2 Choose **TACACS+ Administration**.

Step 3 Click the .csv file corresponding to the date of the logs you wish to view. The TACACS+ Administration .csv page appears (see Figure 5-12).

Figure 5-12 TACACS+ Administration .csv Page on CiscoSecure ACS



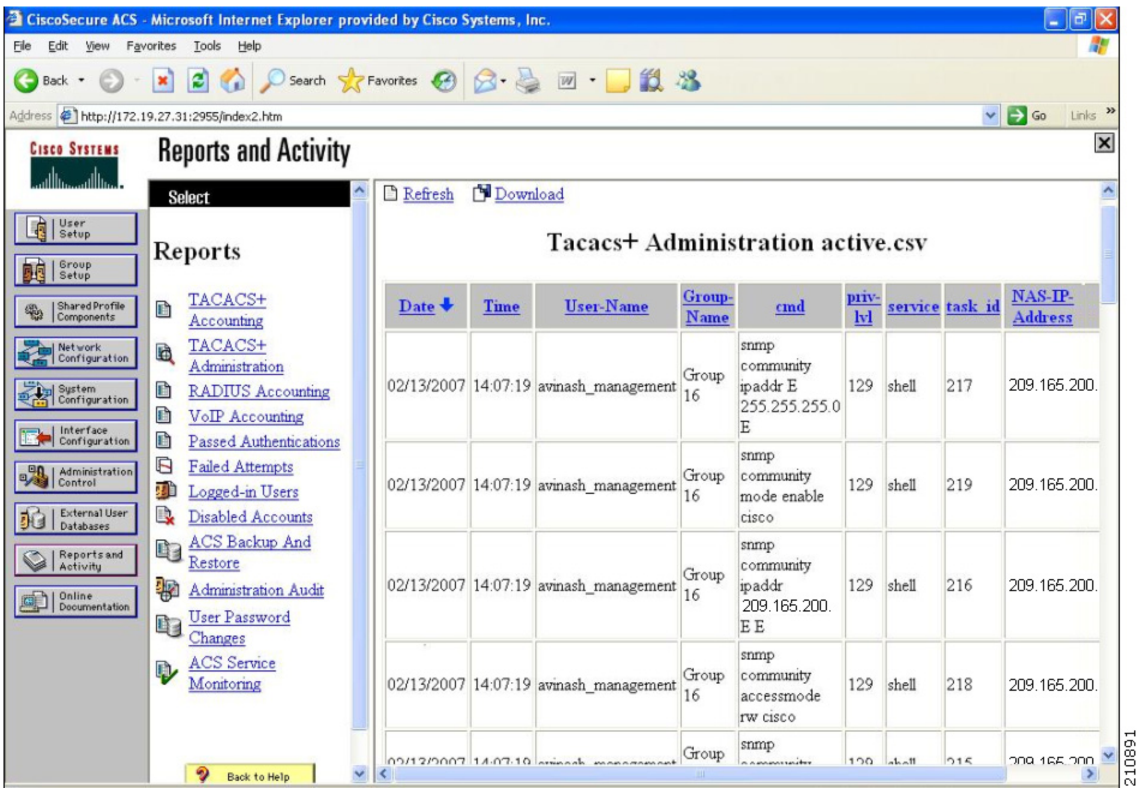
This page provides the following information:

- The date and time the action was taken
- The name and assigned role of the user who took the action
- The group to which the user belongs
- The specific action that the user took

- The privilege level of the user who executed the action
- The IP address of the controller
- The IP address of the laptop or workstation from which the action was executed

Sometimes a single action (or command) is logged multiple times, once for each parameter in the command. For example, if the user enters the **snmp community ipaddr** *ip_address subnet_mask community_name* command, the IP address may be logged on one line while the subnet mask and community name are logged as "E." On another line, the subnet mask maybe logged while the IP address and community name are logged as "E." See the first and third lines in the example in Figure 5-13.

Figure 5-13 TACACS+ Administration .csv Page on CiscoSecure ACS



Note You can click **Refresh** at any time to refresh this page.

Configuring Maximum Local Database Entries

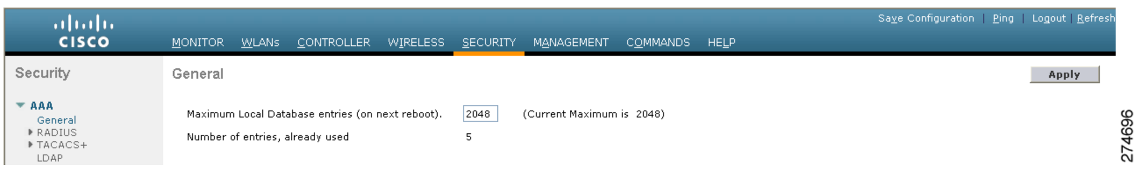
You can use the controller GUI or CLI to specify the maximum number of local database entries used for storing user authentication information. The database entries include local management users (including lobby ambassadors), local network users (including guest users), MAC filter entries, exclusion list entries, and access point authorization list entries. Together they cannot exceed the configured maximum value.

Using the GUI to Configure Maximum Local Database Entries

Using the controller GUI, follow these steps to configure the maximum number of local database entries.

Step 1 Choose **Security** > **AAA** > **General** to open the General page (see Figure 5-14).

Figure 5-14 General Page



Step 2 In the Maximum Local Database Entries field, enter a value for the maximum number of entries that can be added to the local database the next time the controller reboots. The currently configured value appears in parentheses to the right of the field. The valid range is 512 to 2048, and the default setting is 2048.

The Number of Entries, Already Used field shows the number of entries currently in the database.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your settings.

Using the CLI to Configure Maximum Local Database Entries

Using the controller CLI, follow these steps to configure the maximum number of local database entries.

Step 1 To specify the maximum number of entries that can be added to the local database the next time the controller reboots, enter this command:

config database size *max_entries*

Step 2 To save your changes, enter this command:

save config

Step 3 To view the maximum number of database entries and the current database contents, enter this command:

show database summary

Information similar to the following appears:

```
Maximum Database Entries......................... 2048
```

```
Maximum Database Entries On Next Reboot.......... 2048
Database Contents
    MAC Filter Entries.......................... 2
    Exclusion List Entries...................... 0
    AP Authorization List Entries............... 1
    Management Users............................ 1
    Local Network Users......................... 1
        Local Users............................. 1
        Guest Users............................. 0
    Total................................... 5
```

Configuring Local Network Users

This section explains how to add local network users to the local user database on the controller. The local user database stores the credentials (username and password) of all the local network users. These credentials are then used to authenticate the users. For example, local EAP may use the local user database as its backend database to retrieve user credentials. Refer to the "Configuring Local EAP" section on page 5-40 for more information.

Note The controller passes client information to the RADIUS authentication server first. If the client information does not match a RADIUS database entry, the local user database is polled. Clients located in this database are granted access to network services if the RADIUS authentication fails or does not exist.

You can configure local network users through either the GUI or the CLI.

Using the GUI to Configure Local Network Users

Follow these steps to configure local network users using the controller GUI.

Step 1 Choose **Security > AAA > Local Net Users** to open the Local Net Users page (see Figure 5-15).

Figure 5-15 Local Net Users Page

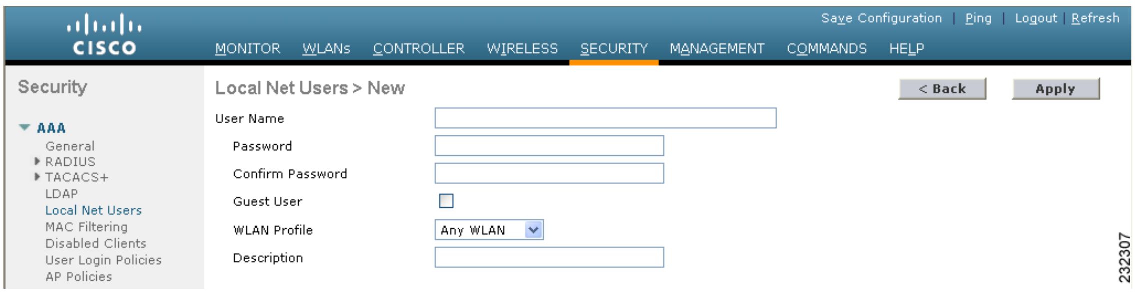
This page lists any local network users that have already been configured. It also specifies any guest users and the QoS role to which they are assigned (if applicable). See the "Configuring Quality of Service Roles" section on page 4-70 for information on configuring QoS roles.

Note If you want to delete an existing user, hover your cursor over the blue drop-down arrow for that user and choose **Remove**.

Step 2 Perform one of the following:

- To edit an existing local network user, click the username for that user. The Local Net Users > Edit page appears.
- To add a local network user, click **New**. The Local Net Users > New page appears (see Figure 5-16).

Figure 5-16 Local Net Users > New Page



Step 3 If you are adding a new user, enter a username for the local user in the User Name field. You can enter up to 24 alphanumeric characters.

Note Local network usernames must be unique because they are all stored in the same database.

Step 4 In the Password and Confirm Password fields, enter a password for the local user. You can enter up to 24 alphanumeric characters.

Step 5 If you are adding a new user, check the **Guest User** check box if you want to limit the amount of time that the user has access to the local network. The default setting is unchecked.

Step 6 If you are adding a new user and you checked the Guest User check box, enter the amount of time (in seconds) that the guest user account is to remain active in the Lifetime field. The valid range is 60 to 2,592,000 seconds (30 days) inclusive, and the default setting is 86,400 seconds.

Step 7 If you are adding a new user, you checked the Guest User check box, and you want to assign a QoS role to this guest user, check the **Guest User Role** check box. The default setting is unchecked.

Note If you do not assign a QoS role to a guest user, the bandwidth contracts for this user are defined in the QoS profile for the WLAN.

Step 8 If you are adding a new user and you checked the Guest User Role check box, choose the QoS role that you want to assign to this guest user from the Role drop-down box.

Note If you want to create a new QoS role, see the "Configuring Quality of Service Roles" section on page 4-70 for instructions.

Step 9 From the WLAN Profile drop-down box, choose the name of the WLAN that is to be accessed by the local user. If you choose **Any WLAN**, which is the default setting, the user can access any of the configured WLANs.

Step 10 In the Description field, enter a descriptive title for the local user (such as "User 1").

Step 11 Click **Apply** to commit your changes.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure Local Network Users

Use the commands in this section to configure local network users using the controller CLI.

Note Refer to the "Using the GUI to Configure Local Network Users" section on page 5-32 for the valid ranges and default values of the parameters used in the CLI commands.

1. Use these commands to configure a local network user:
   - **config netuser add** *username password* **wlan** *wlan_id* **userType permanent description** *description*—Adds a permanent user to the local user database on the controller.
   - **config netuser add** *username password* {**wlan** | **guestlan**} {*wlan_id* | *guest_lan_id*} **userType guest lifetime** *seconds* **description** *description*—Adds a guest user on a WLAN or wired guest LAN to the local user database on the controller.

   Note Instead of adding a permanent user or a guest user to the local user database from the controller, you can choose to create an entry on the RADIUS server for the user and enable RADIUS authentication for the WLAN on which web authentication is performed.

   - **config netuser delete** *username*—Deletes a user from the local user database on the controller.

   Note Local network usernames must be unique because they are all stored in the same database.

2. Use these commands to see information related to the local network users configured on the controller.
   - **show netuser detail** *username*—Shows the configuration of a particular user in the local user database.
   - **show netuser summary**—Lists all the users in the local user database.

   For example, information similar to the following appears for the **show netuser detail** *username* command:

```
User Name............................... abc
WLAN Id................................. Any
Lifetime................................ Permanent
Description.......................... test user
```

3. To save your changes, enter this command:

   save config

Configuring LDAP

This section explains how to configure a Lightweight Directory Access Protocol (LDAP) server as a backend database, similar to a RADIUS or local user database. An LDAP backend database allows the controller to query an LDAP server for the credentials (username and password) of a particular user. These credentials are then used to authenticate the user. For example, local EAP may use an LDAP server as its backend database to retrieve user credentials. Refer to the "Configuring Local EAP" section on page 5-40 for more information.

Note The LDAP backend database supports these local EAP methods: EAP-TLS, EAP-FAST/GTC, and PEAPv1/GTC. LEAP, EAP-FAST/MSCHAPv2, and PEAPv0/MSCHAPv2 are also supported but only if the LDAP server is set up to return a clear-text password. For example, Microsoft Active Directory is not supported because it does not return a clear-text password. If the LDAP server cannot be configured to return a clear-text password, LEAP, EAP-FAST/MSCHAPv2, and PEAPv0/MSCHAPv2 are not supported.

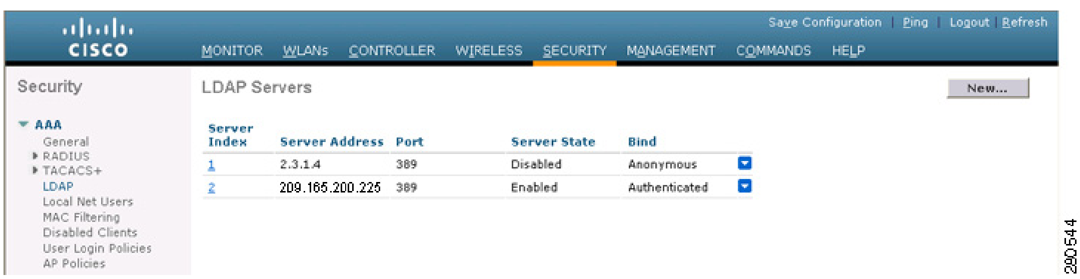
You can configure LDAP through either the GUI or the CLI.

Using the GUI to Configure LDAP

Follow these steps to configure LDAP using the controller GUI.

Step 1 Choose **Security** > **AAA** > **LDAP** to open the LDAP Servers page (see Figure 5-17).

Figure 5-17 LDAP Servers Page



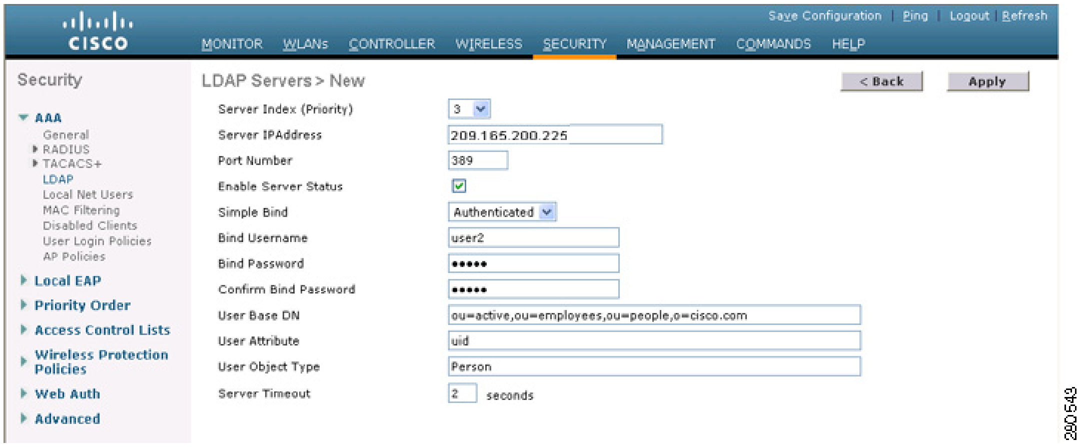
This page lists any LDAP servers that have already been configured.

- If you want to delete an existing LDAP server, hover your cursor over the blue drop-down arrow for that server and choose **Remove**.
- If you want to make sure that the controller can reach a particular server, hover your cursor over the blue drop-down arrow for that server and choose **Ping**.

Step 2 Perform one of the following:

- To edit an existing LDAP server, click the index number for that server. The LDAP Servers > Edit page appears.
- To add an LDAP server, click **New**. The LDAP Servers > New page appears (see Figure 5-18).

Figure 5-18 LDAP Servers > New Page



Step 3 If you are adding a new server, choose a number from the Server Index (Priority) drop-down box to specify the priority order of this server in relation to any other configured LDAP servers. You can configure up to seventeen servers. If the controller cannot reach the first server, it tries the second one in the list and so on.

Step 4 If you are adding a new server, enter the IP address of the LDAP server in the Server IP Address field.

Step 5 If you are adding a new server, enter the LDAP server's TCP port number in the Port Number field. The valid range is 1 to 65535, and the default value is 389.

Step 6 Check the **Enable Server Status** check box to enable this LDAP server or uncheck it to disable it. The default value is disabled.

Step 7 From the Simple Bind drop-down box, choose **Anonymous** or **Authenticated** to specify the local authentication bind method for the LDAP server. The Anonymous method allows anonymous access to the LDAP server whereas the Authenticated method requires that a username and password be entered to secure access. The default value is Anonymous.

Step 8 If you chose Authenticated in Step 7, follow these steps:

a. In the Bind Username field, enter a username to be used for local authentication to the LDAP server. The username can contain up to 80 characters.

> **Note** If the username starts with "cn=" (in lowercase letters), the controller assumes that the username includes the entire LDAP database path and therefore does not append the user base DN. This designation allows the authenticated bind user to be outside the user base DN.

b. In the Bind Password and Confirm Bind Password fields, enter a password to be used for local authentication to the LDAP server. The password can contain up to 32 characters.

Step 9 In the User Base DN field, enter the distinguished name (DN) of the subtree in the LDAP server that contains a list of all the users. For example, ou=organizational unit, .ou=next organizational unit, and o=corporation.com. If the tree containing users is the base DN, type **o=***corporation***.com** or **dc=***corporation***,dc=com**.

Step 10 In the User Attribute field, enter the name of the attribute in the user record that contains the username. You can obtain this attribute from your directory server.

Step 11 In the User Object Type field, enter the value of the LDAP objectType attribute that identifies the record as a user. Often, user records have several values for the objectType attribute, some of which are unique to the user and some of which are shared with other object types.

Step 12 In the Server Timeout field, enter the number of seconds between retransmissions. The valid range is 2 to 30 seconds, and the default value is 2 seconds.

Step 13 Click **Apply** to commit your changes.

Step 14 Click **Save Configuration** to save your changes.

Step 15 Follow these steps to specify LDAP as the priority backend database server for local EAP authentication:

a. Choose **Security** > **Local EAP** > **Authentication Priority** to open the Priority Order > Local-Auth page (see Figure 5-19).

Figure 5-19 Priority Order > Local-Auth Page

b. Highlight **LOCAL** and click **<** to move it to the left User Credentials box.

c. Highlight **LDAP** and click **>** to move it to the right User Credentials box. The database that appears at the top of the right User Credentials box is used when retrieving user credentials.

Note If both LDAP and LOCAL appear in the right User Credentials box with LDAP on the top and LOCAL on the bottom, local EAP attempts to authenticate clients using the LDAP backend database and fails over to the local user database if the LDAP servers are not reachable. If the user is not found, the authentication attempt is rejected. If LOCAL is on the top, local EAP attempts to authenticate using only the local user database. It does not fail over to the LDAP backend database.

d. Click **Apply** to commit your changes.

e. Click **Save Configuration** to save your changes.

Step 16 (Optional) Follow these steps if you wish to assign specific LDAP servers to a WLAN.

a. Choose **WLANs** to open the WLANs page.

b. Click the ID number of the desired WLAN.

c. When the WLANs > Edit page appears, choose the **Security** > **AAA Servers** tabs to open the WLANs > Edit (Security > AAA Servers) page (see Figure 5-20).

Figure 5-20 WLANs > Edit (Security > AAA Servers) Page

d. From the LDAP Servers drop-down boxes, choose the LDAP server(s) that you want to use with this WLAN. You can choose up to three LDAP servers, which are tried in priority order.

> **Note** These LDAP servers apply only to WLANs with web authentication enabled. They are not used by local EAP.

e. Click **Apply** to commit your changes.

f. Click **Save Configuration** to save your changes.

Using the CLI to Configure LDAP

Use the commands in this section to configure LDAP using the controller CLI.

> **Note** Refer to the "Using the GUI to Configure LDAP" section on page 5-35 for the valid ranges and default values of the parameters used in the CLI commands.

1. Use these commands to configure an LDAP server:

- **config ldap add** *index server_ip_address port# user_base user_attr user_type*—Adds an LDAP server.
- **config ldap delete** *index*—Deletes a previously added LDAP server.
- **config ldap** {**enable** | **disable**} *index*—Enables or disables an LDAP server.

- **config ldap simple-bind** {**anonymous** *index* | **authenticated** *index* **username** *username* **password** *password*}—Specifies the local authentication bind method for the LDAP server. The anonymous method allows anonymous access to the LDAP server whereas the authenticated method requires that a username and password be entered to secure access. The default value is anonymous.

  Note The username can contain up to 80 characters.

  Note If the username starts with "cn=" (in lowercase letters), the controller assumes that the username includes the entire LDAP database path and therefore does not append the user base DN. This designation allows the authenticated bind user to be outside the user base DN.

- **config ldap retransmit-timeout** *index timeout*—Configures the number of seconds between retransmissions for an LDAP server.

2. Use this command to specify LDAP as the priority backend database server:

   config local-auth user-credentials ldap

   Note If you enter **config local-auth user-credentials ldap local**, local EAP attempts to authenticate clients using the LDAP backend database and fails over to the local user database if the LDAP servers are not reachable. If the user is not found, the authentication attempt is rejected. If you enter **config local-auth user-credentials local ldap**, local EAP attempts to authenticate using only the local user database. It does not fail over to the LDAP backend database.

3. (Optional) Use these commands if you wish to assign specific LDAP servers to a WLAN:
   - **config wlan ldap add** *wlan_id server_index*—Links a configured LDAP server to a WLAN.

     Note The LDAP servers specified in this command apply only to WLANs with web authentication enabled. They are not used by local EAP.

   - **config wlan ldap delete** *wlan_id* **{all |** *index***}**—Deletes a specific or all configured LDAP server(s) from a WLAN.

4. Use these commands to view information pertaining to configured LDAP servers:
   - **show ldap summary**—Shows a summary of the configured LDAP servers.
   - **show ldap** *index*—Shows detailed LDAP server information.
   - **show ldap statistics**—Shows LDAP server statistics.
   - **show wlan** *wlan_id*—Shows the LDAP servers that are applied to a WLAN.

   For example, information similar to the following appears for the **show ldap** *index* command:

```
Server Index.................................... 2
Address......................................... 10.10.20.22
Port............................................ 389
Enabled......................................... Yes
User DN......................................... ou=active,ou=employees,ou=people,
                                               o=cisco.com
```

```
User Attribute.................................. uid
User Type....................................... Person
Retransmit Timeout.............................. 2 seconds
Bind Method .................................... Authenticated
Bind Username............................... user1
```

Information similar to the following appears for the **show ldap summary** command:

```
Idx  Server Address   Port  Enabled
---  ---------------  ----  -------
1    2.3.1.4          389  No
2    10.10.20.22     389   Yes
```

Information similar to the following appears for the **show ldap statistics** command:

```
Server Index.................................... 1
Server statistics:
  Initialized OK................................ 0
  Initialization failed......................... 0
  Initialization retries........................ 0
  Closed OK..................................... 0
Request statistics:
  Received...................................... 0
  Sent.......................................... 0
  OK............................................ 0
  Success....................................... 0
  Authentication failed......................... 0
  Server not found.............................. 0
  No received attributes........................ 0
  No passed username............................ 0
  Not connected to server....................... 0
  Internal error................................ 0
  Retries....................................... 0

Server Index.................................... 2
...
```

5. To make sure the controller can reach the LDAP server, enter this command:

   ping *server_ip_address*

6. To save your changes, enter this command:

   save config

7. To enable or disable debugging for LDAP, enter this command:

   debug aaa ldap {**enable** | **disable**}

Configuring Local EAP

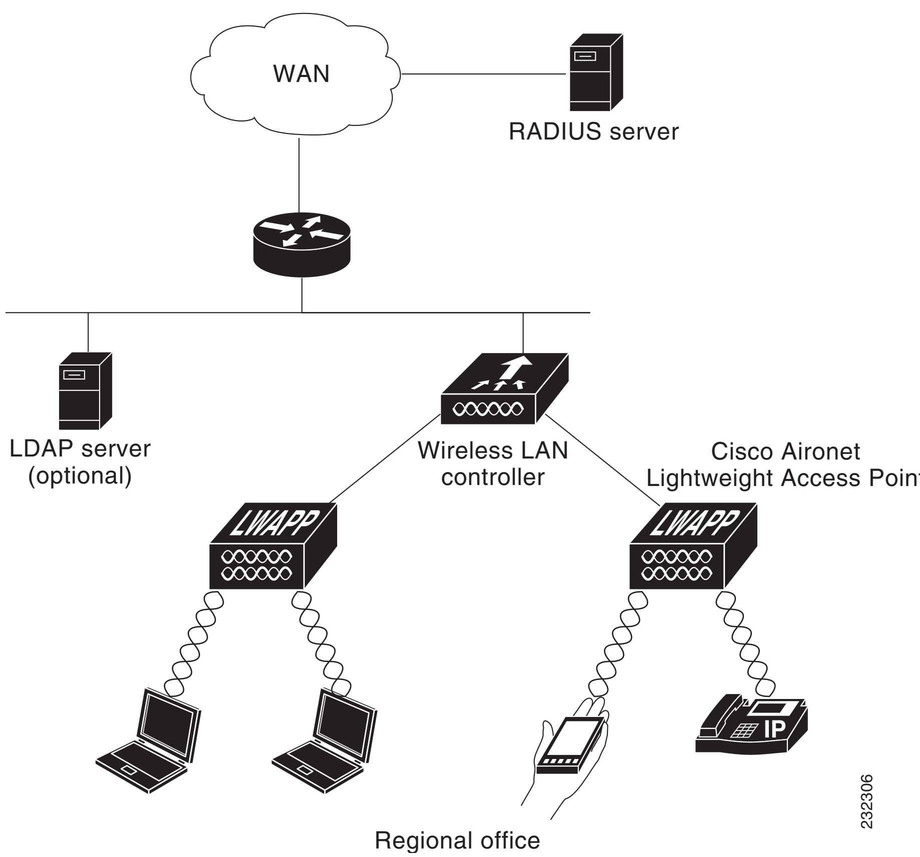
Local EAP is an authentication method that allows users and wireless clients to be authenticated locally. It is designed for use in remote offices that want to maintain connectivity to wireless clients when the backend system becomes disrupted or the external authentication server goes down. When you enable local EAP, the controller serves as the authentication server and the local user database, thereby removing dependence on an external authentication server. Local EAP retrieves user credentials from the local user database or the LDAP backend database to authenticate users. Local EAP supports LEAP, EAP-FAST, EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC authentication between the controller and wireless clients.

Note The LDAP backend database supports these local EAP methods: EAP-TLS, EAP-FAST/GTC, and PEAPv1/GTC. LEAP, EAP-FAST/MSCHAPv2, and PEAPv0/MSCHAPv2 are also supported but only if the LDAP server is set up to return a clear-text password. For example, Microsoft Active Directory is not supported because it does not return a clear-text password. If the LDAP server cannot be configured to return a clear-text password, LEAP, EAP-FAST/MSCHAPv2, and PEAPv0/MSCHAPv2 are not supported.

Note If any RADIUS servers are configured on the controller, the controller tries to authenticate the wireless clients using the RADIUS servers first. Local EAP is attempted only if no RADIUS servers are found, either because the RADIUS servers timed out or no RADIUS servers were configured. If four RADIUS servers are configured, the controller attempts to authenticate the client with the first RADIUS server, then the second RADIUS server, and then local EAP. If the client attempts to then reauthenticate manually, the controller tries the third RADIUS server, then the fourth RADIUS server, and then local EAP. If you never want the controller to try to authenticate clients using an external RADIUS server, enter these CLI commands in this order:
config wlan disable *wlan_id*
config wlan radius_server auth disable *wlan_id*
config wlan enable *wlan_id*

Figure 5-21 provides an example of a remote office using local EAP.

Figure 5-21 Local EAP Example



You can configure local EAP through either the GUI or the CLI.

Using the GUI to Configure Local EAP

Follow these steps to configure local EAP using the controller GUI.

Step 1 EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC use certificates for authentication, and EAP-FAST uses either certificates or PACs. The controller is shipped with Cisco-installed device and Certificate Authority (CA) certificates. However, if you wish to use your own vendor-specific certificates, they must be imported on the controller. If you are configuring local EAP to use one of these EAP types, make sure that the appropriate certificates and PACs (if you will use manual PAC provisioning) have been imported on the controller. Refer to the *Managing Controller Software and Configurations* chapter for instructions on importing certificates and PACs.

Step 2 If you want the controller to retrieve user credentials from the local user database, make sure that you have properly configured the local network users on the controller. See the "Configuring Local Network Users" section on page 5-32 for instructions.

Step 3 If you want the controller to retrieve user credentials from an LDAP backend database, make sure that you have properly configured an LDAP server on the controller. See the "Configuring LDAP" section on page 5-35 for instructions.

Step 4 Follow these steps to specify the order in which user credentials are retrieved from the backend database servers:

a. Choose **Security** > **Local EAP** > **Authentication Priority** to open the Priority Order > Local-Auth page (see Figure 5-22).

Figure 5-22 Priority Order > Local-Auth Page

b. Determine the priority order in which user credentials are to be retrieved from the local and/or LDAP databases. For example, you may want the LDAP database to be given priority over the local user database, or you may not want the LDAP database to be considered at all.

c. When you have decided on a priority order, highlight the desired database. Then use the left and right arrows and the Up and Down buttons to move the desired database to the top of the right User Credentials box.

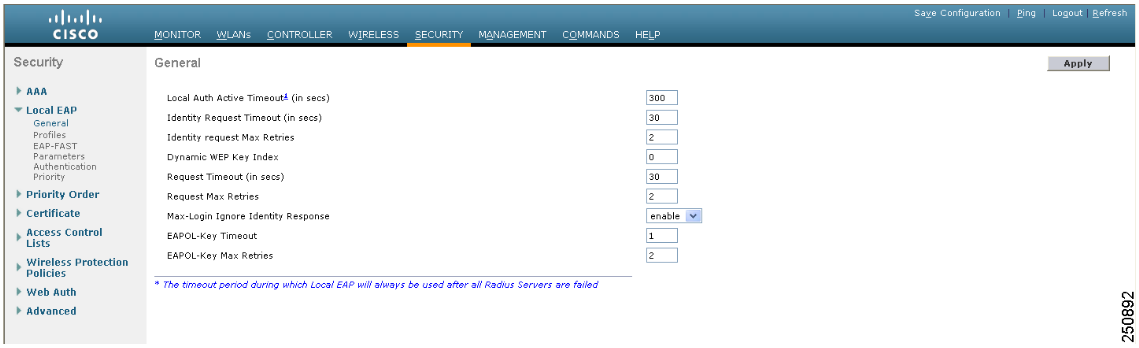
Note If both LDAP and LOCAL appear in the right User Credentials box with LDAP on the top and LOCAL on the bottom, local EAP attempts to authenticate clients using the LDAP backend database and fails over to the local user database if the LDAP servers are not reachable. If the user is not found, the authentication attempt is rejected. If LOCAL is on the top, local EAP attempts to authenticate using only the local user database. It does not fail over to the LDAP backend database.

d. Click **Apply** to commit your changes.

Step 5 Follow these steps to specify values for the local EAP timers:

a. Choose **Security** > **Local EAP** > **General** to open the General page (see Figure 5-23).

Figure 5-23 General Page



b. In the Local Auth Active Timeout field, enter the amount of time (in seconds) in which the controller attempts to authenticate wireless clients using local EAP after any pair of configured RADIUS servers fails. The valid range is 1 to 3600 seconds, and the default setting is 100 seconds.

c. In the Identity Request Timeout field, enter the amount of time (in seconds) in which the controller attempts to send an EAP identity request to wireless clients using local EAP. The valid range is 1 to 120 seconds, and the default setting is 30 seconds.

d. In the Identity Request Max Retries field, enter the maximum number of times that the controller attempts to retransmit the EAP identity request to wireless clients using local EAP. The valid range is 1 to 20 retries, and the default setting is 20 retries.

e. In the Dynamic WEP Key Index field, enter the key index used for dynamic wired equivalent privacy (WEP). The default setting is 0.

f. In the Request Timeout field, enter the amount of time (in seconds) in which the controller attempts to send an EAP request to wireless clients using local EAP. The valid range is 1 to 120 seconds, and the default setting is 30 seconds.

g. In the Request Max Retries field, enter the maximum number of times that the controller attempts to retransmit the EAP request to wireless clients using local EAP. The valid range is 1 to 120 retries, and the default setting is 20 retries.

h. From the Max-Login Ignore Identity Response drop-down box, choose **Enable** to limit the number of devices that can be connected to the controller with the same username. You can log in up to eight times from different devices (PDA, laptop, IP phone, and so on) on the same controller. The default value is enabled.

i. In the EAPOL-Key Timeout field, enter the amount of time (in seconds) in which the controller attempts to send an EAP key over the LAN to wireless clients using local EAP. The valid range is 1 to 5 seconds, and the default setting is 1 second.

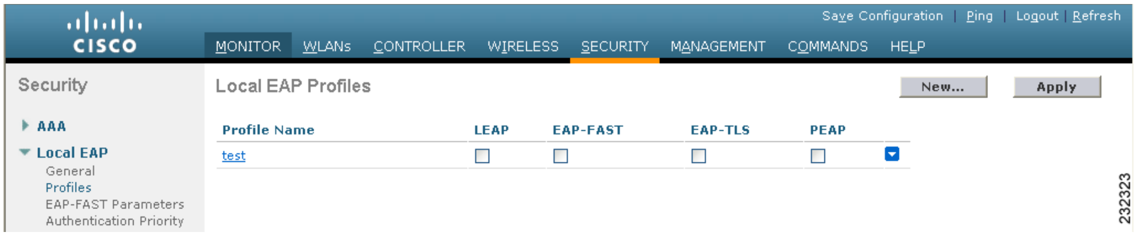
j. In the EAPOL-Key Max Retries field, enter the maximum number of times that the controller attempts to send an EAP key over the LAN to wireless clients using local EAP. The valid range is 0 to 4 retries, and the default setting is 2 retries.

k. Click **Apply** to commit your changes.

Step 6 Follow these steps to create a local EAP profile, which specifies the EAP authentication types that are supported on the wireless clients:

a. Choose **Security** > **Local EAP** > **Profiles** to open the Local EAP Profiles page (see Figure 5-24).

Figure 5-24 Local EAP Profiles Page



This page lists any local EAP profiles that have already been configured and specifies their EAP types. You can create up to 16 local EAP profiles.

Note If you want to delete an existing profile, hover your cursor over the blue drop-down arrow for that profile and choose **Remove**.

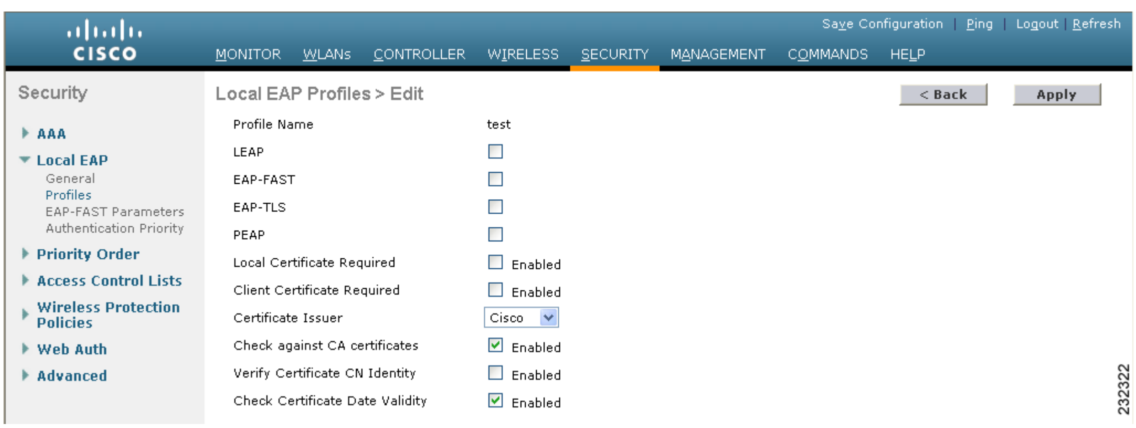
b. Click **New** to open the Local EAP Profiles > New page.

c. In the Profile Name field, enter a name your new profile and then click **Apply**.

Note You can enter up to 63 alphanumeric characters for the profile name. Make sure not to include spaces.

d. When the Local EAP Profiles page reappears, click the name of your new profile. The Local EAP Profiles > Edit page appears (see Figure 5-25).

Figure 5-25 Local EAP Profiles > Edit Page



e. Check the **LEAP**, **EAP-FAST**, **EAP-TLS**, and/or **PEAP** check boxes to specify the EAP type(s) that can be used for local authentication.

> **Note** You can specify more than one EAP type per profile. However, if you choose multiple EAP types that use certificates (such as EAP-FAST with certificates, EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC), all of the EAP types must use the same certificate (from either Cisco or another vendor).

> **Note** If you check the PEAP check box, both PEAPv0/MSCHAPv2 or PEAPv1/GTC are enabled on the controller.

f. If you chose EAP-FAST and want the device certificate on the controller to be used for authentication, check the **Local Certificate Required** check box. If you want to use EAP-FAST with PACs instead of certificates, leave this check box unchecked, which is the default setting.

> **Note** This option applies only to EAP-FAST because device certificates are not used with LEAP and are mandatory for EAP-TLS and PEAP.

g. If you chose EAP-FAST and want the wireless clients to send their device certificates to the controller in order to authenticate, check the **Client Certificate Required** check box. If you want to use EAP-FAST with PACs instead of certificates, leave this check box unchecked, which is the default setting.

> **Note** This option applies only to EAP-FAST because client certificates are not used with LEAP or PEAP and are mandatory for EAP-TLS.

h. If you chose EAP-FAST with certificates, EAP-TLS, or PEAP, choose which certificates will be sent to the client, the ones from **Cisco** or the ones from another **Vendor**, from the Certificate Issuer drop-down box. The default setting is Cisco.

i. If you chose EAP-FAST with certificates or EAP-TLS and want the incoming certificate from the client to be validated against the CA certificates on the controller, check the **Check Against CA Certificates** check box. The default setting is enabled.

j. If you chose EAP-FAST with certificates or EAP-TLS and want the common name (CN) in the incoming certificate to be validated against the CA certificates' CN on the controller, check the **Verify Certificate CN Identity** check box. The default setting is disabled.

k. If you chose EAP-FAST with certificates or EAP-TLS and want the controller to verify that the incoming device certificate is still valid and has not expired, check the **Check Certificate Date Validity** check box. The default setting is enabled.Certificate date validity is checked against the current UTC (GMT) time that is configured on the controller. Timezone offset will be ignored.

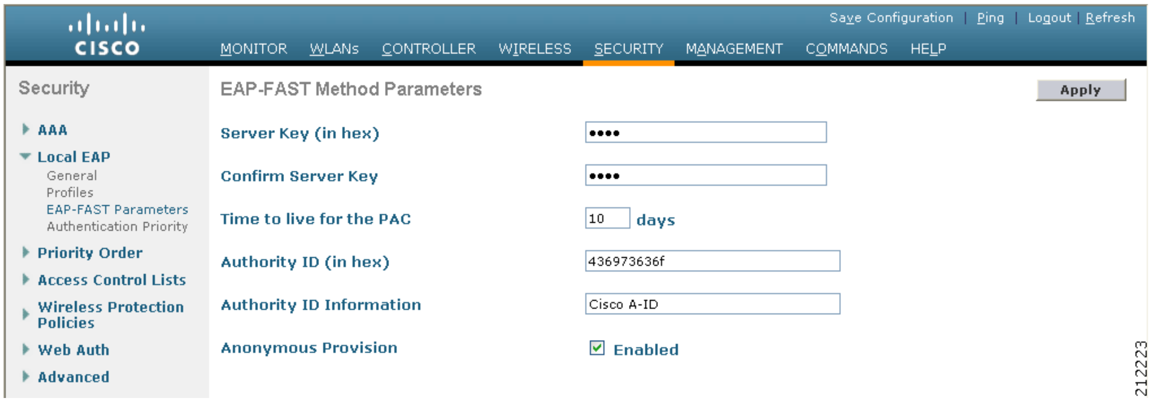
> **Note** Certificate date validity is checked against the current UTC (GMT) time that is configured on the controller. Time zone offset will be ignored.

l. Click **Apply** to commit your changes.

Step 7 If you created an EAP-FAST profile, follow these steps to configure the EAP-FAST parameters:

a. Choose **Security** > **Local EAP** > **EAP-FAST Parameters** to open the EAP-FAST Method Parameters page (see Figure 5-26).

Figure 5-26 EAP-FAST Method Parameters Page



- **b.** In the Server Key and Confirm Server Key fields, enter the key (in hexadecimal characters) used to encrypt and decrypt PACs.
- **c.** In the Time to Live for the PAC field, enter the number of days for the PAC to remain viable. The valid range is 1 to 1000 days, and the default setting is 10 days.
- **d.** In the Authority ID field, enter the authority identifier of the local EAP-FAST server in hexadecimal characters. You can enter up to 32 hexadecimal characters, but you must enter an even number of characters.
- **e.** In the Authority ID Information field, enter the authority identifier of the local EAP-FAST server in text format.
- **f.** If you want to enable anonymous provisioning, check the **Anonymous Provision** check box. This feature allows PACs to be sent automatically to clients that do not have one during PAC provisioning. If you disable this feature, PACS must be manually provisioned. The default setting is enabled.

Note If the local and/or client certificates are required and you want to force all EAP-FAST clients to use certificates, uncheck the **Anonymous Provision** check box.

- **g.** Click **Apply** to commit your changes.

Step 8 Follow these steps to enable local EAP on a WLAN:

- **a.** Choose **WLANs** to open the WLANs page.
- **b.** Click the ID number of the desired WLAN.
- **c.** When the WLANs > Edit page appears, choose the **Security** > **AAA Servers** tabs to open the WLANs > Edit (Security > AAA Servers) page (see Figure 5-27).

Figure 5-27 WLANs > Edit (Security > AAA Servers) Page

d. Check the **Local EAP Authentication** check box to enable local EAP for this WLAN.

e. From the EAP Profile Name drop-down box, choose the EAP profile that you want to use for this WLAN.

f. If desired, choose the LDAP server(s) that you want to use with local EAP on this WLAN from the LDAP Servers drop-down boxes.

g. Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure Local EAP

Follow these steps to configure local EAP using the controller CLI.

Note Refer to the "Using the GUI to Configure Local EAP" section on page 5-42 for the valid ranges and default values of the parameters used in the CLI commands.

Step 1 EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC use certificates for authentication, and EAP-FAST uses either certificates or PACs. The controller is shipped with Cisco-installed device and Certificate Authority (CA) certificates. However, if you wish to use your own vendor-specific certificates, they must be imported on the controller. If you are configuring local EAP to use one of these EAP types, make sure that the appropriate certificates and PACs (if you will use manual PAC provisioning) have been imported on the controller. Refer to the *Managing Controller Software and Configurations* chapter for instructions on importing certificates and PACs.

Step 2 If you want the controller to retrieve user credentials from the local user database, make sure that you have properly configured the local network users on the controller. See the "Configuring Local Network Users" section on page 5-32 for instructions.

Step 3 If you want the controller to retrieve user credentials from an LDAP backend database, make sure that you have properly configured an LDAP server on the controller. See the "Configuring LDAP" section on page 5-35 for instructions.

Step 4 To specify the order in which user credentials are retrieved from the local and/or LDAP databases, enter this command:

config local-auth user-credentials {**local** | **ldap**}

Note If you enter **config local-auth user-credentials ldap local**, local EAP attempts to authenticate clients using the LDAP backend database and fails over to the local user database if the LDAP servers are not reachable. If the user is not found, the authentication attempt is rejected. If you enter **config local-auth user-credentials local ldap**, local EAP attempts to authenticate using only the local user database. It does not fail over to the LDAP backend database.

Step 5 To specify values for the local EAP timers, enter these commands:

- **config local-auth active-timeout** *timeout*—Specifies the amount of time (in seconds) in which the controller attempts to authenticate wireless clients using local EAP after any pair of configured RADIUS servers fails. The valid range is 1 to 3600 seconds, and the default setting is 100 seconds.
- **config advanced eap identity-request-timeout** *timeout*—Specifies the amount of time (in seconds) in which the controller attempts to send an EAP identity request to wireless clients using local EAP. The valid range is 1 to 120 seconds, and the default setting is 30 seconds.
- **config advanced eap identity-request-retries** *retries*—Specifies the maximum number of times that the controller attempts to retransmit the EAP identity request to wireless clients using local EAP. The valid range is 1 to 20 retries, and the default setting is 20 retries.
- **config advanced eap key-index** *index*—Specifies the key index used for dynamic wired equivalent privacy (WEP). The default setting is 0.
- **config advanced eap request-timeout** *timeout*—Specifies the amount of time (in seconds) in which the controller attempts to send an EAP request to wireless clients using local EAP. The valid range is 1 to 120 seconds, and the default setting is 30 seconds.
- **config advanced eap request-retries** *retries*—Specifies the maximum number of times that the controller attempts to retransmit the EAP request to wireless clients using local EAP. The valid range is 1 to 120 retries, and the default setting is 20 retries.
- **config advanced eap eapol-key-timeout** *timeout*—Specifies the amount of time (in seconds) in which the controller attempts to send an EAP key over the LAN to wireless clients using local EAP. The valid range is 1 to 5 seconds, and the default setting is 1 second.
- **config advanced eap eapol-key-retries** *retries*—Specifies the maximum number of times that the controller attempts to send an EAP key over the LAN to wireless clients using local EAP. The valid range is 0 to 4 retries, and the default setting is 2 retries.
- **config advanced eap max-login-ignore-identity-response** {**enable** | **disable**}—When enabled, this command limits the number of devices that can be connected to the controller with the same username. You can log in up to eight times from different devices (PDA, laptop, IP phone, and so on) on the same controller. The default value is enabled.

Step 6 To create a local EAP profile, enter this command:

config local-auth eap-profile add *profile_name*

Note Do not include spaces within the profile name.

Note To delete a local EAP profile, enter this command: **config local-auth eap-profile delete** *profile_name*.

Step 7 To add an EAP method to a local EAP profile, enter this command:

config local-auth eap-profile method add *method profile_name*

The supported methods are leap, fast, tls, and peap.

Note If you choose peap, both PEAPv0/MSCHAPv2 or PEAPv1/GTC are enabled on the controller.

Note You can specify more than one EAP type per profile. However, if you create a profile with multiple EAP types that use certificates (such as EAP-FAST with certificates, EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC), all of the EAP types must use the same certificate (from either Cisco or another vendor).

Note To delete an EAP method from a local EAP profile, enter this command: **config local-auth eap-profile method delete** *method profile_name*.

Step 8 To configure EAP-FAST parameters if you created an EAP-FAST profile, enter this command:

config local-auth method fast *?*

where *?* is one of the following:

- **anon-prov** {**enable** | **disable**}—Configures the controller to allow anonymous provisioning, which allows PACs to be sent automatically to clients that do not have one during PAC provisioning.
- **authority-id** *auth_id*—Specifies the authority identifier of the local EAP-FAST server.
- **pac-ttl** *days*—Specifies the number of days for the PAC to remain viable.
- **server-key** *key*—Specifies the server key used to encrypt and decrypt PACs.

Step 9 To configure certificate parameters per profile, enter these commands:

- **config local-auth eap-profile method fast local-cert** {**enable** | **disable**} *profile_name*—Specifies whether the device certificate on the controller is required for authentication.

  Note This command applies only to EAP-FAST because device certificates are not used with LEAP and are mandatory for EAP-TLS and PEAP.

- **config local-auth eap-profile method fast client-cert** {**enable** | **disable**} *profile_name*—Specifies whether wireless clients are required to send their device certificates to the controller in order to authenticate.

  Note This command applies only to EAP-FAST because client certificates are not used with LEAP or PEAP and are mandatory for EAP-TLS.

- **config local-auth eap-profile cert-issuer {cisco | vendor}** *profile_name*—If you specified EAP-FAST with certificates, EAP-TLS, or PEAP, specifies whether the certificates that will be sent to the client are from Cisco or another vendor.
- **config local-auth eap-profile cert-verify ca-issuer** {**enable** | **disable**} *profile_name*—If you chose EAP-FAST with certificates or EAP-TLS, specifies whether the incoming certificate from the client is to be validated against the CA certificates on the controller.
- **config local-auth eap-profile cert-verify cn-verify** {**enable** | **disable**} *profile_name*—If you chose EAP-FAST with certificates or EAP-TLS, specifies whether the common name (CN) in the incoming certificate is to be validated against the CA certificates' CN on the controller.
- **config local-auth eap-profile cert-verify date-valid** {**enable** | **disable**} *profile_name*—If you chose EAP-FAST with certificates or EAP-TLS, specifies whether the controller is to verify that the incoming device certificate is still valid and has not expired.

Step 10 To enable local EAP and attach an EAP profile to a WLAN, enter this command:

config wlan local-auth enable *profile_name wlan_id*

Note To disable local EAP for a WLAN, enter this command: **config wlan local-auth disable** *wlan_id*.

Step 11 To save your changes, enter this command:

save config

Step 12 To view information pertaining to local EAP, enter these commands:

- **show local-auth config—**Shows the local EAP configuration on the controller.

  Information similar to the following appears for the **show local-auth config** command:

```
User credentials database search order:
   Primary ..................................... Local DB

Timer:
    Active timeout .............................. 300

Configured EAP profiles:
   Name ........................................ fast-cert
     Certificate issuer ........................ vendor
     Peer verification options:
       Check against CA certificates ........... Enabled
       Verify certificate CN identity .......... Disabled
       Check certificate date validity ......... Enabled
     EAP-FAST configuration:
       Local certificate required .............. Yes
       Client certificate required ............. Yes
     Enabled methods ........................... fast
     Configured on WLANs ....................... 1

   Name ........................................ tls
     Certificate issuer ........................ vendor
     Peer verification options:
       Check against CA certificates ........... Enabled
       Verify certificate CN identity .......... Disabled
       Check certificate date validity ......... Enabled
     EAP-FAST configuration:
       Local certificate required .............. No
       Client certificate required ............. No
     Enabled methods ........................... tls
     Configured on WLANs ....................... 2
```

```
EAP Method configuration:
   EAP-FAST:
     Server key ............................... <hidden>
     TTL for the PAC .......................... 10
     Anonymous provision allowed .............. Yes
     Accept client on auth prov ............... No
     Authority ID ............................. 436973636f0000000000000000000000
     Authority Information .................... Cisco A-ID
```

- **show local-auth statistics**—Shows the local EAP statistics.
- **show local-auth certificates**—Shows the certificates available for local EAP.
- **show local-auth user-credentials**—Shows the priority order that the controller uses when retrieving user credentials from the local and/or LDAP databases.
- **show advanced eap**—Shows the timer values for local EAP. Information similar to the following appears:

```
EAP-Identity-Request Timeout (seconds)........... 1
EAP-Identity-Request Max Retries................. 20
EAP Key-Index for Dynamic WEP.................... 0
EAP Max-Login Ignore Identity Response........... enable
EAP-Request Timeout (seconds).................... 20
EAP-Request Max Retries.......................... 20
EAPOL-Key Timeout (seconds)...................... 1
EAPOL-Key Max Retries......................... 2
```

- **show ap stats wlan** *Cisco_AP*—Shows the EAP timeout and failure counters for a specific access point for each WLAN. Information similar to the following appears:

```
WLAN      1
   EAP Id Request Msg Timeouts................... 0
   EAP Id Request Msg Timeouts Failures.......... 0
   EAP Request Msg Timeouts...................... 2
   EAP Request Msg Timeouts Failures............. 1
   EAP Key Msg Timeouts.......................... 0
   EAP Key Msg Timeouts Failures................. 0
WLAN      2
   EAP Id Request Msg Timeouts................... 1
   EAP Id Request Msg Timeouts Failures.......... 0
   EAP Request Msg Timeouts...................... 0
   EAP Request Msg Timeouts Failures............. 0
   EAP Key Msg Timeouts.......................... 3
   EAP Key Msg Timeouts Failures.............. 1
```

- **show client detail** *client_mac*—Shows the EAP timeout and failure counters for a specific associated client. These statistics are useful in troubleshooting client association issues. Information similar to the following appears:

```
...
Client Statistics:
      Number of Bytes Received................... 10
      Number of Bytes Sent....................... 10
      Number of Packets Received................. 2
      Number of Packets Sent..................... 2
      Number of EAP Id Request Msg Timeouts...... 0
      Number of EAP Id Request Msg Failures...... 0
      Number of EAP Request Msg Timeouts......... 2
      Number of EAP Request Msg Failures......... 1
      Number of EAP Key Msg Timeouts............. 0
      Number of EAP Key Msg Failures............. 0
      Number of Policy Errors.................... 0
```

```
        Radio Signal Strength Indicator........... Unavailable
        Signal to Noise Ratio...................... Unavailable
...
```

- **show wlan** *wlan_id*—Shows the status of local EAP on a particular WLAN.

Step 13 If necessary, you can use these commands to troubleshoot local EAP sessions:

- **debug aaa local-auth eap method** {**all** | **errors** | **events** | **packets** | **sm**} {**enable** | **disable**}—Enables or disables debugging of local EAP methods.
- **debug aaa local-auth eap framework** {**all** | **errors** | **events** | **packets** | **sm**} {**enable** | **disable**}—Enables or disables debugging of the local EAP framework.

Note In these two debug commands, **sm** is the state machine.

- **clear stats local-auth**—Clears the local EAP counters.
- **clear stats ap wlan** *Cisco_AP*—Clears the EAP timeout and failure counters for a specific access point for each WLAN.

Configuring the System for SpectraLink NetLink Telephones

For best integration with the Cisco UWN Solution, SpectraLink NetLink Telephones require an extra operating system configuration step: enable long preambles. The radio preamble (sometimes called a header) is a section of data at the head of a packet that contains information that wireless devices need when sending and receiving packets. Short preambles improve throughput performance, so they are enabled by default. However, some wireless devices, such as SpectraLink NetLink phones, require long preambles.

Use one of these methods to enable long preambles:

- Using the GUI to Enable Long Preambles, page 5-52
- Using the CLI to Enable Long Preambles, page 5-53

Using the GUI to Enable Long Preambles

Use this procedure to use the GUI to enable long preambles to optimize the operation of SpectraLink NetLink phones on your wireless LAN.

Step 1 Choose **Wireless > 802.11b/g/n > Network** to open the 802.11b/g Global Parameters page.

Step 2 If the **Short Preamble** check box is checked, continue with this procedure. However, if the **Short Preamble** check box is unchecked (which means that long preambles are enabled), the controller is already optimized for SpectraLink NetLink phones and you do not need to continue this procedure.

Step 3 Uncheck the **Short Preamble** check box to enable long preambles.

Step 4 Click **Apply** to update the controller configuration.

> **Note** If you do not already have an active CLI session to the controller, Cisco recommends that you start a CLI session to reboot the controller and watch the reboot process. A CLI session is also useful because the GUI loses its connection when the controller reboots.

Step 5 Choose **Commands** > **Reboot** > **Reboot > Save and Reboot** to reboot the controller. Click **OK** in response to this prompt:

```
Configuration will be saved and the controller will be rebooted. Click ok to confirm.
```

The controller reboots.

Step 6 Log back into the controller GUI to verify that the controller is properly configured.

Step 7 Choose **Wireless** > **802.11b/g/n** > **Network** to open the 802.11b/g Global Parameters page. If the **Short Preamble** check box is unchecked, the controller is optimized for SpectraLink NetLink phones.

Using the CLI to Enable Long Preambles

Use this procedure to use the CLI to enable long preambles to optimize the operation of SpectraLink NetLink phones on your wireless LAN.

Step 1 Log into the controller CLI.

Step 2 Enter **show 802.11b** and check the Short preamble mandatory parameter. If the parameter indicates that short preambles are enabled, continue with this procedure. This example shows that short preambles are enabled:

```
Short Preamble mandatory....................... Enabled
```

However, if the parameter shows that short preambles are disabled (which means that long preambles are enabled), the controller is already optimized for SpectraLink NetLink phones and you do not need to continue this procedure. This example shows that short preambles are disabled:

```
Short Preamble mandatory....................... Disabled
```

Step 3 Enter **config 802.11b disable network** to disable the 802.11b/g network. (You cannot enable long preambles on the 802.11a network.)

Step 4 Enter **config 802.11b preamble long** to enable long preambles.

Step 5 Enter **config 802.11b enable network** to re-enable the 802.11b/g network.

Step 6 Enter **reset system** to reboot the controller. Enter **y** when this prompt appears:

```
The system has unsaved changes. Would you like to save them now? (y/n)
```

The controller reboots.

Step 7 To verify that the controller is properly configured, log back into the CLI and enter **show 802.11b** to view these parameters:

```
802.11b Network................................ Enabled
Short Preamble mandatory....................... Disabled
```

These parameters show that the 802.11b/g network is enabled and that short preambles are disabled.

Using the CLI to Configure Enhanced Distributed Channel Access

Use this CLI command to configure 802.11 enhanced distributed channel access (EDCA) parameters to support SpectraLink phones:

config advanced edca-parameters {**svp-voice** | **wmm-default**}

where

svp-voice enables SpectraLink voice priority (SVP) parameters and **wmm-default** enables wireless multimedia (WMM) default parameters.

Note To propagate this command to all access points connected to the controller, make sure to disable and then re-enable the 802.11b/g network after entering this command.

Using Management over Wireless

The management over wireless feature allows operators to monitor and configure local controllers using a wireless client. This feature is supported for all management tasks except uploads to and downloads from (transfers to and from) the controller.

Before you can use management over wireless, you must properly configure the controller using one of these sections:

- Using the GUI to Enable Management over Wireless, page 5-54
- Using the CLI to Enable Management over Wireless, page 5-54

Using the GUI to Enable Management over Wireless

Step 1 Choose **Management > Mgmt Via Wireless** to open the Management Via Wireless page.

Step 2 Check the **Enable Controller Management to be accessible from Wireless Clients** check box to enable management over wireless for the WLAN or uncheck it to disable this feature. The default value is unchecked.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 Use a wireless client web browser to connect to the controller management port or distribution system port IP address, and log into the controller GUI to verify that you can manage the WLAN using a wireless client.

Using the CLI to Enable Management over Wireless

Step 1 In the CLI, use the **show network** command to verify whether the management over wireless interface is enabled or disabled. If it is disabled, continue with Step 2. Otherwise, continue with Step 3.

Step 2 To enable management over wireless, enter **config network mgmt-via-wireless enable**.

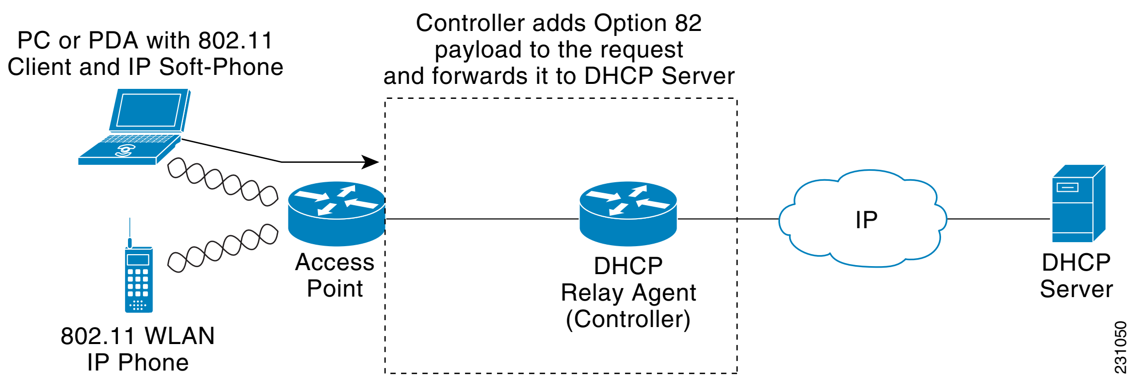
Step 3 Use a wireless client to associate with an access point connected to the controller that you want to manage.

Step 4 Enter **telnet controller-ip-address** and log into the CLI to verify that you can manage the WLAN using a wireless client.

Configuring DHCP Option 82

DHCP option 82 provides additional security when DHCP is used to allocate network addresses. Specifically, it enables the controller to act as a DHCP relay agent to prevent DHCP client requests from untrusted sources. The controller can be configured to add option 82 information to DHCP requests from clients before forwarding the requests to the DHCP server. See Figure 5-28 for an illustration of this process.

Figure 5-28 DHCP Option 82



The access point forwards all DHCP requests from a client to the controller. The controller adds the DHCP option 82 payload and forwards the request to the DHCP server. The payload can contain the MAC address or the MAC address and SSID of the access point, depending on how you configure this option. In controller software release 4.0 or later, you can configure DHCP option 82 using the controller CLI. In controller software release 6.0, you can configure this feature using either the GUI or CLI.

Note In order for DHCP option 82 to operate correctly, you must enable DHCP proxy, which is disabled by default. Refer to the "Configuring DHCP Proxy" section on page 4-41 for instructions on configuring DHCP proxy.

Note Any DHCP packets that already include a relay agent option are dropped at the controller.

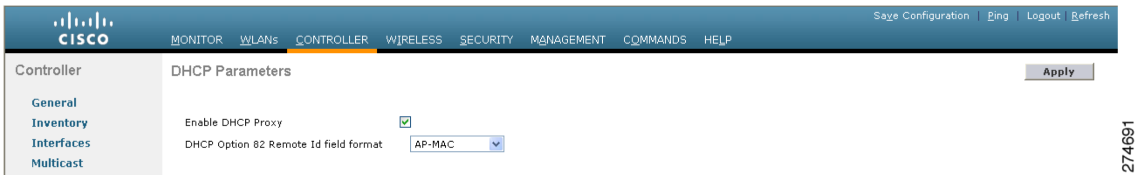
Note DHCP option 82 is not supported for use with auto-anchor mobility, which is described in the *Configuring Mobility Groups* chapter.

Using the GUI to Configure DHCP Option 82

Using the GUI, follow these steps to configure DHCP option 82 on the controller.

Step 1 Choose **Controller** > **Advanced** > **DHCP** to open the DHCP Parameters page (see Figure 5-29).

Figure 5-29 DHCP Parameters Page



Step 2 Choose one of the following options from the DHCP Option 82 Remote ID Field Format drop-down box to specify the format of the DHCP option 82 payload:

- **AP-MAC**—Adds the MAC address of the access point to the DHCP option 82 payload. This is the default value.
- **AP-MAC-SSID**—Adds the MAC address and SSID of the access point to the DHCP option 82 payload.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure DHCP Option 82

Use these CLI commands to configure DHCP option 82 on the controller.

1. To configure the format of the DHCP option 82 payload, enter one of these commands:
   - **config dhcp opt-82 remote-id** *ap_mac*

     This command adds the MAC address of the access point to the DHCP option 82 payload.
   - **config dhcp opt-82 remote-id** *ap_mac*:*ssid*

     This command adds the MAC address and SSID of the access point to the DHCP option 82 payload.
2. To overrride the global DHCP option 82 setting and disable (or enable) this feature for the AP-manager or management interface on the controller, enter this command:

   config interface dhcp {**ap-manager** | **management**} **option-82** {**disable** | **enable**}

3. To see the status of DHCP option 82 on the controller, enter this command:

   show interface detailed ap-manager

   Information similar to the following appears:

```
Interface Name................................. ap-manager
MAC Address.................................... 00:0a:88:25:10:c4
IP Address..................................... 10.30.16.13
IP Netmask..................................... 255.255.248.0
IP Gateway..................................... 10.30.16.1
External NAT IP State.......................... Disabled
External NAT IP Address........................ 0.0.0.0
External NAT IP Netmask........................ 0.0.0.0
VLAN........................................... untagged
Active Physical Port........................... LAG (29)
Primary Physical Port.......................... LAG (29)
Backup Physical Port........................... Unconfigured
Primary DHCP Server............................ 10.1.0.10
Secondary DHCP Server.......................... Unconfigured
DHCP Option 82................................. Enabled
ACL............................................ Unconfigured
AP Manager..................................... Yes
Guest Interface................................ No
```

Configuring and Applying Access Control Lists

An access control list (ACL) is a set of rules used to limit access to a particular interface (for example, if you want to restrict a wireless client from pinging the management interface of the controller). After ACLs are configured on the controller, they can be applied to the management interface, the AP-manager interface, any of the dynamic interfaces, or a WLAN to control data traffic to and from wireless clients or to the controller central processing unit (CPU) to control all traffic destined for the CPU.

You may also want to create a preauthentication ACL for web authentication. Such an ACL could be used to allow certain types of traffic before authentication is complete.

Note If you are using an external web server with a 5500 series controller, a 2100 series controller, or a controller network module, you must configure a preauthentication ACL on the WLAN for the external web server.

You can define up to 64 ACLs, each with up to 64 rules (or filters). Each rule has parameters that affect its action. When a packet matches all of the parameters for a rule, the action set for that rule is applied to the packet.

Note All ACLs have an implicit "deny all rule" as the last rule. If a packet does not match any of the rules, it is dropped by the controller.

Note ACLs in your network might need to be modified if CAPWAP uses different ports than LWAPP.

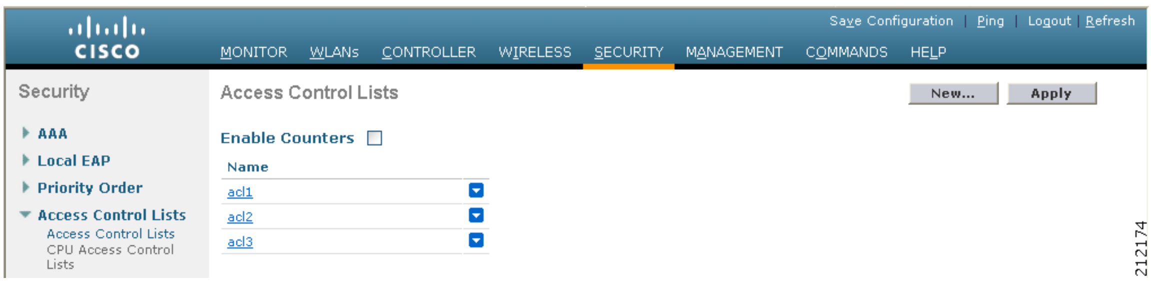
You can configure and apply ACLs through either the GUI or the CLI.

Using the GUI to Configure Access Control Lists

Follow these steps to configure ACLs using the controller GUI.

Step 1 Choose **Security** > **Access Control Lists** > **Access Control Lists** to open the Access Control Lists page (see Figure 5-30).

Figure 5-30 Access Control Lists Page



This page lists all of the ACLs that have been configured for this controller.

> **Note** If you want to delete an existing ACL, hover your cursor over the blue drop-down arrow for that ACL and choose **Remove**.

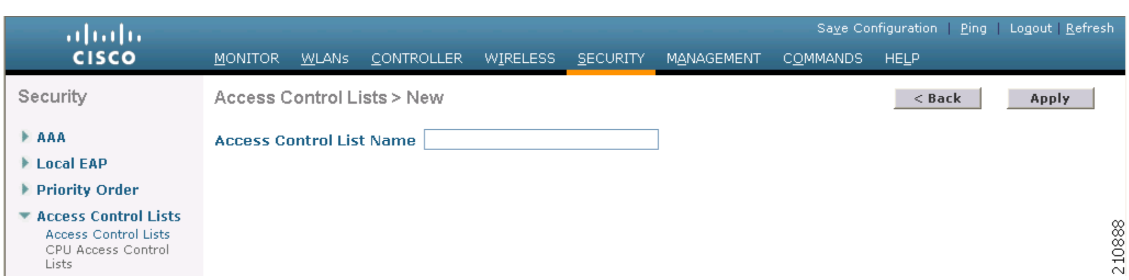
Step 2 If you want to see if packets are hitting any of the ACLs configured on your controller, check the **Enable Counters** check box and click **Apply**. Otherwise, leave the check box unchecked, which is the default value. This feature is useful when troubleshooting your system.

> **Note** If you want to clear the counters for an ACL, hover your cursor over the blue drop-down arrow for that ACL and choose **Clear Counters**.

> **Note** ACL counters are available only on the following controllers: 5500 series, 4400 series, Cisco WiSM, and Catalyst 3750G Integrated Wireless LAN Controller Switch.

Step 3 To add a new ACL, click **New**. The Access Control Lists > New page appears (see Figure 5-31).

Figure 5-31 Access Control Lists > New Page

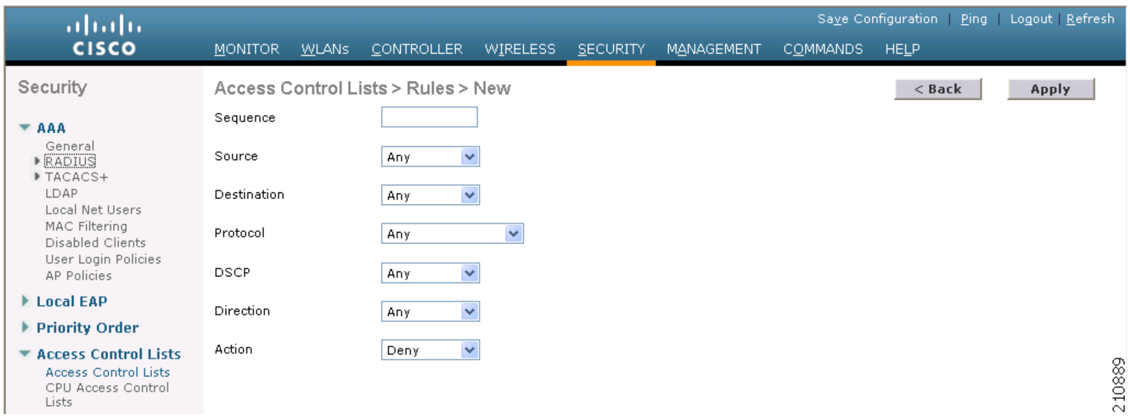


Step 4 In the Access Control List Name field, enter a name for the new ACL. You can enter up to 32 alphanumeric characters.

Step 5 Click **Apply**. When the Access Control Lists page reappears, click the name of the new ACL.

Step 6 When the Access Control Lists > Edit page appears, click **Add New Rule**. The Access Control Lists > Rules > New page appears (see Figure 5-32).

Figure 5-32 Access Control Lists > Rules > New Page



Step 7 Follow these steps to configure a rule for this ACL:

a. The controller supports up to 64 rules for each ACL. These rules are listed in order from 1 to 64. In the Sequence field, enter a value (between 1 and 64) to determine the order of this rule in relation to any other rules defined for this ACL.

Note If rules 1 through 4 are already defined and you add rule 29, it is added as rule 5. If you add or change a sequence number for a rule, the sequence numbers for other rules adjust to maintain a contiguous sequence. For instance, if you change a rule's sequence number from 7 to 5, the rules with sequence numbers 5 and 6 are automatically reassigned as 6 and 7, respectively.

b. From the Source drop-down box, choose one of these options to specify the source of the packets to which this ACL applies:

- **Any**—Any source (This is the default value.)
- **IP Address**—A specific source. If you choose this option, enter the IP address and netmask of the source in the edit boxes.

c. From the Destination drop-down box, choose one of these options to specify the destination of the packets to which this ACL applies:

- **Any**—Any destination (This is the default value.)
- **IP Address**—A specific destination. If you choose this option, enter the IP address and netmask of the destination in the edit boxes.

d. From the Protocol drop-down box, choose the protocol ID of the IP packets to be used for this ACL. These are the protocol options:

- **Any**—Any protocol (This is the default value.)
- **TCP**—Transmission Control Protocol
- **UDP**—User Datagram Protocol
- **ICMP**—Internet Control Message Protocol
- **ESP**—IP Encapsulating Security Payload
- **AH**—Authentication Header
- **GRE**—Generic Routing Encapsulation
- **IP in IP**—Internet Protocol (IP) in IP. Permits or denies IP-in-IP packets.
- **Eth Over IP**—Ethernet-over-Internet Protocol
- **OSPF**—Open Shortest Path First
- **Other**—Any other Internet Assigned Numbers Authority (IANA) protocol

Note If you choose **Other**, enter the number of the desired protocol in the Protocol edit box. You can find the list of available protocols and their corresponding numbers here: http://www.iana.org/assignments/protocol-numbers/protocol-numbers.xml

Note The controller can permit or deny only IP packets in an ACL. Other types of packets (such as ARP packets) cannot be specified.

e. If you chose TCP or UDP in the previous step, two additional parameters appear: Source Port and Destination Port. These parameters enable you to choose a specific source port and destination port or port ranges. The port options are used by applications that send and receive data to and from the networking stack. Some ports are designated for certain applications such as telnet, ssh, http, and so on.

f. From the DSCP drop-down box, choose one of these options to specify the differentiated services code point (DSCP) value of this ACL. DSCP is an IP header field that can be used to define the quality of service across the Internet.

- **Any**—Any DSCP (This is the default value.)
- **Specific**—A specific DSCP from 0 to 63, which you enter in the DSCP edit box

g. From the Direction drop-down box, choose one of these options to specify the direction of the traffic to which this ACL applies:

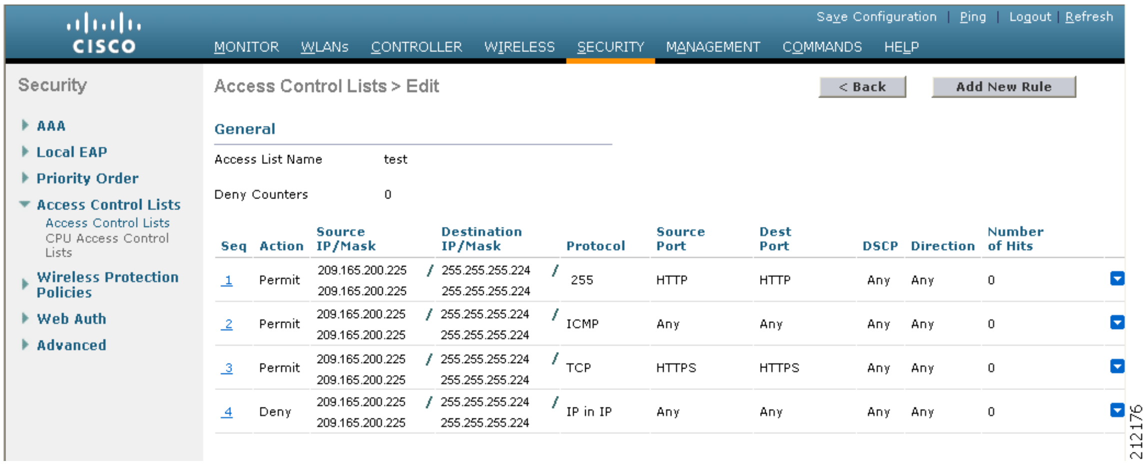
- **Any**—Any direction (This is the default value.)
- **Inbound**—From the client
- **Outbound**—To the client

Note If you are planning to apply this ACL to the controller CPU, choose **Any** or **Inbound** because a CPU ACL applies only to packets that are sent to the CPU, not packets from the CPU.

h. From the Action drop-down box, choose **Deny** to cause this ACL to block packets or **Permit** to cause this ACL to allow packets. The default value is Deny.

i. Click **Apply** to commit your changes. The Access Control Lists > Edit page reappears, showing the rules for this ACL. See Figure 5-33.

Figure 5-33 Access Control Lists > Edit Page



The Deny Counters field shows the number of times that packets have matched the explicit deny ACL rule. The Number of Hits field shows the number of times that packets have matched an ACL rule. You must enable ACL counters on the Access Control Lists page to enable these fields.

Note If you want to edit a rule, click the sequence number of the desired rule to open the Access Control Lists > Rules > Edit page. If you ever want to delete a rule, hover your cursor over the blue drop-down arrow for the desired rule and choose **Remove**.

j. Repeat this procedure to add any additional rules for this ACL.

Step 8 Click **Save Configuration** to save your changes.

Step 9 Repeat this procedure to add any additional ACLs.

Using the GUI to Apply Access Control Lists

Follow the instructions in these sections to apply ACLs using the controller GUI:

- Applying an Access Control List to an Interface, page 5-62
- Applying an Access Control List to the Controller CPU, page 5-64
- Applying an Access Control List to a WLAN, page 5-64
- Applying a Preauthentication Access Control List to a WLAN, page 5-65

Note If you apply an ACL to an interface or a WLAN, wireless throughput is degraded when downloading from a 1-Gbps file server. To improve throughput, remove the ACL from the interface or WLAN, move the ACL to a neighboring wired device with a policy rate-limiting restriction, or connect the file server using 100 Mbps rather than 1 Gbps.

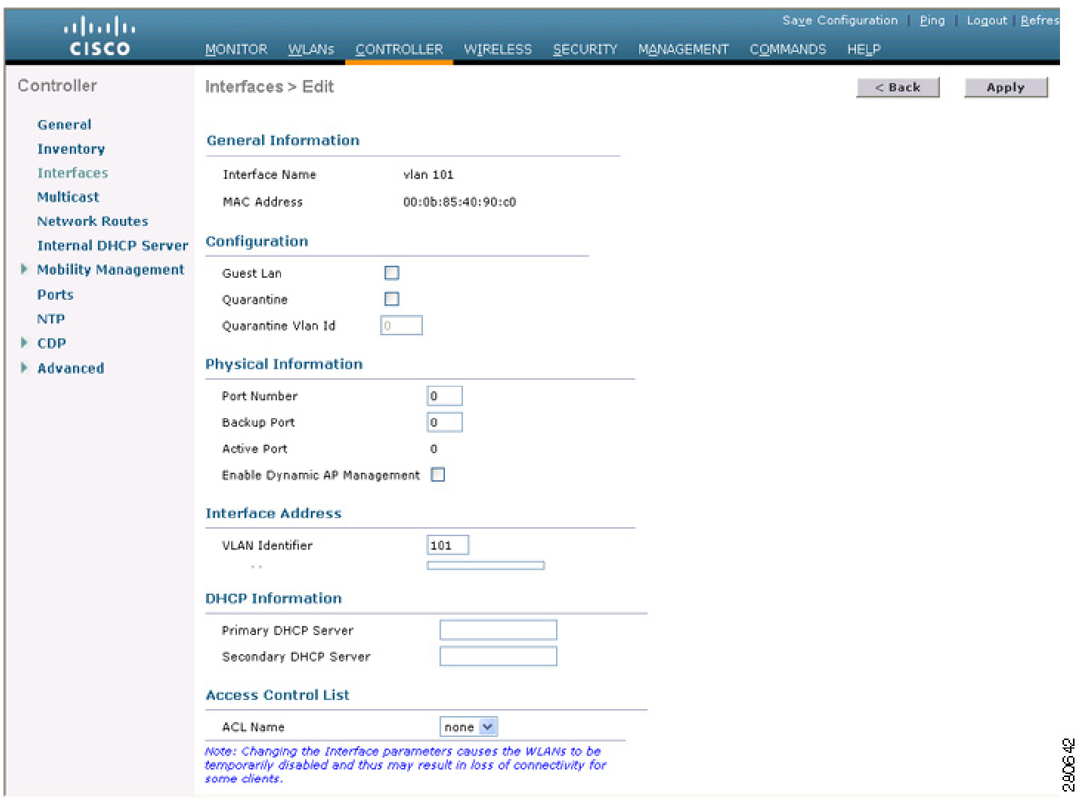
Applying an Access Control List to an Interface

Follow these steps to apply an ACL to a management, AP-manager, or dynamic interface using the controller GUI.

Step 1 Choose **Controller** > **Interfaces**.

Step 2 Click the name of the desired interface. The Interfaces > Edit page for that interface appears (see Figure 5-34).

Figure 5-34 Interfaces > Edit Page



Step 3 Choose the desired ACL from the ACL Name drop-down box and click **Apply**. None is the default value.

Note See the *Configuring Ports and Interfaces* chapter for more information on configuring controller interfaces.

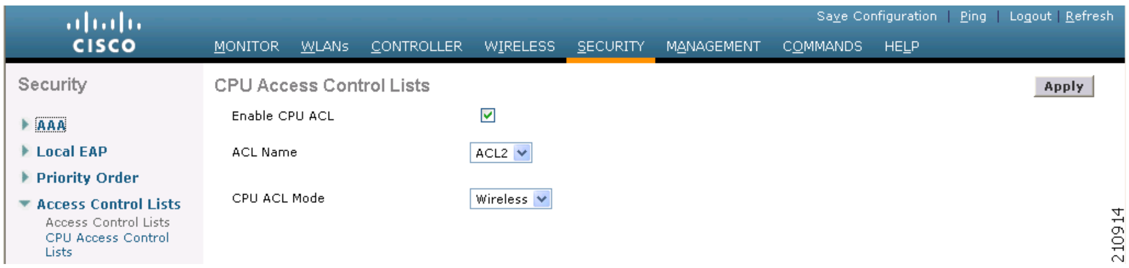
Step 4 Click **Save Configuration** to save your changes.

Applying an Access Control List to the Controller CPU

Follow these steps to apply an ACL to the controller CPU to control traffic to the CPU using the controller GUI.

Step 1 Choose **Security** > **Access Control Lists** > **CPU Access Control Lists**. The CPU Access Control Lists page appears (see Figure 5-35).

Figure 5-35 CPU Access Control Lists Page



Step 2 Check the **Enable CPU ACL** check box to enable a designated ACL to control the traffic to the controller CPU or uncheck the check box to disable the CPU ACL feature and remove any ACL that had been applied to the CPU. The default value is unchecked.

Step 3 From the ACL Name drop-down box, choose the ACL that will control the traffic to the controller CPU. None is the default value when the CPU ACL feature is disabled. If you choose None while the CPU ACL Enable check box is checked, an error message appears indicating that you must choose an ACL.

Note This parameter is available only if you checked the CPU ACL Enable check box.

Step 4 From the CPU ACL Mode drop-down box, choose the type of traffic (wired, wireless, or both) that will be restricted from reaching the controller CPU. Wired is the default value.

Note This parameter is available only if you checked the CPU ACL Enable check box.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Applying an Access Control List to a WLAN

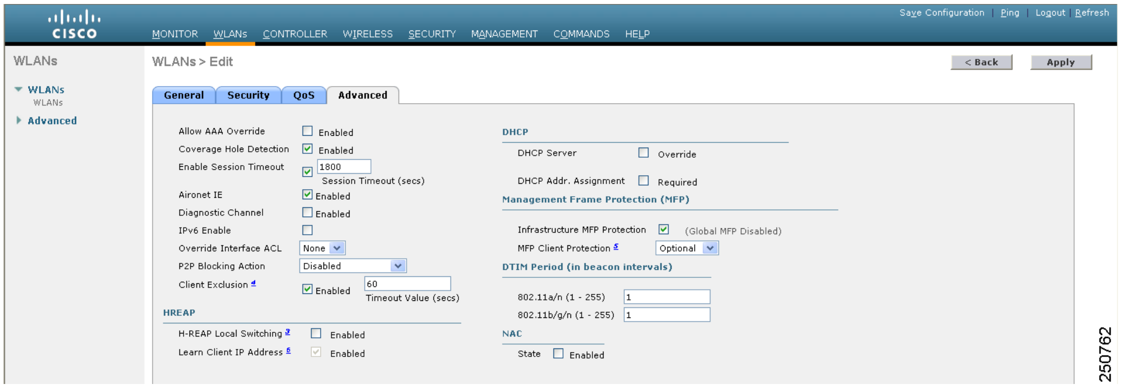
Follow these steps to apply an ACL to a WLAN using the controller GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 5-36).

Figure 5-36 WLANs > Edit (Advanced) Page



Step 4 From the Override Interface ACL drop-down box, choose the ACL that you want to apply to this WLAN. The ACL that you choose overrides any ACL that is configured for the interface. None is the default value.

Note See the Configuring WLANs chapter for more information on configuring WLANs.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Applying a Preauthentication Access Control List to a WLAN

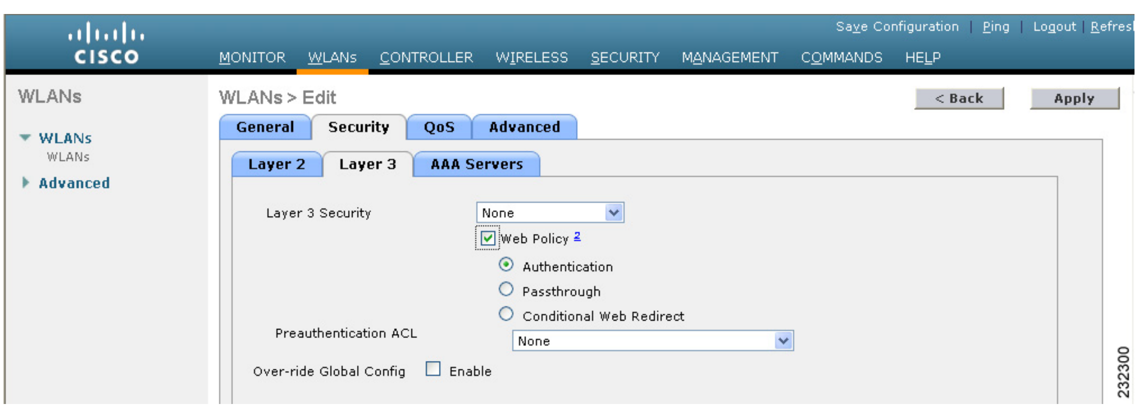
Follow these steps to apply a preauthentication ACL to a WLAN using the controller GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Security** and **Layer 3** tabs to open the WLANs > Edit (Security > Layer 3) page (see Figure 5-37).

Figure 5-37 WLANs > Edit (Security > Layer 3) Page



Step 4 Check the **Web Policy** check box.

Step 5 From the Preauthentication ACL drop-down box, choose the desired ACL and click **Apply**. None is the default value.

> **Note** See the *Configuring WLANs* chapter for more information on configuring WLANs.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure Access Control Lists

Follow these steps to configure ACLs using the controller CLI.

Step 1 To see all of the ACLs that are configured on the controller, enter this command:

show acl summary

Information similar to the following appears:

```
ACL Counter Status        Enabled
-------------------------------------
ACL Name                   Applied
------------------------- -----------
acl1                          Yes
acl2                          Yes
acl3                        Yes
```

Step 2 To see detailed information for a particular ACL, enter this command:

show acl detailed *acl_name*

Information similar to the following appears:

```
            Source         Destination        Source Port Dest Port
I Dir IP Address/Netmask IP Address/Netmask Prot    Range Range   DSCP Action Counter
- --- ------------------ ------------------ ---- ----------- -------- ----- ------ -------
1 Any 0.0.0.0/0.0.0.0   0.0.0.0/0.0.0.0   Any    0-65535  0-65535  0    Deny    0
2 In  0.0.0.0/0.0.0.0   200.200.200.0/     6     80-80    0-65535  Any  Permit  0
                        255.255.255.0

DenyCounter :     0
```

The Counter field increments each time a packet matches an ACL rule, and the DenyCounter field increments each time a packet does not match any of the rules.

Step 3 To enable or disable ACL counters for your controller, enter this command:

config acl counter {**start** | **stop**}

> **Note** If you want to clear the current counters for an ACL, enter this command:
> **clear acl counters** *acl_name*

Note ACL counters are available only on the following controllers: 5500 series, 4400 series, Cisco WiSM, and Catalyst 3750G Integrated Wireless LAN Controller Switch.

Step 4 To add a new ACL, enter this command:

config acl create *acl_name*

You can enter up to 32 alphanumeric characters for the *acl_name* parameter.

Step 5 To add a rule for an ACL, enter this command:

config acl rule add *acl_name rule_index*

Step 6 To configure an ACL rule, enter this command:

config acl rule {

action *acl_name rule_index* {**permit** | **deny**} |

change index *acl_name old_index new_index* |

destination address *acl_name rule_index ip_address netmask* |

destination port range *acl_name rule_index start_port end_port* |

direction *acl_name rule_index* {**in** | **out** | **any**} |

dscp *acl_name rule_index dscp* |

protocol *acl_name rule_index protocol* |

source address *acl_name rule_index ip_address netmask* |

source port range *acl_name rule_index start_port end_port* |

swap index *acl_name index_1 index_2*}

Refer to Step 7 of the "Using the GUI to Configure Access Control Lists" section on page 5-58 for explanations of the rule parameters.

Step 7 To save your settings, enter this command:

save config

Note To delete an ACL, enter **config acl delete** *acl_name*. To delete an ACL rule, enter **config acl rule delete** *acl_name rule_index*.

Using the CLI to Apply Access Control Lists

Follow these steps to apply ACLs using the controller CLI.

Step 1 Perform any of the following:

- To apply an ACL to a management, AP-manager, or dynamic interface, enter this command:

  config interface acl {**management** | **ap-manager** | *dynamic_interface_name*} *acl_name*

  Note To see the ACL that is applied to an interface, enter **show interface detailed** {**management** | **ap-manager** | *dynamic_interface_name*}. To remove an ACL that is applied to an interface, enter **config interface acl** {**management** | **ap-manager** | *dynamic_interface_name*} **none**.

  See the *Configuring Ports and Interfaces* chapter for more information on configuring controller interfaces.

- To apply an ACL to the data path, enter this command:

  config acl apply *acl_name*

- To apply an ACL to the controller CPU to restrict the type of traffic (wired, wireless, or both) reaching the CPU, enter this command:

  config acl cpu *acl_name* {**wired** | **wireless** | **both**}

  Note To see the ACL that is applied to the controller CPU, enter **show acl cpu**. To remove the ACL that is applied to the controller CPU, enter **config acl cpu none**.

- To apply an ACL to a WLAN, enter this command:

  config wlan acl *wlan_id acl_name*

  Note To see the ACL that is applied to a WLAN, enter **show wlan** *wlan_id*. To remove the ACL that is applied to a WLAN, enter **config wlan acl** *wlan_id* **none**.

- To apply a preauthentication ACL to a WLAN, enter this command:

  config wlan security web-auth acl *wlan_id acl_name*

  See the *Configuring WLANs* chapter for more information on configuring WLANs.

Step 2 To save your settings, enter this command:

save config

Configuring Management Frame Protection

Management frame protection (MFP) provides security for the otherwise unprotected and unencrypted 802.11 management messages passed between access points and clients. MFP provides both infrastructure and client support. Controller software release 4.1 or later supports both infrastructure and client MFP while controller software release 4.0 supports only infrastructure MFP.

- **Infrastructure MFP—**Protects management frames by detecting adversaries that are invoking denial-of-service attacks, flooding the network with associations and probes, interjecting as rogue access points, and affecting network performance by attacking the QoS and radio measurement frames. It also provides a quick and effective means to detect and report phishing incidents.

  Specifically, infrastructure MFP protects 802.11 session management functions by adding message integrity check information elements (MIC IEs) to the management frames emitted by access points (and not those emitted by clients), which are then validated by other access points in the network. Infrastructure MFP is passive. It can detect and report intrusions but has no means to stop them.

- **Client MFP—**Shields authenticated clients from spoofed frames, preventing many of the common attacks against wireless LANs from becoming effective. Most attacks, such as deauthentication attacks, revert to simply degrading performance by contending with valid clients.

  Specifically, client MFP encrypts management frames sent between access points and CCXv5 clients so that both the access points and clients can take preventative action by dropping spoofed class 3 management frames (that is, management frames passed between an access point and a client that is authenticated and associated). Client MFP leverages the security mechanisms defined by IEEE 802.11i to protect the following types of class 3 unicast management frames: disassociation, deauthentication, and QoS (WMM) action. Client MFP protects a client-access point session from the most common type of denial-of-service attack. It protects class 3 management frames by using the same encryption method used for the session's data frames. If a frame received by the access point or client fails decryption, it is dropped, and the event is reported to the controller.

  To use client MFP, clients must support CCXv5 MFP and must negotiate WPA2 using either TKIP or AES-CCMP. EAP or PSK may be used to obtain the PMK. CCKM and controller mobility management are used to distribute session keys between access points for Layer 2 and Layer 3 fast roaming.

Note To prevent attacks using broadcast frames, access points supporting CCXv5 will not emit any broadcast class 3 management frames (such as disassociation, deauthentication, or action). CCXv5 clients and access points must discard broadcast class 3 management frames.

Client MFP supplements infrastructure MFP rather than replaces it because infrastructure MFP continues to detect and report invalid unicast frames sent to clients that are not client-MFP capable as well as invalid class 1 and 2 management frames. Infrastructure MFP is applied only to management frames that are not protected by client MFP.

Infrastructure MFP consists of three main components:

- **Management frame protection**—The access point protects the management frames it transmits by adding a MIC IE to each frame. Any attempt to copy, alter, or replay the frame invalidates the MIC, causing any receiving access point configured to detect MFP frames to report the discrepancy.
- **Management frame validation**—In infrastructure MFP, the access point validates every management frame that it receives from other access points in the network. It ensures that the MIC IE is present (when the originator is configured to transmit MFP frames) and matches the content of the management frame. If it receives any frame that does not contain a valid MIC IE from a BSSID belonging to an access point that is configured to transmit MFP frames, it reports the discrepancy to the network management system. In order for the timestamps to operate properly, all controllers must be Network Transfer Protocol (NTP) synchronized.
- **Event reporting**—The access point notifies the controller when it detects an anomaly, and the controller aggregates the received anomaly events and can report the results through SNMP traps to the network management system.

Note Error reports generated on a hybrid-REAP access point in stand-alone mode cannot be forwarded to the controller and are dropped.

Note Client MFP uses the same event reporting mechanisms as infrastructure MFP.

Infrastructure MFP is enabled by default and can be disabled globally. When you upgrade from a previous software release, infrastructure MFP is disabled globally if access point authentication is enabled because the two features are mutually exclusive. Once infrastructure MFP is enabled globally, signature generation (adding MICs to outbound frames) can be disabled for selected WLANs, and validation can be disabled for selected access points.

Client MFP is enabled by default on WLANs that are configured for WPA2. It can be disabled, or it can be made mandatory (in which case only clients that negotiate MFP are allowed to associate) on selected WLANs.

You can configure MFP through either the GUI or the CLI.

Guidelines for Using MFP

Follow these guidelines for using MFP:

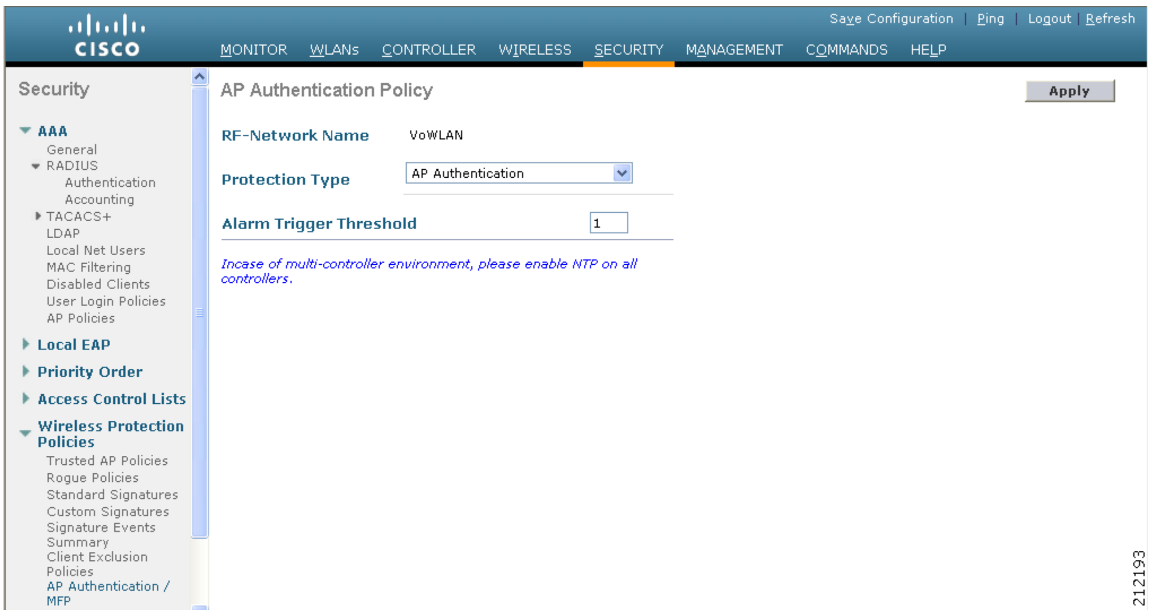
- MFP is supported for use with Cisco Aironet lightweight access points.
- Lightweight access points support infrastructure MFP in local and monitor modes and in hybrid-REAP mode when the access point is connected to a controller. They support Client MFP in local, hybrid-REAP, and bridge modes.
- Client MFP is supported for use only with CCXv5 clients using WPA2 with TKIP or AES-CCMP.
- Non-CCXv5 clients may associate to a WLAN if client MFP is disabled or optional.

Using the GUI to Configure MFP

Follow these steps to configure MFP using the controller GUI.

Step 1 Choose **Security** > **Wireless Protection Policies** > **AP Authentication/MFP**. The AP Authentication Policy page appears (see Figure 5-38).

Figure 5-38 AP Authentication Policy Page



Step 2 To enable infrastructure MFP globally for the controller, choose **Management Frame Protection** from the Protection Type drop-down box.

Step 3 Click **Apply** to commit your changes.

Note If more than one controller is included in the mobility group, you must configure a Network Time Protocol (NTP) server on all controllers in the mobility group that are configured for infrastructure MFP.

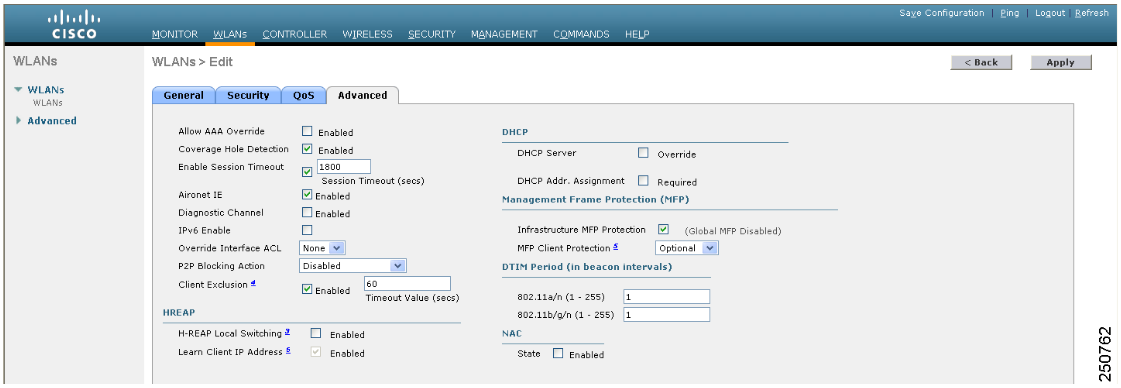
Step 4 Follow these steps if you want to disable or re-enable infrastructure MFP for a particular WLAN after MFP has been enabled globally for the controller:

a. Choose **WLANs**.

b. Click the profile name of the desired WLAN. The WLANs > Edit page appears.

c. Choose **Advanced**. The WLANs > Edit (Advanced) page appears (see Figure 5-39).

Figure 5-39 WLANs > Edit (Advanced) Page



d. Uncheck the **Infrastructure MFP Protection** check box to disable MFP for this WLAN or check this check box to enable infrastructure MFP for this WLAN. The default value is enabled. If global MFP is disabled, a note appears in parentheses to the right of the check box.

e. Choose **Disabled**, **Optional**, or **Required** from the MFP Client Protection drop-down box. The default value is Optional. If you choose Required, clients are allowed to associate only if MFP is negotiated (that is, if WPA2 is configured on the controller and the client supports CCXv5 MFP and is also configured for WPA2).

f. Click **Apply** to commit your changes.

Step 5 Follow these steps if you want to disable or re-enable infrastructure MFP validation for a particular access point after infrastructure MFP has been enabled globally for the controller:

a. Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

b. Click the name of the desired access point.

c. Choose the **Advanced** tab. The All APs > Details for (Advanced) page appears.

d. Uncheck the **MFP Frame Validation** check box to disable MFP for this access point or check this check box to enable MFP for this access point. The default value is enabled. If global MFP is disabled, a note appears in parentheses to the right of the check box.

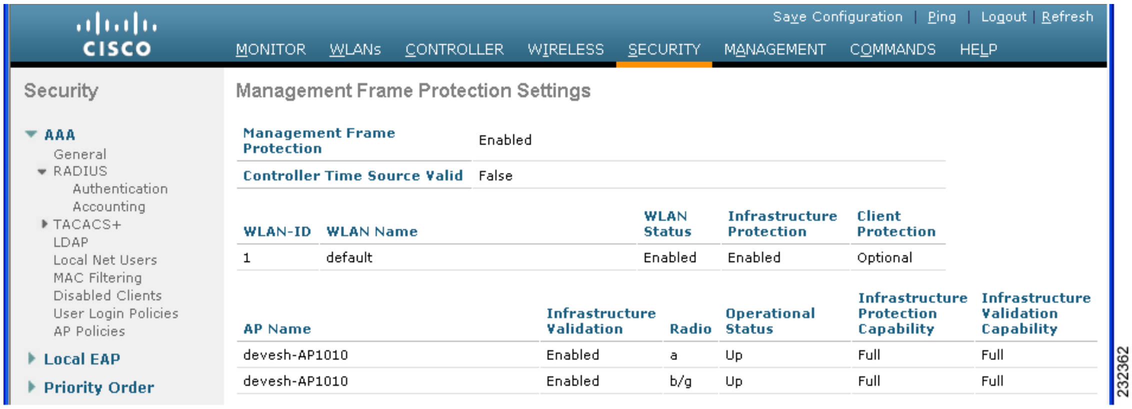
e. Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your settings.

Using the GUI to View MFP Settings

To see the controller's current global MFP settings, choose **Security** > **Wireless Protection Policies** > **Management Frame Protection**. The Management Frame Protection Settings page appears (see Figure 5-40).

Figure 5-40 Management Frame Protection Settings Page



On this page, you can see the following MFP settings:

- The Management Frame Protection field shows if infrastructure MFP is enabled globally for the controller.
- The Controller Time Source Valid field indicates whether the controller time is set locally (by manually entering the time) or through an external source (such as NTP server). If the time is set by an external source, the value of this field is “True.” If the time is set locally, the value is “False.” The time source is used for validating the timestamp on management frames between access points of different controllers within a mobility group.
- The Infrastructure Protection field shows if infrastructure MFP is enabled for individual WLANs.
- The Client Protection field shows if client MFP is enabled for individual WLANs and whether it is optional or required.
- The Infrastructure Validation field shows if infrastructure MFP is enabled for individual access points.

Using the CLI to Configure MFP

Use these commands to configure MFP using the controller CLI.

1. To enable or disable infrastructure MFP globally for the controller, enter this command:

   config wps mfp infrastructure {**enable** | **disable**}

2. To enable or disable infrastructure MFP signature generation on a WLAN, enter this command:

   config wlan mfp infrastructure protection {**enable** | **disable**} *wlan_id*

   Note Signature generation is activated only if infrastructure MFP is globally enabled.

3. To enable or disable infrastructure MFP validation on an access point, enter this command:

   config ap mfp infrastructure validation {**enable** | **disable**} *Cisco_AP*

   Note MFP validation is activated only if infrastructure MFP is globally enabled.

4. To enable or disable client MFP on a specific WLAN, enter this command:

   config wlan mfp client {**enable** | **disable**} *wlan_id* [**required**]

   If you enable client MFP and use the optional **required** parameter, clients are allowed to associate only if MFP is negotiated.

Using the CLI to View MFP Settings

Use these commands to view MFP settings using the controller CLI.

1. To see the controller's current MFP settings, enter this command:

   show wps mfp summary

   Information similar to the following appears:

```
Global Infrastructure MFP state.... Enabled
Controller Time Source Valid....... False

                    WLAN       Infra.      Client
WLAN ID  WLAN Name Status     Protection  Protection
-------  ---------- -------- ----------  -----------
1        test1      Enabled   Disabled   Disabled
2        open       Enabled   Enabled    Required
3        testpsk    Enabled   *Enabled   Optional but inactive (WPA2 not configured)

        Infra.            Operational     --Infra. Capability--
AP Name  Validation  Radio  State           Protection  Validation
-------- ----------- -----  -----------  ----------- -----------
mapAP   Disabled    a      Up              Full        Full
                    b/g    Up              Full        Full
rootAP2  Enabled    a      Up              Full        Full
                    b/g    Up              Full        Full
HReap   *Enabled    b/g    Up             Full        Full
                    a      Down           Full        Full
```

2. To see the current MFP configuration for a particular WLAN, enter this command:

   show wlan *wlan_id*

   Information similar to the following appears:

```
WLAN Identifier.......................... 1
Profile Name............................. test1
Network Name (SSID)...................... test1
Status................................... Enabled
MAC Filtering............................ Disabled
Broadcast SSID........................... Enabled
...
Local EAP Authentication................. Enabled (Profile 'test')
Diagnostics Channel...................... Disabled
Security

   802.11 Authentication:................ Open System
   Static WEP Keys....................... Disabled
   802.1X................................ Enabled
        Encryption:.............................. 104-bit WEP
   Wi-Fi Protected Access (WPA/WPA2)...... Disabled
   CKIP ................................. Disabled
   IP Security........................... Disabled
   IP Security Passthru.................. Disabled
   Web Based Authentication.............. Disabled
   Web-Passthrough....................... Disabled
```

```
   Conditional Web Redirect............... Disabled
   Auto Anchor............................ Enabled
    H-REAP Local Switching................ Disabled
   Infrastructure MFP protection.......... Enabled
   Client MFP............................. Required
...
```

3. To see the current MFP configuration for a particular access point, enter this command:

   show ap config general *AP_name*

   Information similar to the following appears:

```
Cisco AP Identifier.............................. 0
Cisco AP Name.................................... ap:52:c5:c0
AP Regulatory Domain............................. 80211bg: -N 80211a: -N
Switch Port Number .............................. 1
MAC Address...................................... 00:0b:85:52:c5:c0
IP Address Configuration......................... Static IP assigned
IP Address....................................... 10.67.73.33
IP NetMask....................................... 255.255.255.192
...
AP Mode ......................................... Local
Remote AP Debug ................................. Disabled
S/W  Version .................................... 4.0.2.0
Boot  Version ................................... 2.1.78.0
Mini IOS Version ................................      --
Stats Reporting Period .......................... 180
LED State........................................ Enabled
ILP Pre Standard Switch.......................... Disabled
ILP Power Injector............................... Disabled
Number Of Slots.................................. 2
AP Model......................................... AP1020
AP Serial Number................................. WCN09260057
AP Certificate Type.............................. Manufacture Installed
Management Frame Protection Validation .......... Enabled
```

4. To see whether client MFP is enabled for a specific client, enter this command:

   show client detail *client_mac*

```
Client MAC Address............................... 00:14:1c:ed:34:72
...
Policy Type...................................... WPA2
Authentication Key Management.................... PSK
Encryption Cipher................................ CCMP (AES)
Management Frame Protection...................... Yes
...
```

5. To see MFP statistics for the controller, enter this command:

   show wps mfp statistics

   Information similar to the following appears:

Note This report contains no data unless an active attack is in progress. Examples of various error types are shown for illustration only. This table is cleared every 5 minutes when the data is forwarded to any network management stations.

```
BSSID             Radio Validator AP Last Source Addr  Found  Error Type Count Frame Types
----------------- ----- ------------- ----------------- ------ ------------ ----- -------
00:0b:85:56:c1:a0  a    jatwo-1000b 00:01:02:03:04:05 Infra  Invalid MIC 183  Assoc Req
                                                                               Probe Req
                                                                               Beacon
                                                     Infra  Out of seq     4   Assoc Req
                                                     Infra  Unexpected MIC 85 Reassoc Req
                                                     Client Decrypt err  1974 Reassoc Req
                                                                               Disassoc
                                                     Client Replay err     74 Assoc Req
                                                                               Probe Req
                                                                               Beacon
                                                     Client Invalid ICV   174 Reassoc Req
                                                                               Disassoc
                                                     Client Invalid header174 Assoc Req
                                                                               Probe Req
                                                                               Beacon
                                                     Client Brdcst disass 174 Reassoc Req
                                                                               Disassoc
00:0b:85:56:c1:a0  b/g  jatwo-1000b 00:01:02:03:04:05 Infra  Out of seq  185 Reassoc Resp
                                                     Client Not encrypted 174 Assoc Resp
                                                                               Probe Resp
```

Using the CLI to Debug MFP Issues

Use these commands if you experience any problems with MFP:

- **debug wps mfp** *?* {**enable** | **disable**}

  where *?* is one of the following:

  client—Configures debugging for client MFP messages.

  capwap—Configures debugging for MFP messages between the controller and access points.

  detail—Configures detailed debugging for MFP messages.

  report—Configures debugging for MFP reporting.

  mm—Configures debugging for MFP mobility (inter-controller) messages.

Configuring Client Exclusion Policies

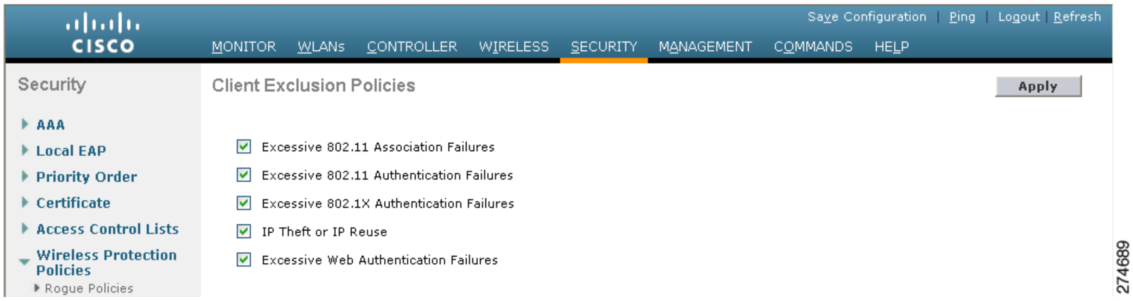
This section explains how to configure the controller to exclude clients under certain conditions using the controller GUI or CLI.

Using the GUI to Configure Client Exclusion Policies

Using the controller GUI, follow these steps to configure client exclusion policies.

Step 1 Choose **Security** > **Wireless Protection Policies** > **Client Exclusion Policies** to open the Client Exclusion Policies page (see Figure 5-41).

Figure 5-41 Client Exclusion Policies Page



Step 2 Check any of these check boxes if you want the controller to exclude clients for the condition specified. The default value for each exclusion policy is enabled.

- **Excessive 802.11 Association Failures**—Clients are excluded on the sixth 802.11 association attempt, after five consecutive failures.
- **Excessive 802.11 Authentication Failures**—Clients are excluded on the sixth 802.11 authentication attempt, after five consecutive failures.
- **Excessive 802.1X Authentication Failures**—Clients are excluded on the fourth 802.1X authentication attempt, after three consecutive failures.
- **IP Theft or IP Reuse**—Clients are excluded if the IP address is already assigned to another device.
- **Excessive Web Authentication Failures**—Clients are excluded on the fourth web authentication attempt, after three consecutive failures.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure Client Exclusion Policies

Using the controller CLI, follow these steps to configure client exclusion policies.

Step 1 To enable or disable the controller to exclude clients on the sixth 802.11 association attempt, after five consecutive failures, enter this command:

config wps client-exclusion 802.11-assoc {**enable** | **disable**}

Step 2 To enable or disable the controller to exclude clients on the sixth 802.11 authentication attempt, after five consecutive failures, enter this command:

config wps client-exclusion 802.11-auth {**enable** | **disable**}

Step 3 To enable or disable the controller to exclude clients on the fourth 802.1X authentication attempt, after three consecutive failures, enter this command:

config wps client-exclusion 802.1x-auth {**enable** | **disable**}

Step 4 To enable or disable the controller to exclude clients if the IP address is already assigned to another device, enter this command:

config wps client-exclusion ip-theft {**enable** | **disable**}

Step 5 To enable or disable the controller to exclude clients on the fourth web authentication attempt, after three consecutive failures, enter this command:

config wps client-exclusion web-auth {**enable** | **disable**}

Step 6 To enable or disable the controller to exclude clients for all of the above reasons, enter this command:

config wps client-exclusion all {**enable** | **disable**}

Step 7 To save your changes, enter this command:

save config

Step 8 To see the client exclusion policy configuration settings, enter this command:

show wps summary

Information similar to the following appears:

```
Auto-Immune
  Auto-Immune.................................... Disabled

Client Exclusion Policy
  Excessive 802.11-association failures.......... Enabled
  Excessive 802.11-authentication failures....... Enabled
  Excessive 802.1x-authentication................ Enabled
  IP-theft....................................... Enabled
  Excessive Web authentication failure........... Enabled

Signature Policy
  Signature Processing....................... Enabled
```

Configuring Identity Networking

These sections explain the identity networking feature, how it is configured, and the expected behavior for various security policies:

- Identity Networking Overview, page 5-78
- RADIUS Attributes Used in Identity Networking, page 5-79
- Configuring AAA Override, page 5-82

Identity Networking Overview

In most wireless LAN systems, each WLAN has a static policy that applies to all clients associated with an SSID. Although powerful, this method has limitations because it requires clients to associate with different SSIDs to inherit different QoS and security policies.

However, the Cisco Wireless LAN Solution supports identity networking, which allows the network to advertise a single SSID but allows specific users to inherit different QoS or security policies based on their user profiles. The specific policies that you can control using identity networking include:

- Quality of Service. When present in a RADIUS Access Accept, the QoS-Level value overrides the QoS value specified in the WLAN profile.
- ACL. When the ACL attribute is present in the RADIUS Access Accept, the system applies the ACL-Name to the client station after it authenticates. This overrides any ACLs that are assigned to the interface.

- VLAN. When a VLAN Interface-Name or VLAN-Tag is present in a RADIUS Access Accept, the system places the client on a specific interface.

Note The VLAN feature only supports MAC filtering, 802.1X, and WPA. The VLAN feature does not support web authentication or IPSec.

- Tunnel Attributes.

Note When any of the other RADIUS attributes (QoS-Level, ACL-Name, Interface-Name, or VLAN-Tag), which are described later in this section, are returned, the Tunnel Attributes must also be returned.

The operating system's local MAC filter database has been extended to include the interface name, allowing local MAC filters to specify to which interface the client should be assigned. A separate RADIUS server can also be used, but the RADIUS server must be defined using the Security menus.

RADIUS Attributes Used in Identity Networking

This section explains the RADIUS attributes used in identity networking.

QoS-Level

This attribute indicates the Quality of Service level to be applied to the mobile client's traffic within the switching fabric, as well as over the air. This example shows a summary of the QoS-Level Attribute format. The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |  Length       |            Vendor-Id
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     Vendor-Id (cont.)          | Vendor type   | Vendor length |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           QoS Level                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- Type – 26 for Vendor-Specific
- Length – 10
- Vendor-Id – 14179
- Vendor type – 2
- Vendor length – 4
- Value – Three octets:
  - 3 – Bronze (Background)
  - 0 – Silver (Best Effort)
  - 1 – Gold (Video)
  - 2 – Platinum (Voice)

ACL-Name

This attribute indicates the ACL name to be applied to the client. A summary of the ACL-Name Attribute format is shown below. The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |  Length       |            Vendor-Id
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     Vendor-Id (cont.)          | Vendor type   | Vendor length |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        ACL Name...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

- Type – 26 for Vendor-Specific
- Length – >7
- Vendor-Id – 14179
- Vendor type – 6
- Vendor length – >0
- Value – A string that includes the name of the ACL to use for the client

Interface-Name

This attribute indicates the VLAN Interface a client is to be associated to. A summary of the Interface-Name Attribute format is shown below. The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |  Length       |            Vendor-Id
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     Vendor-Id (cont.)          |  Vendor type  | Vendor length |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Interface Name...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

- Type – 26 for Vendor-Specific
- Length – >7
- Vendor-Id – 14179
- Vendor type – 5
- Vendor length – >0
- Value – A string that includes the name of the interface the client is to be assigned to.

Note This Attribute only works when MAC filtering is enabled or if 802.1X or WPA is used as the security policy.

VLAN-Tag

This attribute indicates the group ID for a particular tunneled session, and is also known as the Tunnel-Private-Group-ID attribute.

This attribute might be included in the Access-Request packet if the tunnel initiator can predetermine the group resulting from a particular connection and should be included in the Access-Accept packet if this tunnel session is to be treated as belonging to a particular private group. Private groups may be used to associate a tunneled session with a particular group of users. For example, it may be used to facilitate routing of unregistered IP addresses through a particular interface. It should be included in Accounting-Request packets which contain Acct-Status-Type attributes with values of either Start or Stop and which pertain to a tunneled session.

A summary of the Tunnel-Private-Group-ID Attribute format is shown below. The fields are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Type     |    Length     |     Tag       |   String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- Type – 81 for Tunnel-Private-Group-ID.
- Length – >= 3
- Tag – The Tag field is one octet in length and is intended to provide a means of grouping attributes in the same packet which refer to the same tunnel. If the value of the Tag field is greater than 0x00 and less than or equal to 0x1F, it should be interpreted as indicating which tunnel (of several alternatives) this attribute pertains. If the Tag field is greater than 0x1F, it should be interpreted as the first byte of the following String field.
- String – This field must be present. The group is represented by the String field. There is no restriction on the format of group IDs.

Tunnel Attributes

Note When any of the other RADIUS attributes (QoS-Level, ACL-Name, Interface-Name, or VLAN-Tag) are returned, the Tunnel Attributes must also be returned.

Reference RFC2868 defines RADIUS tunnel attributes used for authentication and authorization, and RFC2867 defines tunnel attributes used for accounting. Where the IEEE 802.1X Authenticator supports tunneling, a compulsory tunnel may be set up for the Supplicant as a result of the authentication.

In particular, it may be desirable to allow a port to be placed into a particular Virtual LAN (VLAN), defined in IEEE8021Q, based on the result of the authentication. This can be used, for example, to allow a wireless host to remain on the same VLAN as it moves within a campus network.

The RADIUS server typically indicates the desired VLAN by including tunnel attributes within the Access-Accept. However, the IEEE 802.1X Authenticator may also provide a hint as to the VLAN to be assigned to the Supplicant by including Tunnel attributes within the Access- Request.

For use in VLAN assignment, the following tunnel attributes are used:

- Tunnel-Type=VLAN (13)
- Tunnel-Medium-Type=802
- Tunnel-Private-Group-ID=VLANID

Note that the VLANID is 12-bits, taking a value between 1 and 4094, inclusive. Since the Tunnel-Private-Group-ID is of type String as defined in RFC2868, for use with IEEE 802.1X, the VLANID integer value is encoded as a string.

When Tunnel attributes are sent, it is necessary to fill in the Tag field. As noted in RFC2868, section 3.1:

- The Tag field is one octet in length and is intended to provide a means of grouping attributes in the same packet which refer to the same tunnel. Valid values for this field are 0x01 through 0x1F, inclusive. If the Tag field is unused, it must be zero (0x00).
- For use with Tunnel-Client-Endpoint, Tunnel-Server-Endpoint, Tunnel-Private-Group-ID, Tunnel-Assignment-ID, Tunnel-Client-Auth-ID or Tunnel-Server-Auth-ID attributes (but not Tunnel-Type, Tunnel-Medium-Type, Tunnel-Password, or Tunnel-Preference), a tag field of greater than 0x1F is interpreted as the first octet of the following field.
- Unless alternative tunnel types are provided, (e.g. for IEEE 802.1X Authenticators that may support tunneling but not VLANs), it is only necessary for tunnel attributes to specify a single tunnel. As a result, where it is only desired to specify the VLANID, the tag field should be set to zero (0x00) in all tunnel attributes. Where alternative tunnel types are to be provided, tag values between 0x01 and 0x1F should be chosen.

Configuring AAA Override

The Allow AAA Override option of a WLAN allows you to configure the WLAN for identity networking. It allows you to apply VLAN tagging, QoS, and ACLs to individual clients based on the returned RADIUS attributes from the AAA server.

Note If a client moves to a new interface due to the AAA override and then you apply an ACL to that interface, the ACL does not take effect until the client reauthenticates. To work around this issue, apply the ACL and then enable the WLAN so that all clients connect to the ACL already configured on the interface, or disable and then re-enable the WLAN after you apply the interface so that the clients can reauthenticate.

Most of the configuration for allowing AAA override is done at the RADIUS server, where you should configure the Access Control Server (ACS) with the override properties you would like it to return to the controller (for example, Interface-Name, QoS-Level, and VLAN-Tag).

On the controller, simply enable the Allow AAA Override configuration parameter using the GUI or CLI. Enabling this parameter allows the controller to accept the attributes returned by the RADIUS server. The controller then applies these attributes to its clients.

Updating the RADIUS Server Dictionary File for Proper QoS Values

If you are using a Steel-Belted RADIUS (SBR), FreeRadius, or similar RADIUS server, clients may not obtain the correct QoS values after the AAA override feature is enabled. For these servers, which allow you to edit the dictionary file, you need to update the file to reflect the proper QoS values: Silver = 0, Gold = 1, Platinum = 2, and Bronze = 3. Follow the steps below to do so.

Note This issue does not apply to the Cisco Secure Access Control Server (ACS).

Step 1 Stop the SBR service (or other RADIUS service).

Step 2 Save the following text to the Radius_Install_Directory\Service folder as ciscowlan.dct:

```
################################################################################
# CiscoWLAN.dct- Cisco Wireless Lan Controllers
#
# (See README.DCT for more details on the format of this file)
################################################################################

# Dictionary - Cisco WLAN Controllers
#
# Start with the standard Radius specification attributes
#
@radius.dct
#
# Standard attributes supported by Airespace
#
# Define additional vendor specific attributes (VSAs)
#

MACRO Airespace-VSA(t,s) 26 [vid=14179 type1=%t% len1=+2 data=%s%]

ATTRIBUTE   WLAN-Id                 Airespace-VSA(1, integer)     cr
ATTRIBUTE   Aire-QoS-Level         Airespace-VSA(2, integer)     r
VALUE Aire-QoS-Level Bronze  3
VALUE Aire-QoS-Level Silver   0
VALUE Aire-QoS-Level Gold     1
VALUE Aire-QoS-Level Platinum 2

ATTRIBUTE   DSCP                    Airespace-VSA(3, integer)     r
ATTRIBUTE   802.1P-Tag              Airespace-VSA(4, integer)     r
ATTRIBUTE   Interface-Name          Airespace-VSA(5, string)      r
ATTRIBUTE   ACL-Name                Airespace-VSA(6, string)      r

# This should be last.

################################################################################
# CiscoWLAN.dct - Cisco WLC dictionary
##############################################################################
```

Step 3 Open the dictiona.dcm file (in the same directory) and add the line "@ciscowlan.dct."

Step 4 Save and close the dictiona.dcm file.

Step 5 Open the vendor.ini file (in the same directory) and add the following text:

```
vendor-product       = Cisco WLAN Controller
dictionary           = ciscowlan
ignore-ports         = no
port-number-usage    = per-port-type
help-id             =
```

Step 6 Save and close the vendor.ini file.

Step 7 Start the SBR service (or other RADIUS service).

Step 8 Launch the SBR Administrator (or other RADIUS Administrator).

Step 9 Add a RADIUS client (if not already added). Choose **Cisco WLAN Controller** from the Make/Model drop-down box.

Using the GUI to Configure AAA Override

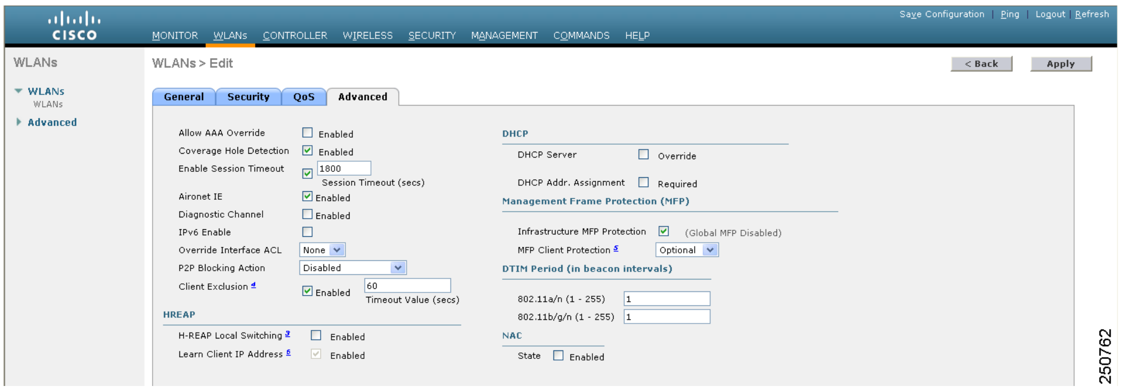
Follow these steps to configure AAA override using the controller GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN that you want to configure. The WLANs > Edit page appears.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 5-42).

Figure 5-42 WLANs > Edit (Advanced) Page



Step 4 Check the **Allow AAA Override** check box to enable AAA override or uncheck it to disable this feature. The default value is disabled.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure AAA Override

Use this command to enable or disable AAA override using the controller CLI:

config wlan aaa-override {**enable** | **disable**} *wlan_id*

For *wlan_id*, enter an ID from 1 to 16.

Managing Rogue Devices

This section describes security solutions for rogue devices. A rogue device is an unknown access point or client that is detected by managed access points in your network as not belonging to your system.

Challenges

Rogue access points can disrupt wireless LAN operations by hijacking legitimate clients and using plain-text or other denial-of-service or man-in-the-middle attacks. That is, a hacker can use a rogue access point to capture sensitive information, such as usernames and passwords. The hacker can then transmit a series of clear-to-send (CTS) frames. This action mimics an access point informing a particular client to transmit and instructing all others to wait, which results in legitimate clients being unable to access network resources. Therefore, wireless LAN service providers have a strong interest in banning rogue access points from the air space.

Because rogue access points are inexpensive and readily available, employees sometimes plug unauthorized rogue access points into existing LANs and build ad-hoc wireless networks without IT department knowledge or consent. These rogue access points can be a serious breach of network security as they can be plugged into a network port behind the corporate firewall. Because employees generally do not enable any security settings on the rogue access point, it is easy for unauthorized users to use the access point to intercept network traffic and hijack client sessions. Even more alarming, wireless users frequently publish unsecure access point locations, increasing the odds of having enterprise security breached.

Detecting Rogue Devices

The controller continuously monitors all nearby access points and automatically discovers and collects information on rogue access points and clients. When the controller discovers a rogue access point, it uses the Rogue Location Discovery Protocol (RLDP) to determine if the rogue is attached to your network.

You can configure the controller to use RLDP on all access points or only on access points configured for monitor (listen-only) mode. The latter option facilitates automated rogue access point detection in a crowded RF space, allowing monitoring without creating unnecessary interference and without affecting regular data access point functionality. If you configure the controller to use RLDP on all access points, the controller always chooses the monitor access point for RLDP operation if a monitor access point and a local (data) access point are both nearby. If RLDP determines that the rogue is on your network, you can choose to either manually or automatically contain the detected rogue.

Classifying Rogue Access Points

Controller software release 5.0 or later improves the classification and reporting of rogue access points through the use of rogue states and user-defined classification rules that enable rogues to automatically move between states. In previous releases, the controller listed all rogue access points on one page sorted by MAC address or BSSID. Now you can create rules that enable the controller to organize and display rogue access points as Friendly, Malicious, or Unclassified.

By default, none of the classification rules are enabled. Therefore, all unknown access points are categorized as Unclassified. When you create a rule, configure conditions for it, and enable the rule, the unclassified access points are reclassified. Whenever you change a rule, it is applied to all access points (friendly, malicious, and unclassified) in the Alert state only.

Note Rule-based rogue classification does not apply to ad-hoc rogues and rogue clients.

Note The 5500 series controllers support up to 2000 rogues (including acknowledged rogues); the 4400 series controllers, Cisco WiSM, and Catalyst 3750G Integrated Wireless LAN Controller Switch support up to 625 rogues; and the 2100 series controllers and Controller Network Module for Integrated Services Routers support up to 125 rogues. Each controller limits the number of rogue containments to three per radio (or six per radio for access points in monitor mode).

When the controller receives a rogue report from one of its managed access points, it responds as follows:

1. The controller verifies that the unknown access point is in the friendly MAC address list. If it is, the controller classifies the access point as Friendly.
2. If the unknown access point is not in the friendly MAC address list, the controller starts applying rogue classification rules.
3. If the rogue is already classified as Malicious, Alert or Friendly, Internal or External, the controller does not reclassify it automatically. If the rogue is classified differently, the controller reclassifies it automatically only if the rogue is in the Alert state.
4. The controller applies the first rule based on priority. If the rogue access point matches the criteria specified by the rule, the controller classifies the rogue according to the classification type configured for the rule.
5. If the rogue access point does not match any of the configured rules, the controller classifies the rogue as Unclassified.
6. The controller repeats the previous steps for all rogue access points.
7. If RLDP determines that the rogue access point is on the network, the controller marks the rogue state as Threat and classifies it as Malicious automatically, even if no rules are configured. You can then manually contain the rogue (unless you have configured RLDP to automatically contain the rogue), which would change the rogue state to Contained. If the rogue access point is not on the network, the controller marks the rogue state as Alert, and you can manually contain the rogue.
8. If desired, you can manually move the access point to a different classification type and rogue state.

Table 5-8 shows the rogue states that can be adopted by a rogue access point in a particular classification type.

Table 5-8 Classification Mapping

Rule-Based Classification Type	Rogue States
Friendly	• Internal—If the unknown access point is inside the network and poses no threat to WLAN security, you would manually configure it as Friendly, Internal. For example, the access points in your lab network. • External—If the unknown access point is outside the network and poses no threat to WLAN security, you would manually configure it as Friendly, External. For example, the access points belonging to a neighboring coffee shop. • Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list.
Malicious	• Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list. • Threat—The unknown access point is found to be on the network and poses a threat to WLAN security. • Contained—The unknown access point is contained. • Contained Pending—The unknown access point is marked Contained, but the action is delayed due to unavailable resources.

Table 5-8 Classification Mapping (continued)

Rule-Based Classification Type	Rogue States
Unclassified	• Pending—On first detection, the unknown access point is put in the Pending state for 3 minutes. During this time, the managed access points determine if the unknown access point is a neighbor access point. • Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list. • Contained—The unknown access point is contained. • Contained Pending—The unknown access point is marked Contained, but the action is delayed due to unavailable resources.

If you upgrade to controller software release 5.0 or later, the classification and state of the rogue access points are reconfigured as follows:

- From Known to Friendly, Internal.
- From Acknowledged to Friendly, External.
- From Contained to Malicious, Contained.

As mentioned previously, the controller can automatically change the classification type and rogue state of an unknown access point based on user-defined rules, or you can manually move the unknown access point to a different classification type and rogue state. Table 5-9 shows the allowable classification types and rogue states from and to which an unknown access point can be configured.

Table 5-9 Allowable Classification Type and Rogue State Transitions

From	To
Friendly (Internal, External, Alert)	Malicious (Alert)
Friendly (Internal, External, Alert)	Unclassified (Alert)
Friendly (Alert)	Friendly (Internal, External)
Malicious (Alert, Threat)	Friendly (Internal, External)
Malicious (Contained, Contained Pending)	Malicious (Alert)
Unclassified (Alert, Threat)	Friendly (Internal, External)
Unclassified (Contained, Contained Pending)	Unclassified (Alert)
Unclassified (Alert)	Malicious (Alert)

If the rogue state is Contained, you have to uncontain the rogue access point before you can change the classification type. If you want to move a rogue access point from Malicious to Unclassified, you must delete the access point and allow the controller to reclassify it.

WCS Interaction

WCS software release 5.0 or later also supports rule-based classification. WCS uses the classification rules configured on the controller. The controller sends traps to WCS after the following events:

- If an unknown access point moves to Friendly for the first time, the controller sends a trap to WCS only if the rogue state is Alert. It does not send a trap if the rogue state is Internal or External.
- If a rogue entry is removed after the timeout expires, the controller sends a trap to WCS for rogue access points categorized as Malicious (Alert, Threat) or Unclassified (Alert). The controller does not remove rogue entries with the following rogue states: Contained, Contained Pending, Internal, and External.

Configuring RLDP

You can configure RLDP to automatically detect and contain rogue devices using the controller GUI or CLI.

Using the GUI to Configure RLDP

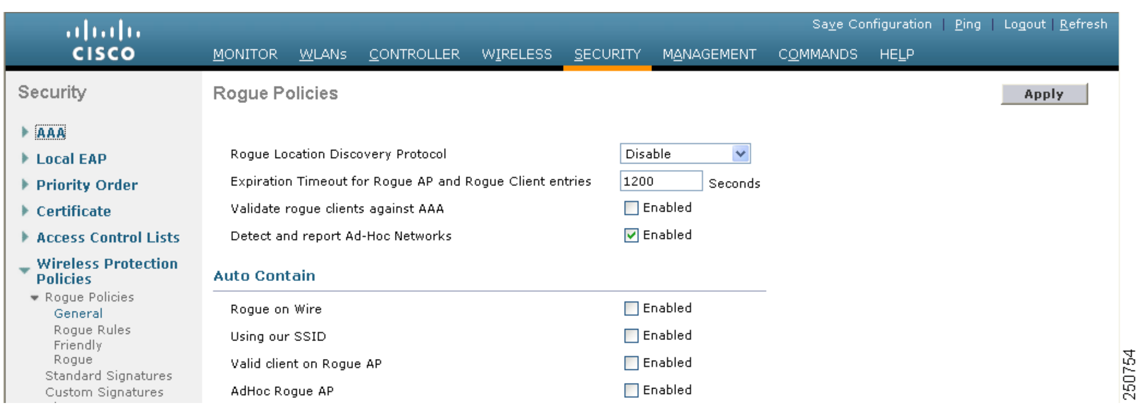
Using the controller GUI, follow these steps to configure RLDP.

Step 1 Make sure that rogue detection is enabled on the desired access points. Rogue detection is enabled by default for all access points joined to the controller (except for OfficeExtend access points). However, in controller software release 6.0, you can enable or disable it for individual access points by checking or unchecking the **Rogue Detection** check box on the All APs > Details for (Advanced) page.

> **Note** Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect a large number of rogue devices.

Step 2 Choose **Security** > **Wireless Protection Policies** > **Rogue Policies** > **General** to open the Rogue Policies page (see Figure 5-43).

Figure 5-43 Rogue Policies Page



Step 3 Choose one of the following options from the Rogue Location Discovery Protocol drop-down box:

- **Disable—**Disables RLDP on all access points. This is the default value.
- **All APs—**Enables RLDP on all access points.
- **Monitor Mode APs**—Enables RLDP only on access points in monitor mode.

Step 4 In the Expiration Timeout for Rogue AP and Rogue Client Entries field, enter the number of seconds after which the rogue access point and client entries expire and are removed from the list. The valid range is 240 to 3600 seconds, and the default value is 1200 seconds.

Note If a rogue access point or client entry times out, it is removed from the controller only if its rogue state is Alert or Threat for any classification type.

Step 5 If desired, check the **Validate Rogue Clients Against AAA** check box to use the AAA server or local database to validate if rogue clients are valid clients. The default value is unchecked.

Step 6 If desired, check the **Detect and Report Ad-Hoc Networks** check box to enable ad-hoc rogue detection and reporting. The default value is checked.

Step 7 If you want the controller to automatically contain certain rogue devices, check the following check boxes. Otherwise, leave the check boxes unchecked, which is the default value.

Caution When you enable any of these parameters, the following warning appears: "Using this feature may have legal consequences. Do you want to continue?" The 2.4- and 5-GHz frequencies in the Industrial, Scientific, and Medical (ISM) band are open to the public and can be used without a license. As such, containing devices on another party's network could have legal consequences.

- **Rogue on Wire**—Automatically contains rogues that are detected on the wired network.
- **Using Our SSID**—Automatically contains rogues that are advertising your network's SSID. If you leave this parameter unchecked, the controller only generates an alarm when such a rogue is detected.
- **Valid Client on Rogue AP**—Automatically contains a rogue access point to which trusted clients are associated. If you leave this parameter unchecked, the controller only generates an alarm when such a rogue is detected.
- **AdHoc Rogue AP**—Automatically contains adhoc networks detected by the controller. If you leave this parameter unchecked, the controller only generates an alarm when such a network is detected.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure RLDP

Using the controller CLI, follow these steps to configure RLDP.

Step 1 Make sure that rogue detection is enabled on the desired access points. Rogue detection is enabled by default for all access points joined to the controller (except for OfficeExtend access points). However, in controller software release 6.0, you can enable or disable it for individual access points by entering this command: **config rogue detection** {**enable** | **disable**} *Cisco_AP*.

Note To see the current rogue detection configuration for a specific access point, enter this command: **show ap config general** *Cisco_AP*.

Note Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect a large number of rogue devices.

Step 2 To enable, disable, or initiate RLDP, enter these commands:

- **config rogue ap rldp enable alarm-only**—Enables RLDP on all access points.
- **config rogue ap rldp enable alarm-only** *monitor_ap_only*—Enables RLDP only on access points in monitor mode.
- **config rogue ap rldp initiate** *rogue_mac_address*—Initiates RLDP on a specific rogue access point.
- **config rogue ap rldp disable**—Disables RLDP on all access points.

Step 3 To specify the number of seconds after which the rogue access point and client entries expire and are removed from the list, enter this command:

config rogue ap timeout *seconds*

The valid range for the *seconds* parameter is 240 to 3600 seconds (inclusive), and the default value is 1200 seconds.

Note If a rogue access point or client entry times out, it is removed from the controller only if its rogue state is Alert or Threat for any classification type.

Step 4 To enable or disable ad-hoc rogue detection and reporting, enter this command:

config rogue adhoc {**enable** | **disable**}

Step 5 To enable or disable the AAA server or local database to validate if rogue clients are valid clients, enter this command:

config rogue client aaa {**enable** | **disable**}

Step 6 If you want the controller to automatically contain certain rogue devices, enter these commands.

Caution When you enter any of these commands, the following warning appears: "Using this feature may have legal consequences. Do you want to continue?" The 2.4- and 5-GHz frequencies in the Industrial, Scientific, and Medical (ISM) band are open to the public and can be used without a license. As such, containing devices on another party's network could have legal consequences.

- **config rogue ap rldp enable auto-contain**—Automatically contains rogues that are detected on the wired network.
- **config rogue ap ssid auto-contain**—Automatically contains rogues that are advertising your network's SSID.

> **Note** If you want the controller to only generate an alarm when such a rogue is detected, enter this command: **config rogue ap ssid alarm**.

- **config rogue ap valid-client auto-contain**—Automatically contains a rogue access point to which trusted clients are associated.

> **Note** If you want the controller to only generate an alarm when such a rogue is detected, enter this command: **config rogue ap valid-client alarm**.

- **config rogue adhoc auto-contain**—Automatically contains adhoc networks detected by the controller.

> **Note** If you want the controller to only generate an alarm when such a network is detected, enter this command: **config rogue adhoc alert**.

Step 7 To save your changes, enter this command:

save config

Configuring Rogue Classification Rules

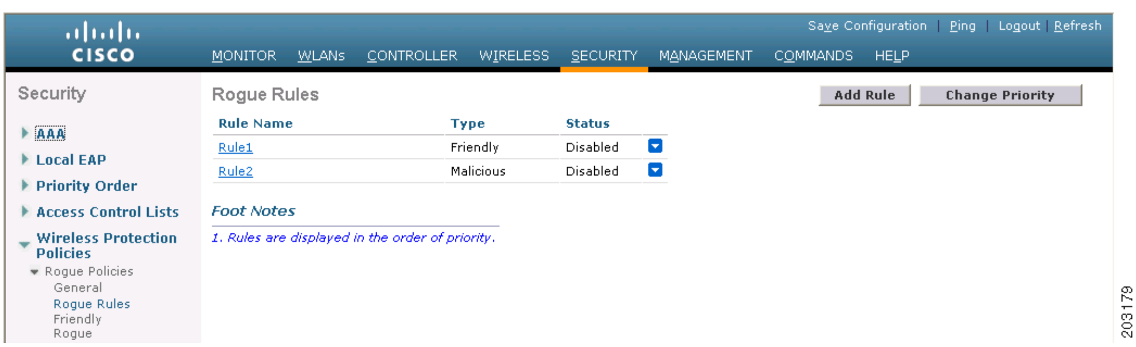
You can configure up to 64 rogue classification rules per controller using the controller GUI or CLI.

Using the GUI to Configure Rogue Classification Rules

Using the controller GUI, follow these steps to configure rogue classification rules.

Step 1 Choose **Security** > **Wireless Protection Policies** > **Rogue Policies** > **Rogue Rules** to open the Rogue Rules page (see Figure 5-44).

Figure 5-44 Rogue Rules Page



Any rules that have already been created are listed in priority order. The name, type, and status of each rule is provided.

Note If you ever want to delete a rule, hover your cursor over the blue drop-down arrow for that rule and click **Remove**.

Step 2 To create a new rule, follow these steps:

a. Click **Add Rule**. An Add Rule section appears at the top of the page.

b. In the Rule Name field, enter a name for the new rule. Make sure that the name does not contain any spaces.

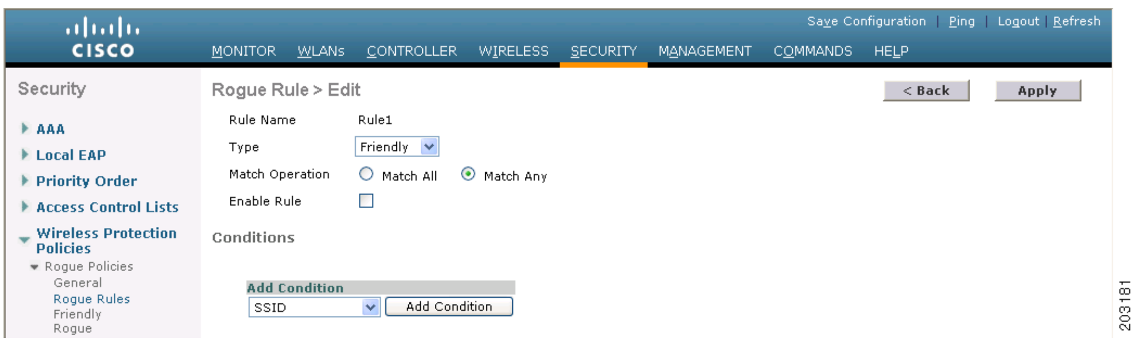
c. From the Rule Type drop-down box, choose **Friendly** or **Malicious** to classify rogue access points matching this rule as friendly or malicious.

d. Click **Add** to add this rule to the list of existing rules, or click **Cancel** to discard this new rule.

Step 3 To edit a rule, follow these steps:

a. Click the name of the rule that you want to edit. The Rogue Rule > Edit page appears (see Figure 5-45).

Figure 5-45 Rogue Rule > Edit Page



b. From the Type drop-down box, choose **Friendly** or **Malicious** to classify rogue access points matching this rule as friendly or malicious.

c. From the Match Operation field, choose one of the following:

- **Match All**—If this rule is enabled, a detected rogue access point must meet all of the conditions specified by the rule in order for the rule to be matched and the rogue to adopt the classification type of the rule.
- **Match Any—**If this rule is enabled, a detected rogue access point must meet any of the conditions specified by the rule in order for the rule to be matched and the rogue to adopt the classification type of the rule. This is the default value.

d. To enable this rule, check the **Enable Rule** check box. The default value is unchecked.

e. From the Add Condition drop-down box, choose one or more of the following conditions that the rogue access point must meet and click **Add Condition**:

- **SSID**—Requires that the rogue access point have a specific user-configured SSID. If you choose this option, enter the SSID in the User Configured SSID field, and click **Add SSID**.

Note To delete an SSID, highlight the SSID and click **Remove**.

- **RSSI**—Requires that the rogue access point have a minimum received signal strength indication (RSSI) value. For example, if the rogue access point has an RSSI that is greater than the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum RSSI value in the Minimum RSSI field. The valid range is –95 to –50 dBm (inclusive), and the default value is 0 dBm.
- **Duration**—Requires that the rogue access point be detected for a minimum period of time. If you choose this option, enter a value for the minimum detection period in the Time Duration field. The valid range is 0 to 3600 seconds (inclusive), and the default value is 0 seconds.
- **Client Count**—Requires that a minimum number of clients be associated to the rogue access point. For example, if the number of clients associated to the rogue access point is greater than or equal to the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum number of clients to be associated to the rogue access point in the Minimum Number of Rogue Clients field. The valid range is 1 to 10 (inclusive), and the default value is 0.
- **No Encryption**—Requires that the rogue access point's advertised WLAN does not have encryption enabled. If a rogue access point has encryption disabled, it is likely that more clients will try to associate to it. No further configuration is required for this option.

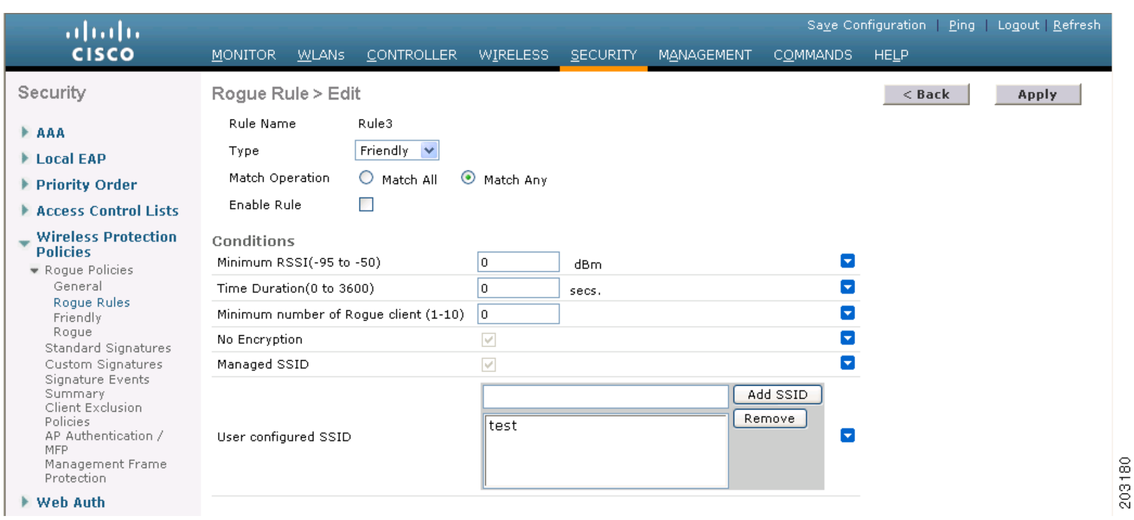
Note WCS refers to this option as "Open Authentication."

- **Managed SSID**—Requires that the rogue access point's managed SSID (the SSID configured for the WLAN) be known to the controller. No further configuration is required for this option.

Note The SSID and Managed SSID conditions cannot be used with the Match All operation as these two SSID lists are mutually exclusive. If you define a rule with Match All and have these two conditions configured, the rogue access points are never classified as friendly or malicious because one of the conditions can never be met.

You can add up to six conditions per rule. When you add a condition, it appears under the Conditions section (see Figure 5-46).

Figure 5-46 Rogue Rule > Edit Page



Note If you ever want to delete a condition from this rule, hover your cursor over the blue drop-down arrow for that condition and click **Remove**.

f. Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 If you want to change the order in which rogue classification rules are applied, follow these steps:

a. Click **Back** to return to the Rogue Rules page.

b. Click **Change Priority** to access the Rogue Rules > Priority page (see Figure 5-47).

Figure 5-47 Rogue Rules > Priority Page

The rogue rules are listed in priority order in the Change Rules Priority edit box.

c. Highlight the rule for which you want to change the priority, and click **Up** to raise its priority in the list or **Down** to lower its priority in the list.

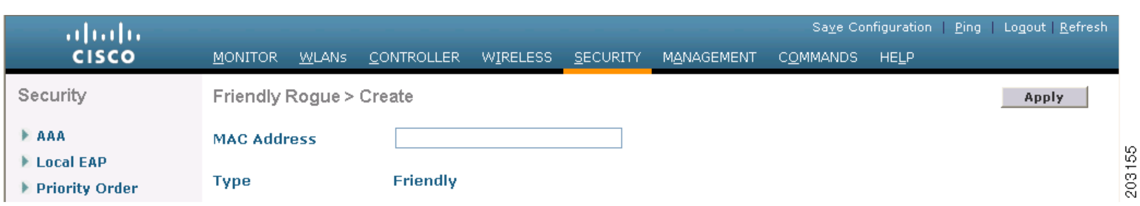
d. Continue to move the rules up or down until the rules are in the desired order.

e. Click **Apply** to commit your changes.

Step 6 If you want to classify any rogue access points as friendly and add them to the friendly MAC address list, follow these steps:

a. Choose **Security** > **Wireless Protection Policies** > **Rogue Policies** > **Friendly Rogue** to access the Friendly Rogue > Create page (see Figure 5-48).

Figure 5-48 Friendly Rogue > Create Page



b. In the MAC Address field, enter the MAC address of the friendly rogue access point.

c. Click **Apply** to commit your changes.

d. Click **Save Configuration** to save your changes. This access point is added to the controller's list of friendly access points and should now appear on the Friendly Rogue APs page.

Using the CLI to Configure Rogue Classification Rules

Using the controller CLI, follow these steps to configure rogue classification rules.

Step 1 To create a rule, enter this command:

config rogue rule add ap priority *priority* **classify** {**friendly** | **malicious**} *rule_name*

Note If you later want to change the priority of this rule and shift others in the list accordingly, enter this command: **config rogue rule priority** *priority rule_name*. If you later want to change the classification of this rule, enter this command: **config rogue rule classify** {**friendly** | **malicious**} *rule_name*.

Note If you ever want to delete all of the rogue classification rules or a specific rule, enter this command: **config rogue rule delete** {**all** | *rule_name*}.

Step 2 To disable all rules or a specific rule, enter this command:

config rogue rule disable {**all** | *rule_name*}

Note A rule must be disabled before you can modify its attributes.

Step 3 To add conditions to a rule that the rogue access point must meet, enter this command:

config rogue rule condition ap set *condition_type condition_value rule_name*

where *condition_type* is one of the following:

- **ssid**—Requires that the rogue access point have a specific SSID. You should add SSIDs that are not managed by the controller. If you choose this option, enter the SSID for the *condition_value* parameter. The SSID is added to the user-configured SSID list.

  Note If you ever want to delete all of the SSIDs or a specific SSID from the user-configured SSID list, enter this command: **config rogue rule condition ap delete ssid** {**all** | *ssid*} *rule_name*.

- **rssi**—Requires that the rogue access point have a minimum RSSI value. For example, if the rogue access point has an RSSI that is greater than the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum RSSI value for the *condition_value* parameter. The valid range is –95 to –50 dBm (inclusive), and the default value is 0 dBm.
- **duration**—Requires that the rogue access point be detected for a minimum period of time. If you choose this option, enter a value for the minimum detection period for the *condition_value* parameter. The valid range is 0 to 3600 seconds (inclusive), and the default value is 0 seconds.

- **client-count**—Requires that a minimum number of clients be associated to the rogue access point. For example, if the number of clients associated to the rogue access point is greater than or equal to the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum number of clients to be associated to the rogue access point for the *condition_value* parameter. The valid range is 1 to 10 (inclusive), and the default value is 0.
- **no-encryption**—Requires that the rogue access point's advertised WLAN does not have encryption enabled. A *condition_value* parameter is not required for this option.
- **managed-ssid—**Requires that the rogue access point's SSID be known to the controller. A *condition_value* parameter is not required for this option.

Note You can add up to six conditions per rule. If you ever want to delete all of the conditions or a specific condition from a rule, enter this command: **config rogue rule condition ap delete** {**all** | *condition_type*} *condition_value rule_name*.

Step 4 To specify whether a detected rogue access point must meet all or any of the conditions specified by the rule in order for the rule to be matched and the rogue access point to adopt the classification type of the rule, enter this command:

config rogue rule match {**all** | **any**} *rule_name*

Step 5 To enable all rules or a specific rule, enter this command:

config rogue rule enable {**all** | *rule_name*}

Note For your changes to become effective, you must enable the rule.

Step 6 To add a new friendly access point entry to the friendly MAC address list or delete an existing friendly access point entry from the list, enter this command:

config rogue ap friendly {**add** | **delete**} *ap_mac_address*

Step 7 To save your changes, enter this command:

save config

Step 8 To view the rogue classification rules that are configured on the controller, enter this command:

show rogue rule summary

Information similar to the following appears:

```
Priority Rule Name  State      Type       Match  Hit Count
-------- ----------- -------- ------------ ------ ---------
1        Rule1      Disabled   Friendly      Any   0
2        Rule2      Enabled    Malicious     Any  339
3       Rule3      Disabled   Friendly     Any   0
```

Step 9 To view detailed information for a specific rogue classification rule, enter this command:

show rogue rule detailed *rule_name*

Information similar to the following appears:

```
Priority........................................ 2
Rule Name....................................... Rule2
State........................................... Enabled
Type............................................ Malicious
Match Operation................................. Any
Hit Count....................................... 352
Total Conditions................................ 6
```

```
Condition 1
    type....................................... Client-count
    value...................................... 10
Condition 2
    type....................................... Duration
    value (seconds)............................ 2000
Condition 3
    type....................................... Managed-ssid
    value...................................... Enabled
Condition 4
    type....................................... No-encryption
    value...................................... Enabled
Condition 5
    type....................................... Rssi
    value (dBm)................................ -50
Condition 6
    type....................................... Ssid
    SSID Count................................. 1
    SSID 1.................................. test
```

Viewing and Classifying Rogue Devices

Using the controller GUI or CLI, you can view rogue devices and determine the action that the controller should take.

Caution When you choose to contain a rogue device, the following warning appears: "There may be legal issues following this containment. Are you sure you want to continue?" The 2.4- and 5-GHz frequencies in the Industrial, Scientific, and Medical (ISM) band are open to the public and can be used without a license. As such, containing devices on another party's network could have legal consequences.

Using the GUI to View and Classify Rogue Devices

Using the controller GUI, follow these steps to view and classify rogue devices.

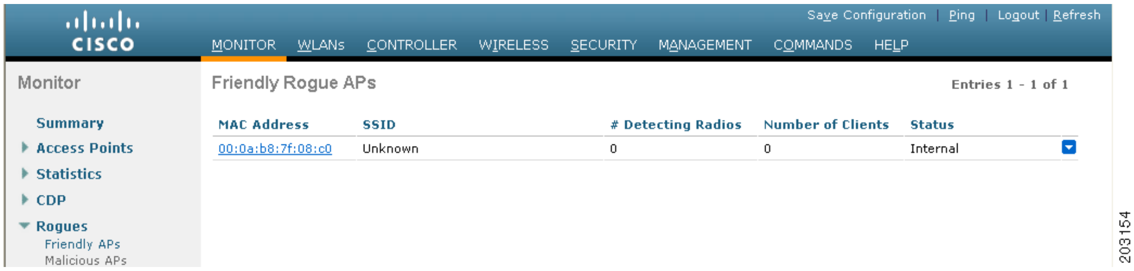
Step 1 Choose **Monitor** > **Rogues**.

Step 2 Choose the following options to view the different types of rogue access points detected by the controller:

- **Friendly APs**
- **Malicious APs**
- **Unclassified APs**

A page similar to the following appears (see Figure 5-49).

Figure 5-49 Friendly Rogue APs Page



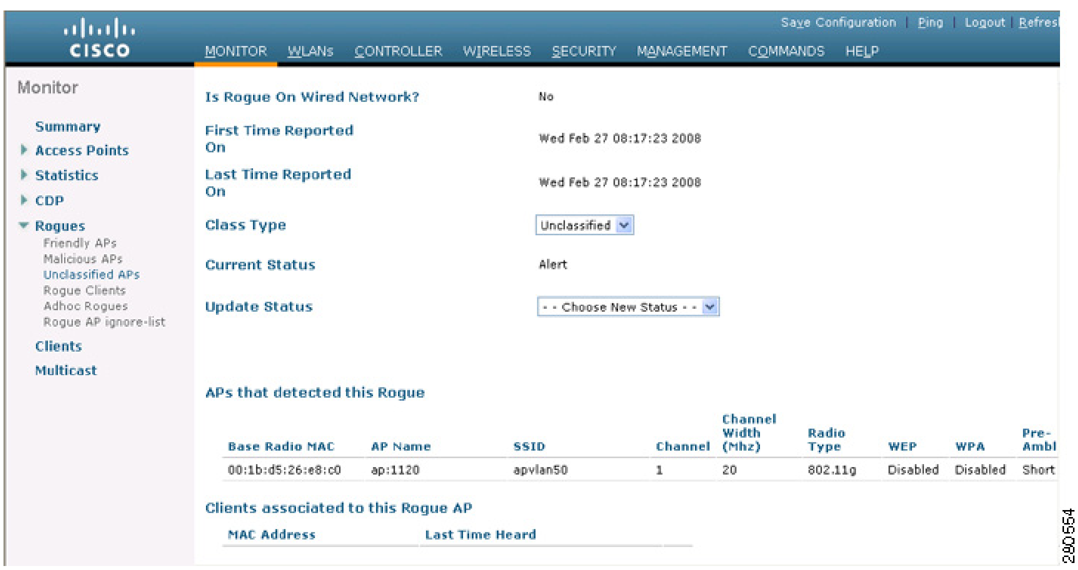
The Friendly Rogue APs page, Malicious Rogue APs page, and Unclassified Rogue APs page provide the following information: the MAC address and SSID of the rogue access point, the number of clients connected to the rogue access point, the number of radios that detected the rogue access point, and the current status of the rogue access point.

Note To remove acknowledged rogues from the database, go to the WLC UI and change the rogue state to Alert Unknown and click Save Configuration. If the rogue is no longer present, it will disappear from the database in 20 minutes.

Note If you ever want to delete a rogue access point from one of these pages, hover your cursor over the blue drop-down arrow and click **Remove**.

Step 3 To obtain more details about a rogue access point, click the MAC address of the access point. The Rogue AP Detail page appears (see Figure 5-50).

Figure 5-50 Rogue AP Detail Page



This page provides the following information: the MAC address of the rogue device, the type of rogue device (such as an access point), whether the rogue device is on the wired network, the dates and times when the rogue device was first and last reported, and the current status of the device.

Step 4 The Class Type field shows the current classification for this rogue access point:

- **Friendly**—An unknown access point that matches the user-defined friendly rules or an existing known and acknowledged rogue access point. Friendly access points cannot be contained.
- **Malicious**—An unknown access point that matches the user-defined malicious rules or is moved manually by the user from the Friendly or Unclassified classification type.

Note Once an access point is classified as Malicious, you cannot apply rules to it in the future, and it cannot be moved to another classification type. If you want to move a malicious access point to the Unclassified classification type, you must delete the access point and allow the controller to reclassify it.

- **Unclassified**—An unknown access point that does not match the user-defined friendly or malicious rules. An unclassified access point can be contained. It can also be moved to the Friendly or Malicious classification type automatically in accordance with user-defined rules or manually by the user.

If you want to change the classification of this device, choose a different classification from the Class Type drop-down box.

Note A rogue access point cannot be moved to another class if its current state is Contain.

Step 5 From the Update Status drop-down box, choose one of the following options to specify how the controller should respond to this rogue access point:

- **Internal**—The controller trusts this rogue access point. This option is available if the Class Type is set to Friendly.
- **External**—The controller acknowledges the presence of this rogue access point. This option is available if the Class Type is set to Friendly.
- **Contain**—The controller contains the offending device so that its signals no longer interfere with authorized clients. This option is available if the Class Type is set to Malicious or Unclassified.
- **Alert—**The controller forwards an immediate alert to the system administrator for further action. This option is available if the Class Type is set to Malicious or Unclassified.

The bottom of the page provides information on both the access points that detected this rogue access point and any clients that are associated to it. To see more details for any of the clients, click **Edit** to open the Rogue Client Detail page.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Step 8 To view any rogue clients that are connected to the controller, choose **Rogue Clients**. The Rogue Clients page appears. This page shows the following information: the MAC address of the rogue client, the MAC address of the access point to which the rogue client is associated, the SSID of the rogue client, the number of radios that detected the rogue client, the date and time when the rogue client was last reported, and the current status of the rogue client.

Step 9 To obtain more details about a rogue client, click the MAC address of the client. The Rogue Client Detail page appears (see Figure 5-51).

Figure 5-51 Rogue Client Detail Page

This page provides the following information: the MAC address of the rogue client, the MAC address of the rogue access point to which this client is associated, the SSID and IP address of the rogue client, the dates and times when the rogue client was first and last reported, and the current status of the rogue client.

Step 10 From the Update Status drop-down box, choose one of the following options to specify how the controller should respond to this rogue client:

- **Contain**—The controller contains the offending device so that its signals no longer interfere with authorized clients.
- **Alert**—The controller forwards an immediate alert to the system administrator for further action.

The bottom of the page provides information on the access points that detected this rogue client.

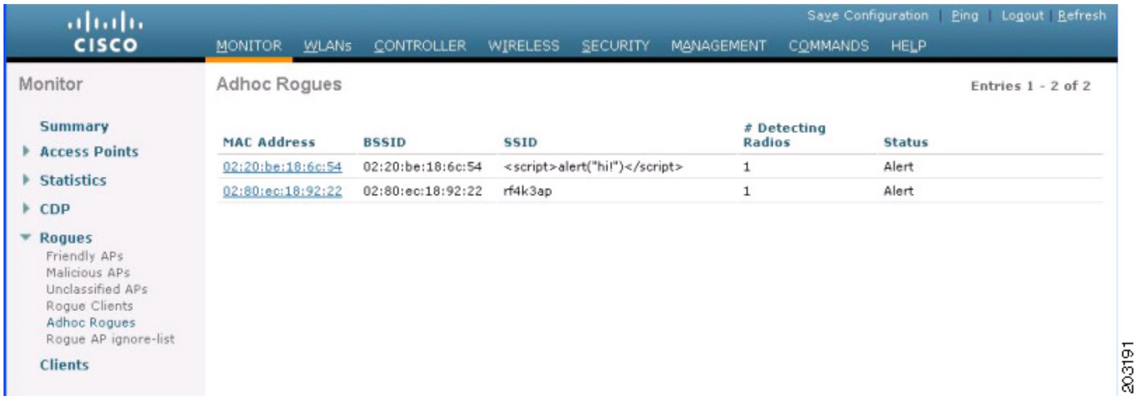
Step 11 Click **Apply** to commit your changes.

Step 12 If desired, you can test the controller's connection to this client by clicking **Ping**.

Step 13 Click **Save Configuration** to save your changes.

Step 14 To view any ad-hoc rogues detected by the controller, choose **Adhoc Rogues**. The Adhoc Rogues page appears (see Figure 5-52).

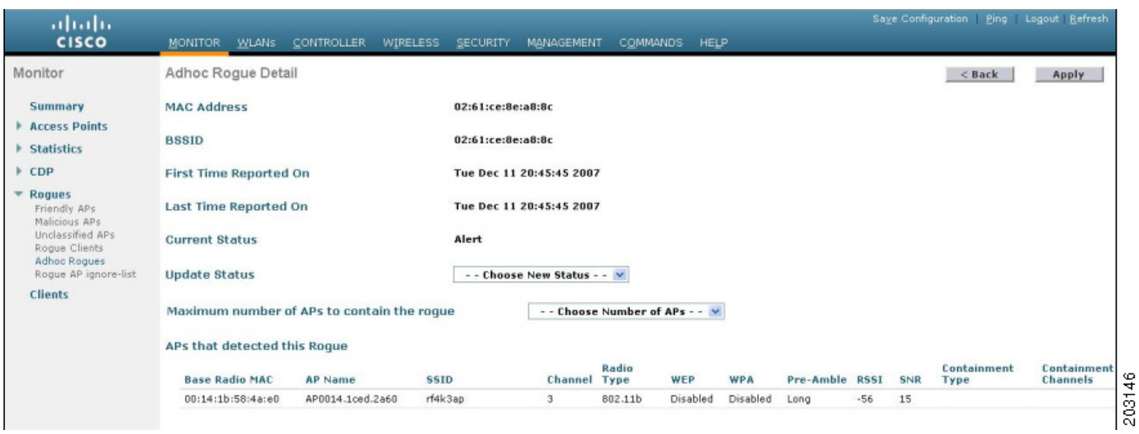
Figure 5-52 Adhoc Rogues Page



This page shows the following information: the MAC address, BSSID, and SSID of the ad-hoc rogue, the number of radios that detected the ad-hoc rogue, and the current status of the ad-hoc rogue.

Step 15 To obtain more details about an ad-hoc rogue, click the MAC address of the rogue. The Adhoc Rogue Detail page appears (see Figure 5-53).

Figure 5-53 Adhoc Rogue Detail Page



This page provides the following information: the MAC address and BSSID of the adhoc rogue, the dates and times when the rogue was first and last reported, and the current status of the rogue.

Step 16 From the Update Status drop-down box, choose one of the following options to specify how the controller should respond to this ad-hoc rogue:

- **Contain**—The controller contains the offending device so that its signals no longer interfere with authorized clients.
- **Alert**—The controller forwards an immediate alert to the system administrator for further action.
- **Internal**—The controller trusts this rogue access point.
- **External**—The controller acknowledges the presence of this rogue access point.

Step 17 From the Maximum Number of APs to Contain the Rogue drop-down box, choose one of the following options to specify the maximum number of access points used to contain this ad-hoc rogue: **1**, **2**, **3**, or **4.**

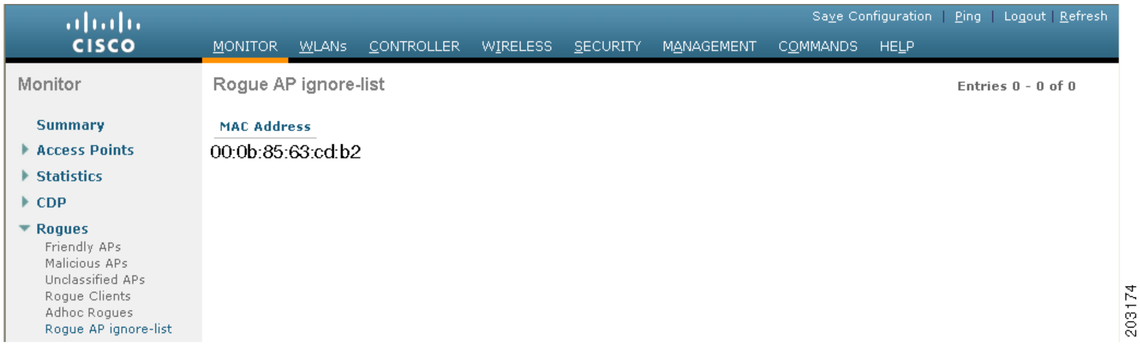
The bottom of the page provides information on the access points that detected this ad-hoc rogue.

Step 18 Click **Apply** to commit your changes.

Step 19 Click **Save Configuration** to save your changes.

Step 20 To view any access points that have been configured to be ignored, choose **Rogue AP Ignore-List**. The Rogue AP Ignore-List page appears (see Figure 5-54).

Figure 5-54 Rogue AP Ignore-List Page



This page shows the MAC addresses of any access points that are configured to be ignored. The rogue-ignore list contains a list of any autonomous access points that have been manually added to WCS maps by WCS users. The controller regards these autonomous access points as rogues even though WCS is managing them. The rogue-ignore list allows the controller to ignore these access points. The list is updated as follows:

- When the controller receives a rogue report, it checks to see if the unknown access point is in the rogue-ignore access point list.
- If the unknown access point is in the rogue-ignore list, the controller ignores this access point and continues to process other rogue access points.
- If the unknown access point is not in the rogue-ignore list, the controller sends a trap to WCS. If WCS finds this access point in its autonomous access point list, WCS sends a command to the controller to add this access point to the rogue-ignore list. This access point is then ignored in future rogue reports.
- If a user removes an autonomous access point from WCS, WCS sends a command to the controller to remove this access point from the rogue-ignore list.

Using the CLI to View and Classify Rogue Devices

Using the controller CLI, enter these commands to view and classify rogue devices.

1. To view a list of all rogue access points detected by the controller, enter this command:

   show rogue ap summary

Information similar to the following appears:

```
Rogue Location Discovery Protocol................ Enabled
Rogue AP timeout................................ 1200

MAC Address        Classification     # APs # Clients Last Heard
-----------------  ------------------ ----- --------- -----------------------
00:0a:b8:7f:08:c0  Friendly           0     0         Not Heard
00:0b:85:01:30:3f  Malicious          1     0         Fri Nov 30 11:30:59 2007
00:0b:85:63:70:6f  Malicious          1     0         Fri Nov 30 11:20:14 2007
00:0b:85:63:cd:bf Malicious         1        0        Fri Nov 30 11:23:12 2007
...
```

2. To view a list of the friendly rogue access points detected by the controller, enter this command:

   show rogue ap friendly summary

   Information similar to the following appears:

```
Number of APs.................................... 1

MAC Address        State              # APs # Clients Last Heard
-----------------  ------------------ ----- --------- ---------------------------
00:0a:b8:7f:08:c0  Internal           1   0        Tue Nov 27 13:52:04 2007
```

3. To view a list of the malicious rogue access points detected by the controller, enter this command:

   show rogue ap malicious summary

   Information similar to the following appears:

```
Number of APs.................................... 264

MAC Address        State              # APs # Clients Last Heard
-----------------  ------------------ ----- --------- -----------------------
00:0b:85:01:30:3f  Alert              1     0         Fri Nov 30 11:20:01 2007
00:0b:85:63:70:6f  Alert              1     0         Fri Nov 30 11:20:14 2007
00:0b:85:63:cd:bf  Alert              1     0         Fri Nov 30 11:23:12 2007
00:0b:85:63:cd:dd  Alert              1     0         Fri Nov 30 11:27:03 2007
00:0b:85:63:cd:de  Alert              1     0         Fri Nov 30 11:26:23 2007
00:0b:85:63:cd:df Alert            1      0        Fri Nov 30 11:26:50 2007
...
```

4. To view a list of the unclassified rogue access points detected by the controller, enter this command:

   show rogue ap unclassified summary

   Information similar to the following appears:

```
Number of APs.................................... 164

MAC Address        State              # APs # Clients Last Heard
-----------------  ------------------ ----- --------- -----------------------
00:0b:85:63:cd:bd  Alert              1     0         Fri Nov 30 11:12:52 2007
00:0b:85:63:cd:e7  Alert              1     0         Fri Nov 30 11:29:01 2007
00:0b:85:63:ce:05  Alert              1     0         Fri Nov 30 11:26:23 2007
00:0b:85:63:ce:07  Alert               1      0         Fri Nov 30 11:26:23 2007
...
```

5. To view detailed information for a specific rogue access point, enter this command:

   show rogue ap detailed *ap_mac_address*

   Information similar to the following appears:

```
Rogue BSSID..................................... 00:0b:85:63:d1:94
Is Rogue on Wired Network....................... No
Classification.................................. Unclassified
State........................................... Alert
First Time Rogue was Reported................... Fri Nov 30 11:24:56 2007
Last Time Rogue was Reported.................... Fri Nov 30 11:24:56 2007
Reported By
    AP 1
        MAC Address.............................. 00:12:44:bb:25:d0
        Name..................................... HReap
        Radio Type............................... 802.11g
        SSID..................................... edu-eap
        Channel.................................. 6
        RSSI..................................... -61 dBm
        SNR...................................... -1 dB
        Encryption............................... Enabled
        ShortPreamble............................ Enabled
        WPA Support.............................. Disabled
        Last reported by this AP............. Fri Nov 30 11:24:56 2007
```

6. To see the rogue report (which shows the number of rogue devices detected on different channel widths) for a specific 802.11a/n radio, enter this command:

   show ap auto-rf 802.11a *Cisco_AP*

   Information similar to the following appears:

```
Number Of Slots.................................. 2
AP Name.......................................... AP2
MAC Address...................................... 00:1b:d5:13:39:74
  Radio Type..................................... RADIO_TYPE_80211a
  Noise Information
    Noise Profile................................ PASSED
    Channel 36...................................  -80 dBm
    Channel 40...................................  -78 dBm
    ...
  Interference Information
    Interference Profile......................... PASSED
    Channel 36...................................  -81 dBm @   8 % busy
    Channel 40...................................  -66 dBm @   4 % busy
   ...
Rogue Histogram (20/40_ABOVE/40_BELOW)
    Channel 36.................................. 21/ 1/ 0
    Channel 40..................................  7/ 0/ 0
    ...
```

7. To view a list of all rogue clients that are associated to a rogue access point, enter this command:

   show rogue ap clients *ap_mac_address*

   Information similar to the following appears:

```
MAC Address        State              # APs  Last Heard
-----------------  ------------------ ----- -------------------------
00:bb:cd:12:ab:ff  Alert               1      Fri Nov 30 11:26:23 2007
```

8. To view a list of all rogue clients detected by the controller, enter this command:

show rogue client summary

Information similar to the following appears:

```
Validate rogue clients against AAA............... Disabled

MAC Address        State              # APs Last Heard
-----------------  ------------------ ----- ------------------------
00:0a:8a:7d:f5:f5  Alert              1     Mon Dec  3 21:56:36 2007
00:18:ba:78:c4:44  Alert              1     Mon Dec  3 21:59:36 2007
00:18:ba:78:c4:d1  Alert              1     Mon Dec  3 21:47:36 2007
00:18:ba:78:ca:f8 Alert            1      Mon Dec  3 22:02:36 2007
...
```

9. To view detailed information for a specific rogue client, enter this command:

show rogue client detailed *client_mac_address*

Information similar to the following appears:

```
Rogue BSSID..................................... 00:0b:85:23:ea:d1
State........................................... Alert
First Time Rogue was Reported................... Mon Dec  3 21:50:36 2007
Last Time Rogue was Reported.................... Mon Dec  3 21:50:36 2007
Rogue Client IP address......................... Not known
Reported By
    AP 1
        MAC Address.............................. 00:15:c7:82:b6:b0
        Name..................................... AP0016.47b2.31ea
        Radio Type............................... 802.11a
        RSSI..................................... -71 dBm
        SNR...................................... 23 dB
        Channel.................................. 149
        Last reported by this AP............. Mon Dec  3 21:50:36 2007
```

10. To view a list of all ad-hoc rogues detected by the controller, enter this command:

show rogue adhoc summary

Information similar to the following appears:

```
Detect and report Ad-Hoc Networks................ Enabled

Client MAC Address  Adhoc BSSID         State     # APs   Last Heard
------------------  ------------------  ----------- -------  ------------------------
00:bb:cd:12:ab:ff  super              Alert       1      Fri Nov 30 11:26:23 2007
```

11. To view detailed information for a specific ad-hoc rogue, enter this command:

show rogue adhoc detailed *rogue_mac_address*

Information similar to the following appears:

```
Adhoc Rogue MAC address......................... 02:61:ce:8e:a8:8c
Adhoc Rogue BSSID............................... 02:61:ce:8e:a8:8c
State........................................... Alert
First Time Adhoc Rogue was Reported............. Tue Dec 11 20:45:45 2007
Last Time Adhoc Rogue was Reported.............. Tue Dec 11 20:45:45 2007
Reported By
    AP 1
        MAC Address.............................. 00:14:1b:58:4a:e0
        Name..................................... AP0014.1ced.2a60
        Radio Type............................... 802.11b
        SSID..................................... rf4k3ap
        Channel.................................. 3
```

```
 RSSI.................................... -56 dBm
 SNR..................................... 15 dB
 Encryption.............................. Disabled
 ShortPreamble........................... Disabled
 WPA Support............................. Disabled
Last reported by this AP.............. Tue Dec 11 20:45:45 2007
```

12. To view a list of rogue access points that are configured to be ignored, enter this command:

    show rogue ignore-list

    Information similar to the following appears:

```
MAC Address
------------------
10:bb:17:cc:01:ef
```

> **Note** Refer to Step 20 of the "Using the GUI to View and Classify Rogue Devices" section on page 5-97 for more information on the rogue-ignore access point list.

13. To classify a rogue access point as friendly, enter this command:

    config rogue ap classify friendly state {**internal** | **external**} *ap_mac_address*

    where

    - **internal** means that the controller trusts this rogue access point.
    - **external** means that the controller acknowledges the presence of this rogue access point.

> **Note** A rogue access point cannot be moved to the Friendly class if its current state is Contain.

14. To mark a rogue access point as malicious, enter this command:

    config rogue ap classify malicious state {**alert** | **contain**} *ap_mac_address*

    where

    - **contain** means that the controller contains the offending device so that its signals no longer interfere with authorized clients.
    - **alert** means that the controller forwards an immediate alert to the system administrator for further action.

> **Note** A rogue access point cannot be moved to the Malicious class if its current state is Contain.

15. To mark a rogue access point as unclassified, enter this command:

    config rogue ap classify unclassified state {**alert** | **contain**} *ap_mac_address*

> **Note** A rogue access point cannot be moved to the Unclassified class if its current state is Contain.

16. To specify how the controller should respond to a rogue client, enter one of these commands:

    - **config rogue client alert** *client_mac_address*—The controller forwards an immediate alert to the system administrator for further action.
    - **config rogue client contain** *client_mac_address*—The controller contains the offending device so that its signals no longer interfere with authorized clients.

17. To specify how the controller should respond to an adhoc rogue, enter one these commands:
    - **config rogue adhoc alert** *rogue_mac_address*—The controller forwards an immediate alert to the system administrator for further action.
    - **config rogue adhoc contain** *rogue_mac_address*—The controller contains the offending device so that its signals no longer interfere with authorized clients.
    - **config rogue adhoc external** *rogue_mac_address*—The controller acknowledges the presence of this ad-hoc rogue.
18. To save your changes, enter this command:

    save config

Configuring IDS

The Cisco intrusion detection system/intrusion prevention system (CIDS/IPS) instructs controllers to block certain clients from accessing the wireless network when attacks involving these clients are detected at Layer 3 through Layer 7. This system offers significant network protection by helping to detect, classify, and stop threats including worms, spyware/adware, network viruses, and application abuse. Two methods are available to detect potential attacks:

- IDS sensors, see below
- IDS signatures, see page 5-112

Note The Cisco wireless intrusion prevention system (wIPS) is also supported on the controller through WCS. Refer to the "Configuring wIPS" section on page 5-124 for more information.

Configuring IDS Sensors

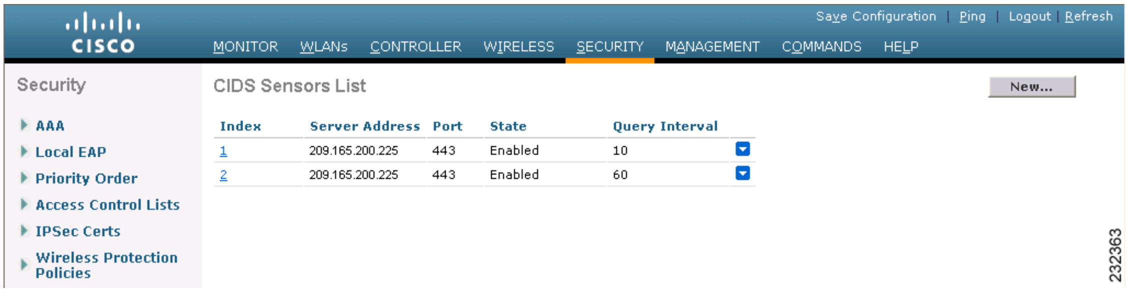
You can configure IDS sensors to detect various types of IP-level attacks in your network. When the sensors identify an attack, they can alert the controller to shun the offending client. When you add a new IDS sensor, you register the controller with that IDS sensor so that the controller can query the sensor to get the list of shunned clients. You can configure IDS sensor registration through either the GUI or the CLI.

Using the GUI to Configure IDS Sensors

Follow these steps to configure IDS sensors using the controller GUI.

Step 1 Choose **Security** > **Advanced** > **CIDs** > **Sensors** to open the CIDS Sensors List page appears (see Figure 5-55).

Figure 5-55 CIDS Sensors List Page

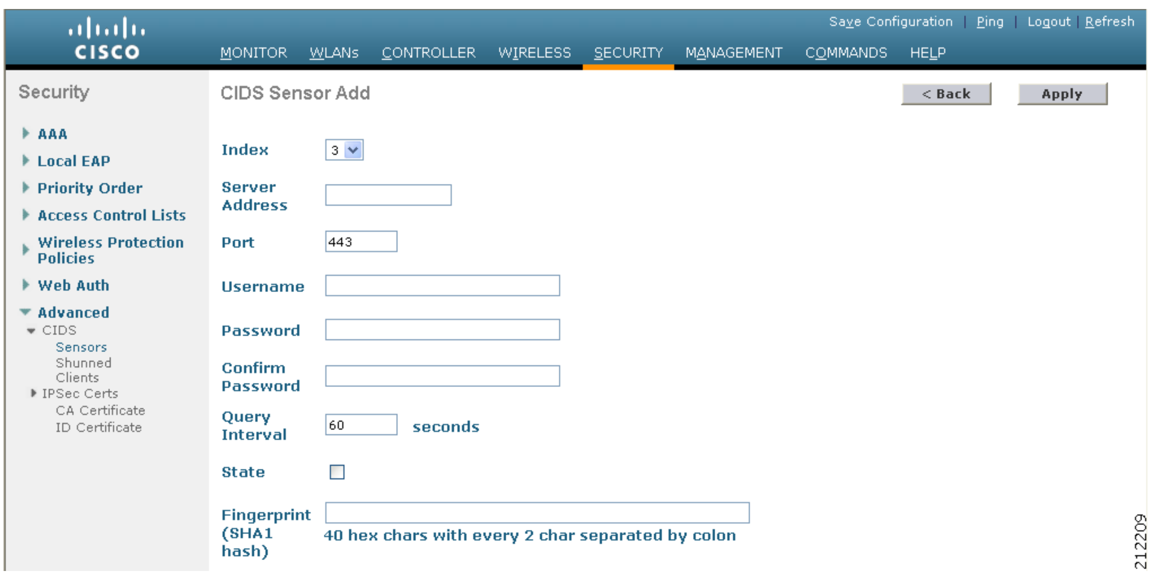


This page lists all of the IDS sensors that have been configured for this controller.

> **Note** If you want to delete an existing sensor, hover your cursor over the blue drop-down arrow for that sensor and choose **Remove**.

Step 2 To add an IDS sensor to the list, click **New**. The CIDS Sensor Add page appears (see Figure 5-56).

Figure 5-56 CIDS Sensor Add Page



Step 3 The controller supports up to five IDS sensors. From the Index drop-down box, choose a number (between 1 and 5) to determine the sequence in which the controller consults the IDS sensors. For example, if you choose 1, the controller consults this IDS sensor first.

Step 4 In the Server Address field, enter the IP address of your IDS server.

Step 5 The Port field contains the number of the HTTPS port through which the controller is to communicate with the IDS sensor. Cisco recommends that you set this parameter to 443 because the sensor uses this value to communicate by default.

Default: 443

Range: 1 to 65535

Step 6 In the Username field, enter the name that the controller uses to authenticate to the IDS sensor.

> **Note** This username must be configured on the IDS sensor and have at least a read-only privilege.

Step 7 In the Password and Confirm Password fields, enter the password that the controller uses to authenticate to the IDS sensor.

Step 8 In the Query Interval field, enter the time (in seconds) for how often the controller should query the IDS server for IDS events.

Default: 60 seconds

Range: 10 to 3600 seconds

Step 9 Check the **State** check box to register the controller with this IDS sensor or uncheck this check box to disable registration. The default value is disabled.

Step 10 Enter a 40-hexadecimal-character security key in the Fingerprint field. This key is used to verify the validity of the sensor and is used to prevent security attacks.

> **Note** Do not include the colons that appear between every two bytes within the key. For example, enter AABBCCDD instead of AA:BB:CC:DD.

Step 11 Click **Apply**. Your new IDS sensor appears in the list of sensors on the CIDS Sensors List page.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure IDS Sensors

Follow these steps to configure IDS sensors using the controller CLI.

Step 1 To add an IDS sensor, enter this command:

config wps cids-sensor add *index ids_ip_address username password*

The *index* parameter determines the sequence in which the controller consults the IDS sensors. The controller supports up to five IDS sensors. Enter a number (between 1 and 5) to determine the priority of this sensor. For example, if you enter 1, the controller consults this IDS sensor first.

> **Note** The username must be configured on the IDS sensor and have at least a read-only privilege.

Step 2 (Optional) To specify the number of the HTTPS port through which the controller is to communicate with the IDS sensor, enter this command:

config wps cids-sensor port *index port_number*

For the *port-number* parameter, you can enter a value between 1 and 65535. The default value is 443. This step is optional because Cisco recommends that you use the default value of 443. The sensor uses this value to communicate by default.

Step 3 To specify how often the controller should query the IDS server for IDS events, enter this command:

config wps cids-sensor interval *index interval*

For the *interval* parameter, you can enter a value between 10 and 3600 seconds. The default value is 60 seconds.

Step 4 To enter a 40-hexadecimal-character security key used to verify the validity of the sensor, enter this command:

config wps cids-sensor fingerprint *index* **sha1** *fingerprint*

You can get the value of the fingerprint by entering **show tls fingerprint** on the sensor's console.

Note Make sure to include the colons that appear between every two bytes within the key (for example, AA:BB:CC:DD).

Step 5 To enable or disable this controller's registration with an IDS sensor, enter this command:

config wps cids-sensor {**enable** | **disable**} *index*

Step 6 To enable or disable protection from DoS attacks, enter this command:

config wps auto-immune {**enable** | **disable**}

The default value is disabled.

Note A potential attacker can use specially crafted packets to mislead the IDS into treating a legitimate client as an attacker. It causes the controller to wrongly disconnect this legitimate client and launches a DoS attack. The auto-immune feature, when enabled, is designed to protect against such attacks. However, conversations using Cisco 792x phones might be interrupted intermittently when the auto-immune feature is enabled. If you experience frequent disruptions when using 792x phones, you might want to disable this feature.

Step 7 To save your settings, enter this command:

save config

Step 8 To view the IDS sensor configuration, enter one of these commands:

- **show wps cids-sensor summary**
- **show wps cids-sensor detail** *index*

The second command provides more information than the first.

Step 9 To see the auto-immune configuration setting, enter this command:

show wps summary

Information similar to the following appears:

```
Auto-Immune
  Auto-Immune.................................... Disabled

Client Exclusion Policy
  Excessive 802.11-association failures.......... Enabled
  Excessive 802.11-authentication failures....... Enabled
  Excessive 802.1x-authentication................ Enabled
  IP-theft....................................... Enabled
  Excessive Web authentication failure........... Enabled
```

```
Signature Policy
  Signature Processing.......................... Enabled
```

Step 10 To obtain debug information regarding IDS sensor configuration, enter this command:

debug wps cids enable

Note If you ever want to delete or change the configuration of a sensor, you must first disable it by entering **config wps cids-sensor disable** *index*. To then delete the sensor, enter **config wps cids-sensor delete** *index*.

Viewing Shunned Clients

When an IDS sensor detects a suspicious client, it alerts the controller to shun this client. The shun entry is distributed to all controllers within the same mobility group. If the client to be shunned is currently joined to a controller in this mobility group, the anchor controller adds this client to the dynamic exclusion list, and the foreign controller removes the client. The next time the client tries to connect to a controller, the anchor controller rejects the handoff and informs the foreign controller that the client is being excluded. See the *Configuring Mobility Groups* chapter for more information on mobility groups.

You can view the list of clients that the IDS sensors have identified to be shunned through either the GUI or the CLI.

Using the GUI to View Shunned Clients

Follow these steps to view the list of clients that the IDS sensors have identified to be shunned using the controller GUI.

Step 1 Choose **Security** > **Advanced** > **CIDS** > **Shunned Clients**. The CIDS Shun List page appears (see Figure 5-57).

Figure 5-57 CIDS Shun List Page

This page shows the IP address and MAC address of each shunned client, the length of time that the client's data packets should be blocked by the controller as requested by the IDS sensor, and the IP address of the IDS sensor that discovered the client.

Step 2 Click **Re-sync** to purge and reset the list as desired.

Using the CLI to View Shunned Clients

Follow these steps to view the list of clients that the IDS sensors have identified to be shunned using the controller CLI.

Step 1 To view the list of clients to be shunned, enter this command:

show wps shun-list

Step 2 To force the controller to sync up with other controllers in the mobility group for the shun list, enter this command:

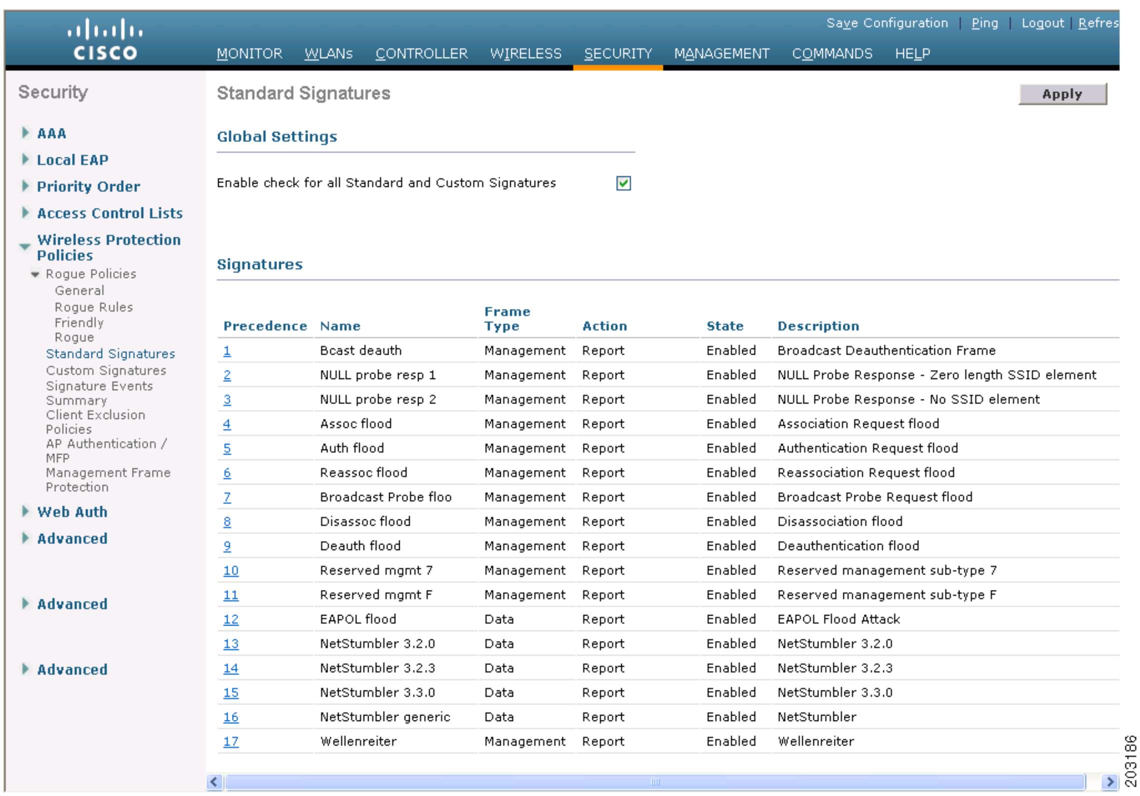
config wps shun-list re-sync

Configuring IDS Signatures

You can configure IDS signatures, or bit-pattern matching rules used to identify various types of attacks in incoming 802.11 packets, on the controller. When the signatures are enabled, the access points joined to the controller perform signature analysis on the received 802.11 data or management frames and report any discrepancies to the controller. If an attack is detected, appropriate mitigation is initiated.

Cisco supports 17 standard signatures on the controller as shown on the Standard Signatures page (see Figure 5-58).

Figure 5-58 Standard Signatures Page



These signatures are divided into six main groups. The first four groups contain management signatures, and the last two groups contain data signatures.

- **Broadcast deauthentication frame signatures**—During a broadcast deauthentication frame attack, a hacker sends an 802.11 deauthentication frame to the broadcast MAC destination address of another client. This attack causes the destination client to disassociate from the access point and lose its connection. If this action is repeated, the client experiences a denial of service. When the broadcast deauthentication frame signature (precedence 1) is used to detect such an attack, the access point listens for clients transmitting broadcast deauthentication frames that match the characteristics of the signature. If the access point detects such an attack, it alerts the controller. Depending on how your system is configured, the offending device is contained so that its signals no longer interfere with authorized clients, or the controller forwards an immediate alert to the system administrator for further action, or both.
- **NULL probe response signatures**—During a NULL probe response attack, a hacker sends a NULL probe response to a wireless client adapter. As a result, the client adapter locks up. When a NULL probe response signature is used to detect such an attack, the access point identifies the wireless client and alerts the controller. The NULL probe response signatures include:
  - NULL probe resp 1 (precedence 2)
  - NULL probe resp 2 (precedence 3)
- **Management frame flood signatures**—During a management frame flood attack, a hacker floods an access point with 802.11 management frames. The result is a denial of service to all clients associated or attempting to associate to the access point. This attack can be implemented with different types of management frames: association requests, authentication requests, reassociation requests, probe requests, disassociation requests, deauthentication requests, and reserved management subtypes.

  When a management frame flood signature is used to detect such an attack, the access point identifies management frames matching the entire characteristic of the signature. If the frequency of these frames is greater than the value of the frequency set in the signature, an access point that hears these frames triggers an alarm. The controller generates a trap and forwards it to WCS.

  The management frame flood signatures include:
  - Assoc flood (precedence 4)
  - Auth flood (precedence 5)
  - Reassoc flood (precedence 6)
  - Broadcast probe flood (precedence 7)
  - Disassoc flood (precedence 8)
  - Deauth flood (precedence 9)
  - Reserved mgmt 7 (precedence 10)
  - Reserved mgmt F (precedence 11)

  The reserved management frame signatures 7 and F are reserved for future use.
- **Wellenreiter signature**—Wellenreiter is a wireless LAN scanning and discovery utility that can reveal access point and client information. When the Wellenreiter signature (precedence 17) is used to detect such an attack, the access point identifies the offending device and alerts the controller.

- **EAPOL flood signature**—During an EAPOL flood attack, a hacker floods the air with EAPOL frames containing 802.1X authentication requests. As a result, the 802.1X authentication server cannot respond to all of the requests and fails to send successful authentication responses to valid clients. The result is a denial of service to all affected clients. When the EAPOL flood signature (precedence 12) is used to detect such an attack, the access point waits until the maximum number of allowed EAPOL packets is exceeded. It then alerts the controller and proceeds with the appropriate mitigation.
- **NetStumbler signatures**—NetStumbler is a wireless LAN scanning utility that reports access point broadcast information (such as operating channel, RSSI information, adapter manufacturer name, SSID, WEP status, and the latitude and longitude of the device running NetStumbler when a GPS is attached). If NetStumbler succeeds in authenticating and associating to an access point, it sends a data frame with the following strings, depending on the NetStumbler version:

Version	String
3.2.0	"Flurble gronk bloopit, bnip Frundletrune"
3.2.3	"All your 802.11b are belong to us"
3.3.0	Sends white spaces

  When a NetStumbler signature is used to detect such an attack, the access point identifies the offending device and alerts the controller. The NetStumbler signatures include:
  - NetStumbler 3.2.0 (precedence 13)
  - NetStumbler 3.2.3 (precedence 14)
  - NetStumbler 3.3.0 (precedence 15)
  - NetStumbler generic (precedence 16)

A standard signature file exists on the controller by default. You can upload this signature file from the controller, or you can create a custom signature file and download it to the controller or modify the standard signature file to create a custom signature. You can configure signatures through either the GUI or the CLI.

Using the GUI to Configure IDS Signatures

You must follow these instructions to configure signatures using the controller GUI:

- Uploading or downloading IDS signatures
- Enabling or disabling IDS signatures
- Viewing IDS signature events

Using the GUI to Upload or Download IDS Signatures

Follow these steps to upload or download IDS signatures using the controller GUI.

Step 1 If desired, create your own custom signature file.

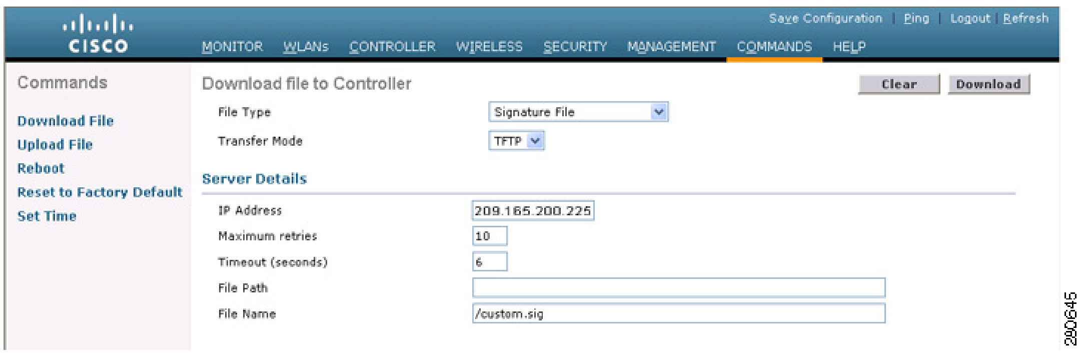
Step 2 Make sure that you have a Trivial File Transfer Protocol (TFTP) server available. Keep these guidelines in mind when setting up a TFTP server:

- If you are downloading through the service port, the TFTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP server cannot run on the same computer as the Cisco WCS because the WCS built-in TFTP server and the third-party TFTP server require the same communication port.

Step 3 If you are downloading a custom signature file (*.sig), copy it to the default directory on your TFTP server.

Step 4 Choose **Commands** to open the Download File to Controller page (see Figure 5-59).

Figure 5-59 Download File to Controller Page



Step 5 Perform one of the following:

- If you want to download a custom signature file to the controller, choose **Signature File** from the File Type drop-down box on the Download File to Controller page.
- If you want to upload a standard signature file from the controller, choose **Upload File** and then **Signature File** from the File Type drop-down box on the Upload File from Controller page.

Step 6 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 7 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 8 If you are downloading the signature file using a TFTP server, enter the maximum number of times the controller should attempt to download the signature file in the Maximum Retries field.

Range: 1 to 254

Default: 10

Step 9 If you are downloading the signature file using a TFTP server, enter the amount of time in seconds before the controller times out while attempting to download the signature file in the Timeout field.

Range: 1 to 254 seconds

Default: 6 seconds

Step 10 In the File Path field, enter the path of the signature file to be downloaded or uploaded. The default value is "/."

Step 11 In the File Name field, enter the name of the signature file to be downloaded or uploaded.

> **Note** When uploading signatures, the controller uses the filename you specify as a base name and then adds "_std.sig" and "_custom.sig" to it in order to upload *both* standard and custom signature files to the TFTP server. For example, if you upload a signature file called "ids1," the controller automatically generates and uploads both ids1_std.sig and ids1_custom.sig to the TFTP server. If desired, you can then modify ids1_custom.sig on the TFTP server (making sure to set "Revision = custom") and download it by itself.

Step 12 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the download occurs. The default value is 21.

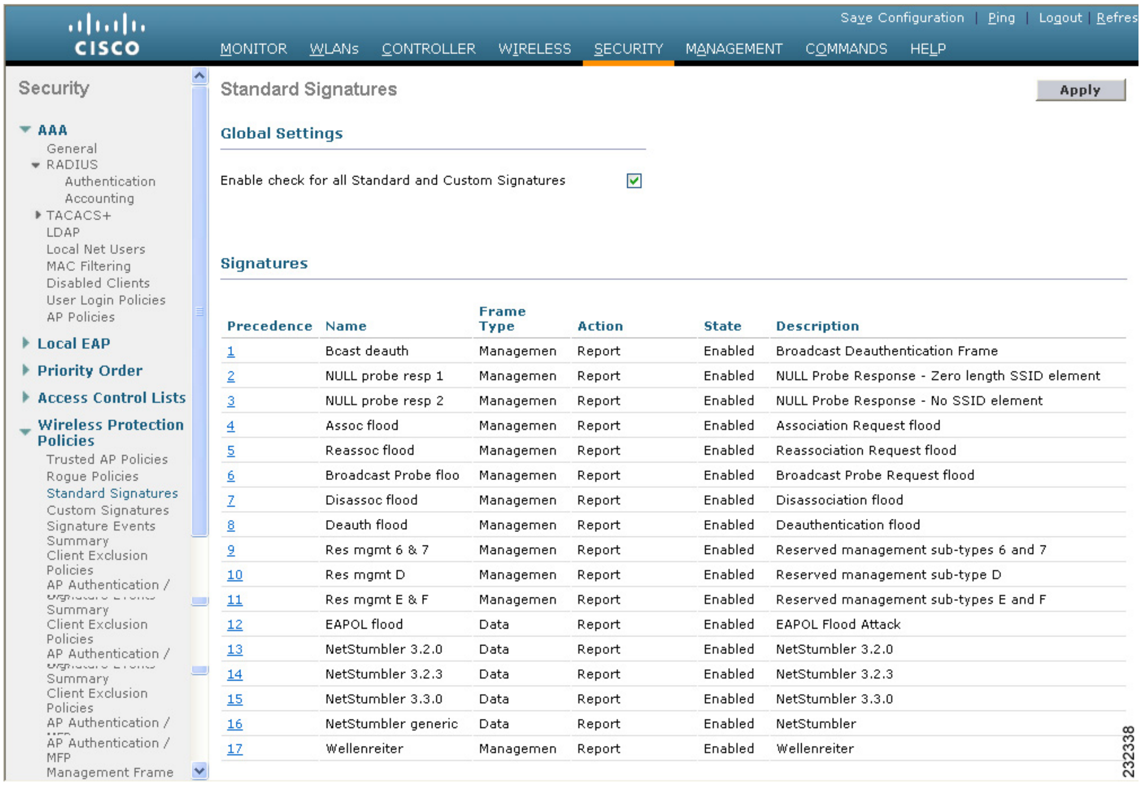
Step 13 Choose **Download** to download the signature file to the controller or **Upload** to upload the signature file from the controller.

Using the GUI to Enable or Disable IDS Signatures

Follow these steps to enable or disable IDS signatures using the controller GUI.

Step 1 Choose **Security** > **Wireless Protection Policies** > **Standard Signatures** or **Custom Signatures**. The Standard Signatures page (see Figure 5-60) or the Custom Signatures page appears.

Figure 5-60 ***Standard Signatures Page***



The Standard Signatures page shows the list of Cisco-supplied signatures that are currently on the controller. The Custom Signatures page shows the list of customer-supplied signatures that are currently on the controller. This page shows the following information for each signature:

- The order, or precedence, in which the controller performs the signature checks.
- The name of the signature, which specifies the type of attack that the signature is trying to detect.
- The frame type on which the signature is looking for a security attack. The possible frame types are data and management.
- The action that the controller is directed to take when the signature detects an attack. The possible action are None and Report.
- The state of the signature, which indicates whether the signature is enabled to detect security attacks.
- A description of the type of attack that the signature is trying to detect.

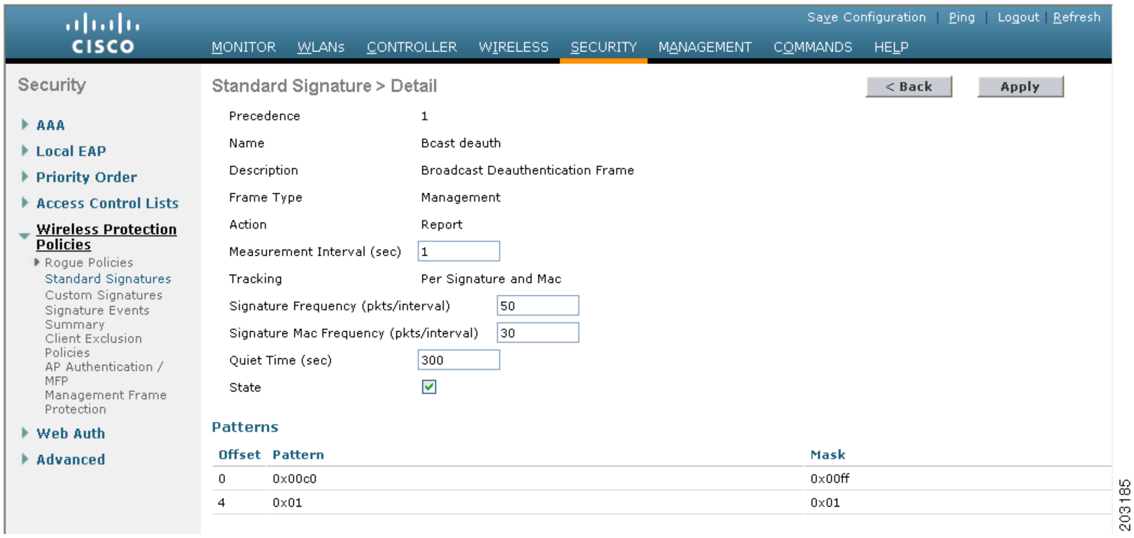
Step 2 Perform one of the following:

- If you want to allow all signatures (both standard and custom) whose individual states are set to Enabled to remain enabled, check the **Enable Check for All Standard and Custom Signatures** check box at the top of either the Standard Signatures page or the Custom Signatures page. The default value is enabled (or checked). When the signatures are enabled, the access points joined to the controller perform signature analysis on the received 802.11 data or management frames and report any discrepancies to the controller.
- If you want to disable all signatures (both standard and custom) on the controller, uncheck the **Enable Check for All Standard and Custom Signatures** check box. If you uncheck this check box, all signatures are disabled, even the ones whose individual states are set to Enabled.

Step 3 Click **Apply** to commit your changes.

Step 4 To enable or disable an individual signature, click the precedence number of the desired signature. The Standard Signature (or Custom Signature) > Detail page appears (see Figure 5-61).

Figure 5-61 Standard Signature > Detail Page



This page shows much of the same information as the Standard Signatures and Custom Signatures pages but provides these additional details:

- The tracking method used by the access points to perform signature analysis and report the results to the controller. The possible values are:
  - Per Signature—Signature analysis and pattern matching are tracked and reported on a per-signature and per-channel basis.
  - Per MAC—Signature analysis and pattern matching are tracked and reported separately for individual client MAC addresses on a per-channel basis.
  - Per Signature and MAC—Signature analysis and pattern matching are tracked and reported on a per-signature and per-channel basis as well as on a per-MAC-address and per-channel basis.
- The pattern that is being used to detect a security attack

Step 5 In the Measurement Interval field, enter the number of seconds that must elapse before the signature frequency threshold is reached within the configured interval. The range is 1 to 3600 seconds, and the default value varies per signature.

Step 6 In the Signature Frequency field, enter the number of matching packets per interval that must be identified at the individual access point level before an attack is detected. The range is 1 to 32,000 packets per interval, and the default value varies per signature.

Step 7 In the Signature MAC Frequency field, enter the number of matching packets per interval that must be identified per client per access point before an attack is detected. The range is 1 to 32,000 packets per interval, and the default value varies per signature.

Step 8 In the Quiet Time field, enter the length of time (in seconds) after which no attacks have been detected at the individual access point level and the alarm can stop. The range is 60 to 32,000 seconds, and the default value varies per signature.

Step 9 Check the **State** check box to enable this signature to detect security attacks or uncheck it to disable this signature. The default value is enabled (or checked).

Step 10 Click **Apply** to commit your changes. The Standard Signatures or Custom Signatures page reflects the signature's updated state.

Step 11 Click **Save Configuration** to save your changes.

Using the GUI to View IDS Signature Events

Follow these steps to view signature events using the controller GUI.

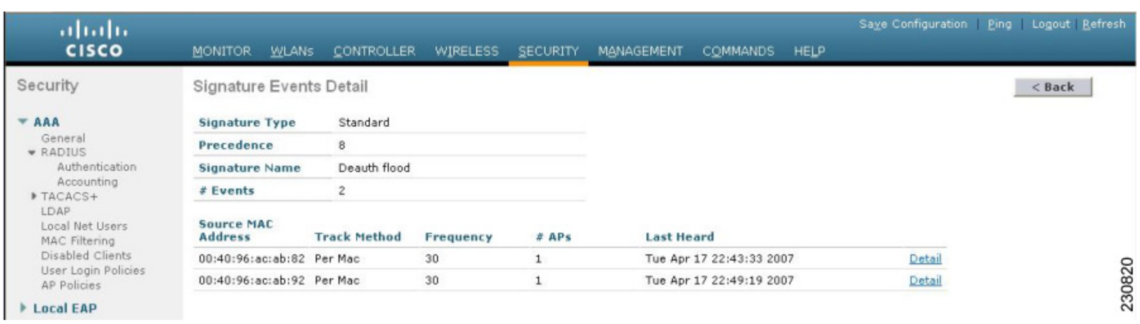
Step 1 Choose **Security** > **Wireless Protection Policies** > **Signature Events Summary**. The Signature Events Summary page appears (see Figure 5-62).

Figure 5-62 Signature Events Summary Page

This page shows the number of attacks detected by the enabled signatures.

Step 2 To see more information on the attacks detected by a particular signature, click the signature type link for that signature. The Signature Events Detail page appears (see Figure 5-63).

Figure 5-63 Signature Events Detail Page



This page shows the following information:

- The MAC addresses of the clients identified as attackers
- The method used by the access point to track the attacks
- The number of matching packets per second that were identified before an attack was detected

- The number of access points on the channel on which the attack was detected
- The day and time when the access point detected the attack

Step 3 To see more information for a particular attack, click the **Detail** link for that attack. The Signature Events Track Detail page appears (see Figure 5-64).

Figure 5-64 Signature Events Track Detail Page

This page shows the following information:

- The MAC address of the access point that detected the attack
- The name of the access point that detected the attack
- The type of radio (802.11a or 802.11b/g) used by the access point to detect the attack
- The radio channel on which the attack was detected
- The day and time when the access point reported the attack

Using the CLI to Configure IDS Signatures

Follow these steps to configure IDS signatures using the controller CLI.

Step 1 If desired, create your own custom signature file.

Step 2 Make sure that you have a TFTP server available. See the guidelines for setting up a TFTP server in Step 2 of the "Using the GUI to Upload or Download IDS Signatures" section on page 5-114.

Step 3 Copy the custom signature file (*.sig) to the default directory on your TFTP server.

Step 4 To specify the download or upload mode, enter **transfer** {**download** | **upload**} **mode tftp**.

Step 5 To specify the type of file to be downloaded or uploaded, enter **transfer** {**download** | **upload**} **datatype signature**.

Step 6 To specify the IP address of the TFTP server, enter **transfer** {**download** | **upload**} **serverip** *tftp-server-ip-address*.

Note Some TFTP servers require only a forward slash (/) as the TFTP server IP address, and the TFTP server automatically determines the path to the correct directory.

Step 7 To specify the download or upload path, enter **transfer** {**download** | **upload**} **path** *absolute-tftp-server-path-to-file*.

Step 8 To specify the file to be downloaded or uploaded, enter **transfer** {**download** | **upload**} **filename** *filename.sig*.

> **Note** When uploading signatures, the controller uses the filename you specify as a base name and then adds "_std.sig" and "_custom.sig" to it in order to upload *both* standard and custom signature files to the TFTP server. For example, if you upload a signature file called "ids1," the controller automatically generates and uploads both ids1_std.sig and ids1_custom.sig to the TFTP server. If desired, you can then modify ids1_custom.sig on the TFTP server (making sure to set "Revision = custom") and download it by itself.

Step 9 Enter **transfer** {**download** | **upload**} **start** and answer **y** to the prompt to confirm the current settings and start the download or upload.

Step 10 To specify the number of seconds that must elapse before the signature frequency threshold is reached within the configured interval, enter this command:

config wps signature interval *signature_id interval*

where *signature_id* is a number used to uniquely identify a signature. The range is 1 to 3600 seconds, and the default value varies per signature.

Step 11 To specify the number of matching packets per interval that must be identified at the individual access point level before an attack is detected, enter this command:

config wps signature frequency *signature_id frequency*

The range is 1 to 32,000 packets per interval, and the default value varies per signature.

Step 12 To specify the number of matching packets per interval that must be identified per client per access point before an attack is detected, enter this command:

config wps signature mac-frequency *signature_id mac_frequency*

The range is 1 to 32,000 packets per interval, and the default value varies per signature.

Step 13 To specify the length of time (in seconds) after which no attacks have been detected at the individual access point level and the alarm can stop, enter this command:

config wps signature quiet-time *signature_id quiet_time*

The range is 60 to 32,000 seconds, and the default value varies per signature.

Step 14 To enable or disable IDS signatures, perform one of the following:

- To enable or disable an individual IDS signature, enter this command:

  config wps signature {**standard** | **custom**} **state** *signature_id* {**enable** | **disable**}

- To enable or disable IDS signature processing, which enables or disables the processing of all IDS signatures, enter this command:

  config wps signature {**enable** | **disable**}

  > **Note** If IDS signature processing is disabled, all signatures are disabled, regardless of the state configured for individual signatures.

Step 15 To save your changes, enter this command:

save config

Step 16 If desired, you can reset a specific signature or all signatures to default values. To do so, enter this command:

config wps signature reset {*signature_id* | **all**}

> **Note** You can reset signatures to default values only through the controller CLI.

Using the CLI to View IDS Signature Events

Use these commands to view signature events using the controller CLI.

1. To see whether IDS signature processing is enabled or disabled on the controller, enter this command:

   show wps summary

   Information similar to the following appears:

```
Auto-Immune
  Auto-Immune.................................... Disabled

Client Exclusion Policy
  Excessive 802.11-association failures.......... Enabled
  Excessive 802.11-authentication failures....... Enabled
  Excessive 802.1x-authentication................ Enabled
  IP-theft....................................... Enabled
  Excessive Web authentication failure........... Enabled

Signature Policy
  Signature Processing........................... Enabled
```

   > **Note** If IDS signature processing is disabled, all signatures are disabled, regardless of the state configured for individual signatures.

2. To see individual summaries of all of the standard and custom signatures installed on the controller, enter this command:

   show wps signature summary

   Information similar to the following appears:

```
Signature-ID..................................... 1
Precedence....................................... 1
Signature Name................................... Bcast deauth
Type............................................. standard
FrameType........................................ management
State............................................ enabled
Action........................................... report
Tracking......................................... per Signature and Mac
Signature Frequency.............................. 50 pkts/interval
Signature Mac Frequency.......................... 30 pkts/interval
Interval......................................... 1 sec
Quiet Time....................................... 300 sec
Description...................................... Broadcast Deauthentication Frame
```

```
Patterns:
                0(Header):0x00c0:0x00ff
               4(Header):0x01:0x01
```

3. To see the number of attacks detected by the enabled signatures, enter this command:

   show wps signature events summary

   Information similar to the following appears:

```
Precedence Signature Name     Type     # Events
---------- ------------------ -----   -----------
1           Bcast deauth       Standard    2
2           NULL probe resp 1  Standard    1
```

4. To see more information on the attacks detected by a particular standard or custom signature, enter this command:

   show wps signature events {**standard** | **custom**} *precedence#* **summary**

   Information similar to the following appears:

```
Precedence....................................... 1
Signature Name................................... Bcast deauth
Type............................................. Standard
Number of active events...................... 2

Source MAC Addr   Track Method  Frequency No. APs Last Heard
----------------- ------------  --------- -------- ------------------------
00:01:02:03:04:01 Per Signature   4          3    Tue Dec 6 00:17:44 2005
00:01:02:03:04:01 Per Mac         6          2    Tue Dec 6 00:30:04 2005
```

5. To see information on attacks that are tracked by access points on a per-signature and per-channel basis, enter this command:

   show wps signature events {**standard** | **custom**} *precedence#* **detailed per-signature** *source_mac*

6. To see information on attacks that are tracked by access points on an individual-client basis (by MAC address), enter this command:

   show wps signature events {**standard** | **custom**} *precedence#* **detailed per-mac** *source_mac*

   Information similar to the following appears:

```
Source MAC....................................... 00:01:02:03:04:01
Precedence....................................... 1
Signature Name................................... Bcast deauth
Type............................................. Standard
Track............................................ Per Mac
Frequency........................................ 6
Reported By
    AP 1
        MAC Address.............................. 00:0b:85:01:4d:80
        Name..................................... Test_AP_1
        Radio Type............................... 802.11bg
        Channel.................................. 4
        Last reported by this AP................. Tue Dec 6 00:17:49 2005
    AP 2
        MAC Address.............................. 00:0b:85:26:91:52
        Name..................................... Test_AP_2
        Radio Type............................... 802.11bg
        Channel.................................. 6
         Last reported by this AP................. Tue Dec 6 00:30:04 2005
```

Configuring wIPS

The Cisco Adaptive wireless intrusion prevention system (wIPS) is an advanced approach to wireless threat detection and performance management. It combines network traffic analysis, network device and topology information, signature-based techniques, and anomaly detection to deliver highly accurate and complete wireless threat prevention. With a fully infrastructure-integrated solution, you can continually monitor wireless traffic on both the wired and wireless networks and use that network intelligence to analyze attacks from many sources to more accurately pinpoint and proactively prevent attacks rather than waiting until damage or exposure has occurred.

The Cisco Adaptive wIPS is enabled by the Cisco 3300 Series Mobility Services Engine (MSE), which is an appliance-based solution that centralizes the processing of intelligence collected by the continuous monitoring of Cisco Aironet access points. With Cisco Adaptive wIPS functionalities and WCS integration into the MSE, the wIPS service can configure, monitor, and report wIPS policies and alarms.

The Cisco Adaptive wIPS is not configured on the controller. Instead, WCS forwards the profile configuration to the wIPS service, which in turn forwards the profile to the controller. The profile is stored in flash memory on the controller and sent to access points when they join the controller. When an access point disassociates and joins another controller, it receives the wIPS profile from the new controller.

Access points in monitor mode periodically send alarms based on the policy profile to the wIPS service through the controller. The wIPS service stores and processes the alarms and generates SNMP traps. WCS configures its IP address as a trap destination to receive SNMP traps from the MSE.

Table 5-10 lists all the SNMP trap controls and their respective traps. When a trap control is enabled, all the traps of the trap control are also enabled.

Table 5-10 SNMP Trap Controls and their respective Traps

Tab Name	Trap Control	Trap
General	Link (Port) Up/Down	linkUp, linkDown
	Spanning Tree	newRoot, topologyChange, stpInstanceNewRootTrap, stpInstanceTopologyChangeTrap
	Config Save	bsnDot11EssCreated, bsnDot11EssDeleted, bsnConfigSaved, ciscoLwappScheduledResetNotif, ciscoLwappClearResetNotif, ciscoLwappResetFailedNotif, ciscoLwappSysInvalidXmlConfig
AP	AP Register	bsnAPDisassociated, bsnAPAssociated
	Ap Interface Up/Down	bsnAPIfUp, bsnAPIfDown
Client Traps	802.11 Association	bsnDot11StationAssociate
	802.11 Disassociation	bsnDot11StationDisassociate
	802.11 Deauthentication	bsnDot11StationDeauthenticate
	802.11 Failed Authentication	bsnDot11StationAuthenticateFail
	802.11 Failed Association	bsnDot11StationAssociateFail
	Exclusion	bsnDot11StationBlacklisted

Table 5-10 SNMP Trap Controls and their respective Traps (continued)

Tab Name	Trap Control	Trap
Security Traps	User Authentication	bsnTooManyUnsuccessLoginAttempts, cLWAGuestUserLoggedIn, cLWAGuestUserLoggedOut
	RADIUS Servers Not Responding	bsnRADIUSServerNotResponding, ciscoLwappAAARadiusReqTimedOut
	WEP Decrypt Error	bsnWepKeyDecryptError
	Rogue AP	bsnAdhocRogueAutoContained, bsnRogueApAutoContained, bsnTrustedApHasInvalidEncryption, bsnMaxRogueCountExceeded, bsnMaxRogueCountClear, bsnApMaxRogueCountExceeded, bsnApMaxRogueCountClear, bsnTrustedApHasInvalidRadioPolicy, bsnTrustedApHasInvalidSsid, bsnTrustedApIsMissing
	SNMP Authentication	agentSnmpAuthenticationTrapFlag
	Multiple Users	multipleUsersTrap
Auto RF Profile Traps	Load Profile	bsnAPLoadProfileFailed
	Noise Profile	bsnAPNoiseProfileFailed
	Interference Profile	bsnAPInterferenceProfileFailed
	Coverage Profile	bsnAPCoverageProfileFailed
Auto RF Update Traps	Channel Update	bsnAPCurrentChannelChanged
	Tx Power Update	bsnAPCurrentTxPowerChanged
Mesh Traps	Child Excluded Parent	ciscoLwappMeshChildExcludedParent
	Parent Change	ciscoLwappMeshParentChange
	Authfailure Mesh	ciscoLwappMeshAuthorizationFailure
	Child Moved	ciscoLwappMeshChildMoved
	Excessive Parent Change	ciscoLwappMeshExcessiveParentChange
	Excessive Children	ciscoLwappMeshExcessiveChildren
	Poor SNR	ciscoLwappMeshAbateSNR, ciscoLwappMeshOnsetSNR
	Console Login	ciscoLwappMeshConsoleLogin
	Excessive Association	ciscoLwappMeshExcessiveAssociation
	Default Bridge Group Name	ciscoLwappMeshDefaultBridgeGroupName

Note The remaining traps do not have trap controls. These are traps, which are not generated too frequently and thus do not require any trap control. Thus, any other trap generated by the Controller cannot be turned off.

Note In all of the above cases, the controller functions solely as a forwarding device.

Note For more information on the Cisco Adaptive wIPS, refer to the *Cisco Wireless Control System Configuration Guide, Release 6.0* and the *Cisco 3300 Series Mobility Services Engine Configuration Guide, Release 6.0*.

Configuring wIPS on an Access Point

Using the controller CLI, follow these steps to configure wIPS on an access point. These steps are required in order to enable wIPS.

Step 1 To configure an access point for monitor mode, enter this command:

config ap mode monitor *Cisco_AP*

Step 2 When warned that the access point will be rebooted and asked if you want to continue, enter **Y**.

Step 3 To save your changes, enter this command:

save config

Step 4 To disable the access point radio, enter this command:

config {**802.11a** | **802.11b**} **disable** *Cisco_AP*

Step 5 To configure the wIPS submode on the access point, enter this command:

config ap mode monitor submode wips *Cisco_AP*

Note To disable wIPS on the access point, enter this command: **config ap mode monitor submode none** *Cisco_AP*.

Step 6 To enable wIPS optimized channel scanning for the access point, enter this command:

config ap monitor-mode wips-optimized *Cisco_AP*

The access point scans each channel for 250 milliseconds. It derives the list of channels to be scanned from the monitor configuration. Three channel sets are available:

- **All**—All channels supported by the access point's radio
- **Country**—Only the channels supported by the access point's country of operation
- **DCA**—Only the channel set used by the dynamic channel assignment (DCA) algorithm, which by default includes all of the non-overlapping channels allowed in the access point's country of operation

The 802.11a or 802.11b Monitor Channels field in the output of the **show advanced** {**802.11a** | **802.11b**} **monitor** command shows the monitor configuration channel set:

```
Default 802.11b AP monitoring
  802.11b Monitor Mode........................... enable
  802.11b Monitor Channels....................... Country channels
  802.11b AP Coverage Interval................... 180 seconds
  802.11b AP Load Interval....................... 60 seconds
  802.11b AP Noise Interval...................... 180 seconds
  802.11b AP Signal Strength Interval............ 60 seconds
```

Step 7 To re-enable the access point radio, enter this command:

config {**802.11a** | **802.11b**} **enable** *Cisco_AP*

Step 8 To save your changes, enter this command:

save config

Viewing wIPS Information

Using the controller CLI, enter these commands to view wIPS information.

Note You can also view the access point submode from the controller GUI. To do so, choose **Wireless** > **Access Points** > **All APs** > the access point name > the **Advanced** tab. The AP Sub Mode field shows *wIPS* if the access point in is monitor mode and the wIPS submode is configured on the access point or *None* if the access point is not in monitor mode or the access point is in monitor mode but the wIPS submode is not configured.

1. To view the wIPS submode on the access point, enter this command:

   show ap config general *Cisco_AP*

   Information similar to the following appears:

```
Cisco AP Identifier.............................. 3
Cisco AP Name.................................... AP1131:46f2.98ac
...
AP Mode ......................................... Monitor
Public Safety ................................... Disabled  Disabled
AP SubMode ...................................... WIPS
...
```

2. To see the wIPS optimized channel scanning configuration on the access point, enter this command:

   show ap monitor-mode summary

   Information similar to the following appears:

```
AP Name            Ethernet MAC         Status      Scanning Channel List
------------------ -------------------- ----------  ------------------------
AP1131:46f2.98ac    00:16:46:f2:98:ac     wIPS          1, 6, NA, NA
```

3. To view the wIPS configuration forwarded by WCS to the controller, enter this command:

   show wps wips summary

   Information similar to the following appears:

```
Policy Name.............. Default
Policy Version.......... 3
```

4. To view the current state of wIPS operation on the controller, enter this command:

   show wps wips statistics

   Information similar to the following appears:

```
Policy Assignment Requests............ 1
Policy Assignment Responses........... 1
Policy Update Requests................ 0
Policy Update Responses............... 0
Policy Delete Requests................ 0
Policy Delete Responses............... 0
Alarm Updates......................... 13572
Device Updates........................ 8376
Device Update Requests................ 0
Device Update Responses............... 0
Forensic Updates...................... 1001
Invalid WIPS Payloads................. 0
Invalid Messages Received............. 0
NMSP Transmitted Packets.............. 22950
NMSP Transmit Packets Dropped......... 0
NMSP Largest Packet................... 1377
```

5. To clear the wIPS statistics on the controller, enter this command:

   clear stats wps wips

Detecting Active Exploits

The controller supports three active exploit alarms that serve as notifications of potential threats. They are enabled by default and therefore require no configuration on the controller.

- **ASLEAP detection**—The controller raises a trap event if an attacker launches a LEAP crack tool. The trap message is visible in the controller's trap log.
- **Fake access point detection**—The controller tweaks the fake access point detection logic to avoid false access point alarms in high-density access point environments.
- **Honeypot access point detection**—The controller raises a trap event if a rogue access point is using managed SSIDs (WLANs configured on the controller). The trap message is visible in the controller's trap log.

Configuring WLANs

This chapter describes how to configure up to 512 WLANs for your Cisco UWN Solution. It contains these sections:

WLAN Overview

The Cisco UWN solution can control up to 512 WLANs for lightweight access points. Each WLAN has a separate WLAN ID (1 through 512), a separate profile name, and a WLAN SSID and can be assigned unique security policies. All controllers publish up to 16 WLANs to each connected access point, but you can create up to 512 WLANs and then selectively publish these WLANs (using access point groups) to different access points to better manage your wireless network.

Note Cisco 2106, 2112, and 2125 controllers support only up to 16 WLANs.

Note All OfficeExtend access points should be in the same access point group, and that group should contain no more than 15 WLANs. A controller with OfficeExtend access points in an access point group publishes only up to 15 WLANs to each connected OfficeExtend access point because it reserves one WLAN for the personal SSID.

You can associate up to 16 WLANs with each access point group and assign specific access points to each group. Each access point advertises only the enabled WLANs that belong to its access point group. The access point does not advertise disabled WLANs in its access point group or WLANs that belong to another group. Refer to the "Creating Access Point Groups" section on page 6-54 for more information on access point groups.

Note Controller software releases prior to 5.2 support up to only 16 WLANs. Cisco does not support downgrading the controller from software release 5.2 or later to a previous release as inconsistencies might occur for WLANs and wired guest LANs. As a result, you would need to reconfigure your WLAN, mobility anchor, and wired LAN configurations.

Note Cisco recommends that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that controllers properly route VLAN traffic.

Configuring WLANs

These sections describe how to configure WLANs:

Creating WLANs

This section provides instructions for creating up to 512 WLANs using either the controller GUI or CLI.

Note Each AP can broadcast only up to 16 WLANs.

WLANs with ID that is higher than 16 are not applied to the default AP group, regardless of the number of WLANs configured. For WLANs with ID that is higher than 16, you need to configure a separate AP group.

You can configure WLANs with different service set identifiers (SSIDs) or with the same SSID. An SSID identifies the specific wireless network that you want the controller to access. Creating WLANs with the same SSID enables you to assign different Layer 2 security policies within the same wireless LAN. To distinguish among WLANs with the same SSID, you must create a unique profile name for each WLAN.

WLANs with the same SSID must have unique Layer 2 security policies so that clients can make a WLAN selection based on information advertised in beacon and probe responses. These are the available Layer 2 security policies:

- None (open WLAN)
- Static WEP or 802.1X

  Note Because static WEP and 802.1X are both advertised by the same bit in beacon and probe responses, they cannot be differentiated by clients. Therefore, they cannot both be used by multiple WLANs with the same SSID.

- CKIP
- WPA/WPA2

Note Although WPA and WPA2 cannot both be used by multiple WLANs with the same SSID, two WLANs with the same SSID could be configured with WPA/TKIP with PSK and WPA/TKIP with 802.1X, respectively, or with WPA/TKIP with 802.1X or WPA/AES with 802.1X, respectively.

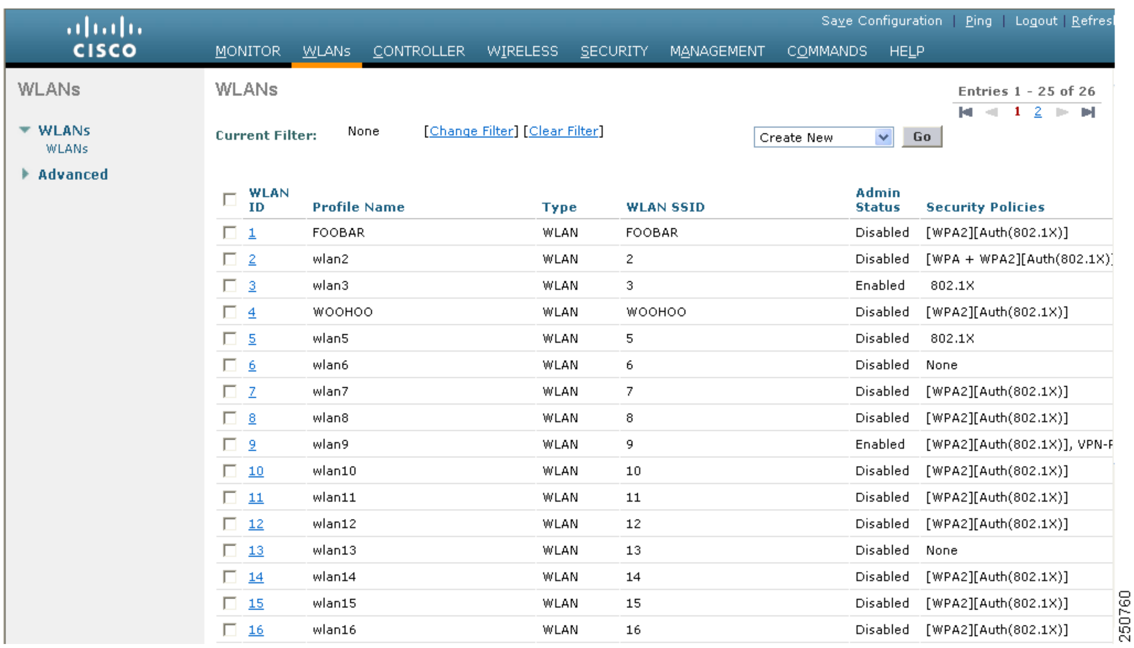
Note If a WLAN is configured to an 802.11g only radio policy and a LAP is configured to channel 14, then the WLAN clients try to associate with the LAP, which does not work as expected because of the 802.11g only policy. The workaround to the problem is one of the following:
- Disable channel 14 manually when 802.11g only policy is configured in WLANs.
- Do not select 802.11g only policy when channel 14 is configured to a LAP.

Using the GUI to Create WLANs

Follow these steps to create WLANs using the GUI.

Step 1 Choose **WLANs** to open the WLANs page (see Figure 6-1).

Figure 6-1 WLANs Page



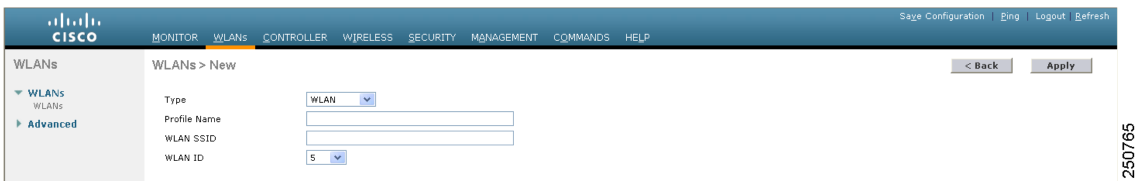
This page lists all of the WLANs currently configured on the controller. For each WLAN, you can see its WLAN ID, profile name, type, SSID, status, and security policies.

The total number of WLANs appears in the upper right-hand corner of the page. If the list of WLANs spans multiple pages, you can access these pages by clicking the page number links.

Note If you want to delete a WLAN, hover your cursor over the blue drop-down arrow for that WLAN and choose **Remove**, or check the check box to the left of the WLAN, choose **Remove Selected** from the drop-down box, and click **Go**. A message appears asking you to confirm your decision. If you proceed, the WLAN is removed from any access point group to which it is assigned and from the access point's radio.

Step 2 To create a new WLAN, choose **Create New** from the drop-down box and click **Go**. The WLANs > New page appears (see Figure 6-2).

Figure 6-2 WLANs > New Page



Step 3 From the Type drop-down box, choose **WLAN** to create a WLAN.

Note If you want to create a guest LAN for wired guest users, choose **Guest LAN** and follow the instructions in the "Configuring Wired Guest Access" section on page 10-28.

Step 4 In the Profile Name field, enter up to 32 alphanumeric characters for the profile name to be assigned to this WLAN. The profile name must be unique.

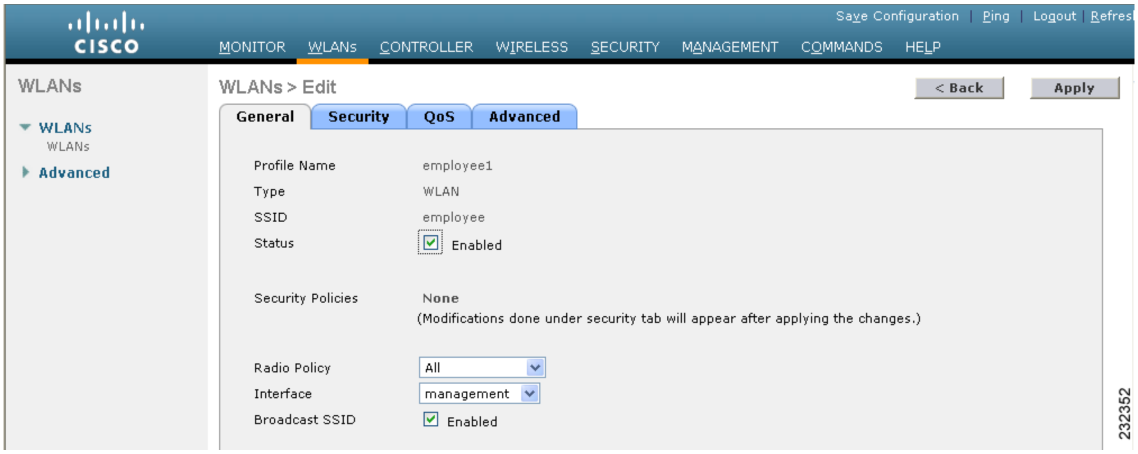
Step 5 In the WLAN SSID field, enter up to 32 alphanumeric characters for the SSID to be assigned to this WLAN.

Step 6 From the WLAN ID drop-down box, choose the ID number for this WLAN.

Step 7 Click **Apply** to commit your changes. The WLANs > Edit page appears (see Figure 6-3).

Note You can also open the WLANs > Edit page from the WLANs page by clicking the ID number of the WLAN that you want to edit.

Figure 6-3 WLANs > Edit Page



Step 8 Use the parameters on the General, Security, QoS, and Advanced tabs to configure this WLAN. Refer to the sections in the rest of this chapter for instructions on configuring specific features for WLANs.

Step 9 On the General tab, check the **Status** check box to enable this WLAN. Be sure to leave it unchecked until you have finished making configuration changes to the WLAN.

> **Note** You can also enable or disable WLANs from the WLANs page by checking the check boxes to the left of the WLANs that you want to enable or disable, choosing **Enable Selected** or **Disable Selected** from the drop-down box, and clicking **Go**.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Create WLANs

Use these commands to create WLANs using the CLI.

1. To view the list of existing WLANs and to see whether they are enabled or disabled, enter this command:

   show wlan summary

2. To create a new WLAN, enter this command:

   config wlan create *wlan_id* {*profile_name* | *foreign_ap*} *ssid*

   > **Note** If you do not specify an *ssid*, the *profile_name* parameter is used for both the profile name and the SSID.

Note When WLAN 1 is created in the configuration wizard, it is created in enabled mode. Disable it until you have finished configuring it. When you create a new WLAN using the **config wlan create** command, it is created in disabled mode. Leave it disabled until you have finished configuring it.

Note If you want to create a guest LAN for wired guest users, follow the instructions in the "Configuring Wired Guest Access" section on page 10-28.

3. To disable a WLAN (for example, before making any modifications to a WLAN), enter this command:

   config wlan disable {*wlan_id* | *foreign_ap* | **all**}

   where

   - *wlan_id* is a WLAN ID between 1 and 512,
   - *foreign_ap* is a third-party access point, and
   - **all** is all WLANs.

Note If the management and AP-manager interfaces are mapped to the same port and are members of the same VLAN, you must disable the WLAN before making a port-mapping change to either interface. If the management and AP-manager interfaces are assigned to different VLANs, you do not need to disable the WLAN.

4. To enable a WLAN (for example, after you have finished making configuration changes to the WLAN), enter this command:

   config wlan enable {*wlan_id* | *foreign_ap* | **all**}

Note If the command fails, an error message appears (for example, "Request failed for wlan 10 - Static WEP key size does not match 802.1X WEP key size").

5. To delete a WLAN, enter this command:

config wlan delete {*wlan_id* | *foreign_ap*}

> **Note** An error message appears if you try to delete a WLAN that is assigned to an access point group. If you proceed, the WLAN is removed from the access point group and from the access point's radio.

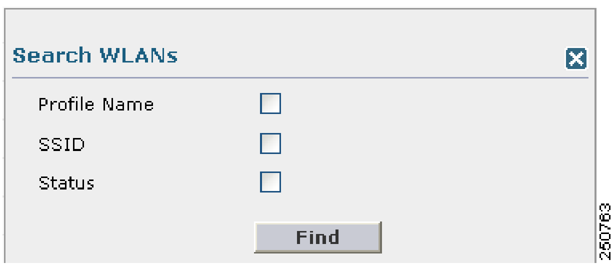
Searching WLANs

You can search for specific WLANs in the list of up to 512 WLANs on the WLANs page. This feature is especially useful if your WLANs span multiple pages, preventing you from viewing them all at once.

Follow these steps to search for WLANs using the controller GUI.

Step 1 On the WLANs page, click **Change Filter**. The Search WLANs window appears (see Figure 6-4).

Figure 6-4 Search WLANs Window



Step 2 Perform one of the following:

- To search for WLANs based on profile name, check the **Profile Name** check box and enter the desired profile name in the edit box.
- To search for WLANs based on SSID, check the **SSID** check box and enter the desired SSID in the edit box.
- To search for WLANs based on their status, check the **Status** check box and choose **Enabled** or **Disabled** from the drop-down box.
- To close the Search WLANs window without making any changes, click the **X** in the upper right-hand corner.

Step 3 Click **Find**. Only the WLANs that match your search criteria appear on the WLANs page, and the Current Filter field at the top of the page specifies the search criteria used to generate the list (for example, None, Profile Name:user1, SSID:test1, Status:disabled).

> **Note** To clear any configured search criteria and display the entire list of WLANs, click **Clear Filter**.

Configuring DHCP

WLANs can be configured to use the same or different Dynamic Host Configuration Protocol (DHCP) servers or no DHCP server. Two types of DHCP servers are available: internal and external.

Internal DHCP Server

The controllers contain an internal DHCP server. This server is typically used in branch offices that do not already have a DHCP server. The wireless network generally contains 10 access points or fewer, with the access points on the same IP subnet as the controller. The internal server provides DHCP addresses to wireless clients, direct-connect access points, appliance-mode access points on the management interface, and DHCP requests that are relayed from access points. Only lightweight access points are supported. When you want to use the internal DHCP server, you must set the management interface IP address of the controller as the DHCP server IP address.

DHCP option 43 is not supported on the internal server. Therefore, the access point must use an alternative method to locate the management interface IP address of the controller, such as local subnet broadcast, DNS, priming, or over-the-air discovery.

Note Refer to Chapter 7, "Controlling Lightweight Access Points" or the *Controller Deployment Guide* at this URL for more information on how access points find controllers:

http://www.cisco.com/c/en/us/support/wireless/4400-series-wireless-lan-controllers/products-technical-reference-list.html

External DHCP Servers

The operating system is designed to appear as a DHCP Relay to the network and as a DHCP server to clients with industry-standard external DHCP servers that support DHCP Relay. This means that each controller appears as a DHCP Relay agent to the DHCP server. This also means that the controller appears as a DHCP server at the virtual IP Address to wireless clients.

Because the controller captures the client IP address obtained from a DHCP server, it maintains the same IP address for that client during intra-controller, inter-controller, and inter-subnet client roaming.

DHCP Assignment

You can configure DHCP on a per-interface or per-WLAN basis. The preferred method is to use the primary DHCP server address assigned to a particular interface.

Per-Interface Assignment

You can assign DHCP servers for individual interfaces. The management interface, AP-manager interface, and dynamic interfaces can be configured for a primary and secondary DHCP server, and the service-port interface can be configured to enable or disable DHCP servers.

Note Refer to the *Configuring Ports and Interfaces* chapter for information on configuring the controller's interfaces.

Per-WLAN Assignment

You can also define a DHCP server on a WLAN. This server will override the DHCP server address on the interface assigned to the WLAN.

Security Considerations

For enhanced security, Cisco recommends that you require all clients to obtain their IP addresses from a DHCP server. To enforce this requirement, all WLANs can be configured with a DHCP Addr. Assignment Required setting, which disallows client static IP addresses. If DHCP Addr. Assignment Required is selected, clients must obtain an IP address via DHCP. Any client with a static IP address is not be allowed on the network. The controller monitors DHCP traffic because it acts as a DHCP proxy for the clients.

Note WLANs that support management over wireless must allow management (device-servicing) clients to obtain an IP address from a DHCP server. See the "Using Management over Wireless" section on page 5-54 for instructions on configuring management over wireless.

If slightly less security is tolerable, you can create WLANs with DHCP Addr. Assignment Required disabled. Clients then have the option of using a static IP address or obtaining an IP address from a designated DHCP server.

You are also allowed to create separate WLANs with DHCP Addr. Assignment Required disabled; then define the primary/secondary DHCP server as 0.0.0.0 on the interface assigned to the WLAN. These WLANs drop all DHCP requests and force clients to use a static IP address. Note that these WLANs do not support management over wireless connections.

Note Refer to the *Configuring Controller Settings* chapter for instructions on globally configuring DHCP proxy.

Note If you want to specify a static IP address for an access point rather than having one assigned automatically by a DHCP server, refer to the "Configuring a Static IP Address on a Lightweight Access Point" section on page 7-47 for more information.

This section provides both GUI and CLI instructions for configuring DHCP.

Using the GUI to Configure DHCP

Follow these steps to configure DHCP using the GUI.

Step 1 Follow the instructions in the "Using the GUI to Configure the Management, AP-Manager, Virtual, and Service-Port Interfaces" section on page 3-12 or "Using the GUI to Configure Dynamic Interfaces" section on page 3-18 to configure a primary DHCP server for a management, AP-manager, or dynamic interface that will be assigned to the WLAN.

Note When you want to use the internal DHCP server, you must set the management interface IP address of the controller as the DHCP server IP address.

Step 2 Choose **WLANs** to open the WLANs page.

Step 3 Click the ID number of the WLAN for which you wish to assign an interface. The WLANs > Edit (General) page appears.

Step 4 On the General tab, uncheck the **Status** check box and click **Apply** to disable the WLAN.

Step 5 Re-click the ID number of the WLAN.

Step 6 On the General tab, choose the interface for which you configured a primary DHCP server to be used with this WLAN from the **Interface** drop-down box.

Step 7 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page.

Step 8 If you want to define a DHCP server on the WLAN that will override the DHCP server address on the interface assigned to the WLAN, check the **DHCP Server Override** check box and enter the IP address of the desired DHCP server in the **DHCP Server IP Addr** edit box. The default value for the check box is disabled.

> **Note** The preferred method for configuring DHCP is to use the primary DHCP address assigned to a particular interface instead of the DHCP server override.

Step 9 If you want to require all clients to obtain their IP addresses from a DHCP server, check the **DHCP Addr. Assignment Required** check box. When this feature is enabled, any client with a static IP address is not allowed on the network. The default value is disabled.

Step 10 Click **Apply** to commit your changes.

Step 11 On the General tab, check the **Status** check box and click **Apply** to re-enable the WLAN.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure DHCP

Follow these steps to configure DHCP using the CLI.

Step 1 Follow the instructions in the "Using the GUI to Configure the Management, AP-Manager, Virtual, and Service-Port Interfaces" section on page 3-12 or "Using the GUI to Configure Dynamic Interfaces" section on page 3-18 to configure a primary DHCP server for a management, AP-manager, or dynamic interface that will be assigned to the WLAN.

Step 2 To disable the WLAN, enter this command:

config wlan disable *wlan_id*

Step 3 To specify the interface for which you configured a primary DHCP server to be used with this WLAN, enter this command:

config wlan interface *wlan_id interface_name*

Step 4 If you want to define a DHCP server on the WLAN that will override the DHCP server address on the interface assigned to the WLAN, enter this command:

config wlan dhcp_server *wlan_id dhcp_server_ip_address*

> **Note** The preferred method for configuring DHCP is to use the primary DHCP address assigned to a particular interface instead of the DHCP server override. If you enable the override, you can use the **show wlan** command to verify that the DHCP server has been assigned to the WLAN.

Step 5 To re-enable the WLAN, enter this command:

config wlan enable *wlan_id*

Using the CLI to Debug DHCP

Use these CLI commands to obtain debug information:

- **debug dhcp packet** {**enable** | **disable**}—Enables or disables debugging of DHCP packets.
- **debug dhcp message** {**enable** | **disable**}—Enables or disables debugging of DHCP error messages.
- **debug dhcp service-port** {**enable** | **disable**}—Enables or disables debugging of DHCP packets on the service port.

Configuring DHCP Scopes

Controllers have built-in DHCP relay agents. However, when network administrators desire network segments that do not have a separate DHCP server, the controllers can have built-in DHCP scopes that assign IP addresses and subnet masks to wireless clients. Typically, one controller can have one or more DHCP scopes that each provide a range of IP addresses.

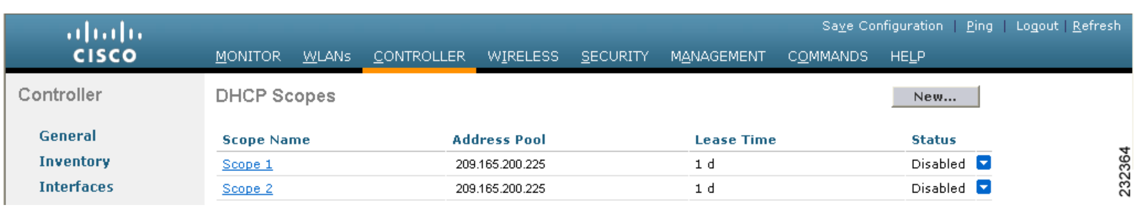
DHCP scopes are needed for internal DHCP to work. Once DHCP is defined on the controller, we can then point the primary DHCP server IP address on the management, AP-manager, and dynamic interfaces to controller's management interface. You can configure up to 16 DHCP scopes using the controller GUI or CLI.

Using the GUI to Configure DHCP Scopes

Follow these steps to configure DHCP scopes using the GUI.

Step 1 Choose **Controller** > **Internal DHCP Server** > **DHCP Scope** to open the DHCP Scopes page (see Figure 6-5).

Figure 6-5 DHCP Scopes Page



This page lists any DHCP scopes that have already been configured.

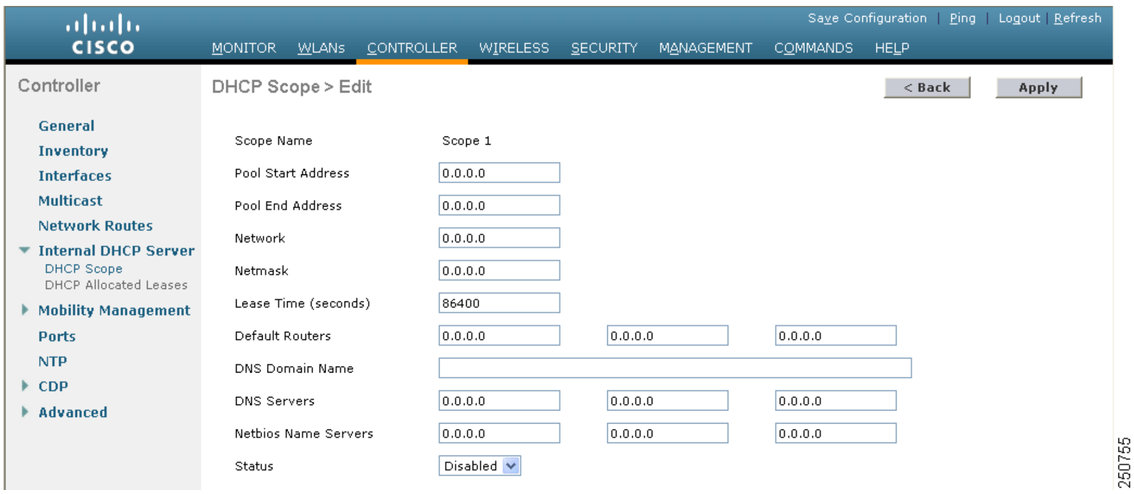
Note If you ever want to delete an existing DHCP scope, hover your cursor over the blue drop-down arrow for that scope and choose **Remove**.

Step 2 To add a new DHCP scope, click **New**. The DHCP Scope > New page appears.

Step 3 In the Scope Name field, enter a name for the new DHCP scope.

Step 4 Click **Apply**. When the DHCP Scopes page reappears, click the name of the new scope. The DHCP Scope > Edit page appears (see Figure 6-6).

Figure 6-6 DHCP Scope > Edit Page



Step 5 In the Pool Start Address field, enter the starting IP address in the range assigned to the clients.

Note This pool must be unique for each DHCP scope and must not include the static IP addresses of routers or other servers.

Step 6 In the Pool End Address field, enter the ending IP address in the range assigned to the clients.

Note This pool must be unique for each DHCP scope and must not include the static IP addresses of routers or other servers.

Step 7 In the Network field, enter the network served by this DHCP scope. This is the IP address used by the management interface with Netmask applied, as configured on the Interfaces page.

Step 8 In the Netmask field, enter the subnet mask assigned to all wireless clients.

Step 9 In the Lease Time field, enter the amount of time (from 0 to 65536 seconds) that an IP address is granted to a client.

Step 10 In the Default Routers field, enter the IP address of the optional router(s) connecting the controllers. Each router must include a DHCP forwarding agent, which allows a single controller to serve the clients of multiple controllers.

Step 11 In the DNS Domain Name field, enter the optional domain name system (DNS) domain name of this DHCP scope for use with one or more DNS servers.

Step 12 In the DNS Servers field, enter the IP address of the optional DNS server(s). Each DNS server must be able to update a client's DNS entry to match the IP address assigned by this DHCP scope.

Step 13 In the Netbios Name Servers field, enter the IP address of the optional Microsoft Network Basic Input Output System (NetBIOS) name server(s), such as a s Internet Naming Service (WINS) server.

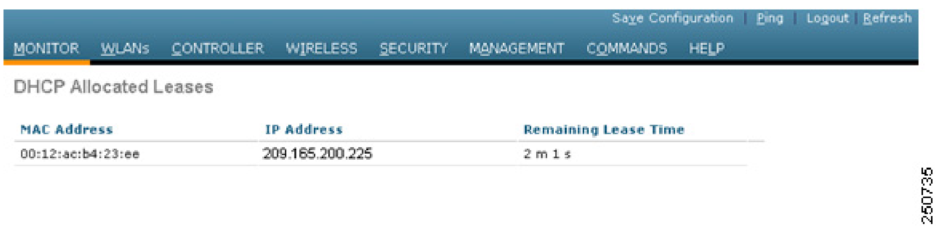
Step 14 From the Status drop-down box, choose **Enabled** to enable this DHCP scope or **Disabled** to disable it.

Step 15 Click **Apply** to commit your changes.

Step 16 Click **Save Configuration** to save your changes.

Step 17 To see the remaining lease time for wireless clients, choose **DHCP Allocated Leases**. The DHCP Allocated Lease page appears (see Figure 6-7), showing the MAC address, IP address, and remaining lease time for the wireless clients.

Figure 6-7 DHCP Allocated Lease Page



Using the CLI to Configure DHCP Scopes

Follow these steps to configure DHCP scopes using the CLI.

Step 1 To create a new DHCP scope, enter this command:

config dhcp create-scope *scope*

> **Note** If you ever want to delete a DHCP scope, enter this command: **config dhcp delete-scope** *scope*.

Step 2 To specify the starting and ending IP address in the range assigned to the clients, enter this command:

config dhcp address-pool *scope start end*

> **Note** This pool must be unique for each DHCP scope and must not include the static IP addresses of routers or other servers.

Step 3 To specify the network served by this DHCP scope (the IP address used by the management interface with Netmask applied) and the subnet mask assigned to all wireless clients, enter this command:

config dhcp network *scope network netmask*

Step 4 To specify the amount of time (from 0 to 65536 seconds) that an IP address is granted to a client, enter this command:

config dhcp lease *scope lease_duration*

Step 5 To specify the IP address of the optional router(s) connecting the controllers, enter this command:

config dhcp default-router *scope router_1* [*router_2*] [*router_3*]

Each router must include a DHCP forwarding agent, which allows a single controller to serve the clients of multiple controllers.

Step 6 To specify the optional domain name system (DNS) domain name of this DHCP scope for use with one or more DNS servers, enter this command:

config dhcp domain *scope domain*

Step 7 To specify the IP address of the optional DNS server(s), enter this command:

config dhcp dns-servers *scope dns1* [*dns2*] [*dns3*]

Each DNS server must be able to update a client's DNS entry to match the IP address assigned by this DHCP scope

Step 8 To specify the IP address of the optional Microsoft Network Basic Input Output System (NetBIOS) name server(s), such as a s Internet Naming Service (WINS) server, enter this command:

config dhcp netbios-name-server *scope wins1* [*wins2*] [*wins3*]

Step 9 To enable or disable this DHCP scope, enter this command:

config dhcp {**enable** | **disable**} *scope*

Step 10 To save your changes, enter this command:

save config

Step 11 To see the list of configured DHCP scopes, enter this command:

show dhcp summary

Information similar to the following appears:

```
Scope Name           Enabled          Address Range
Scope 1               No          0.0.0.0 -> 0.0.0.0
Scope 2               No          0.0.0.0 -> 0.0.0.0
```

Step 12 To display the DHCP information for a particular scope, enter this command:

show dhcp *scope*

Information similar to the following appears:

```
Enabled....................................... No
Lease Time.................................... 0
Pool Start.................................... 0.0.0.0
Pool End...................................... 0.0.0.0
Network....................................... 0.0.0.0
Netmask....................................... 0.0.0.0
Default Routers............................... 0.0.0.0 0.0.0.0 0.0.0.0
DNS Domain....................................
DNS........................................... 0.0.0.0 0.0.0.0 0.0.0.0
Netbios Name Servers.......................... 0.0.0.0 0.0.0.0 0.0.0.0
```

Configuring MAC Filtering for WLANs

When you use MAC filtering for client or administrator authorization, you need to enable it at the WLAN level first. If you plan to use local MAC address filtering for any WLAN, use the commands in this section to configure MAC filtering for a WLAN.

Enabling MAC Filtering

Use these commands to enable MAC filtering on a WLAN:

- Enter **config wlan mac-filtering enable** *wlan_id* to enable MAC filtering.
- Enter **show wlan** to verify that you have MAC filtering enabled for the WLAN.

When you enable MAC filtering, only the MAC addresses that you add to the WLAN are allowed to join the WLAN. MAC addresses that have not been added are not allowed to join the WLAN.

Creating a Local MAC Filter

Controllers have built-in MAC filtering capability, similar to that provided by a RADIUS authorization server.

Use these commands to add MAC addresses to a WLAN MAC filter:

- Enter **config macfilter add** *mac_addr wlan_id* [*interface_name*] [*description*] [*IP_addr*] to create a MAC filter entry on the controller, where the following parameters are optional:
  - *mac_addr*—MAC address of the the client.
  - *wlan_id*—WLAN id on which the client is associating.
  - *interface_name*—The name of the interface. This interface name is used to override the interface configured to the WLAN.

  Note You must have AAA enabled on the WLAN to override the interface name.

  - *description*—A brief description of the interface in double quotes (for example, “Interface1”).
  - *IP_addr*—The IP address which is used for a passive client with the MAC address specified by the *mac_addr* value above.
- Enter **config macfilter ip-address** *mac_addr IP_addr* to assign an IP address to an existing MAC filter entry, if one was not assigned in the **config macfilter add** command.
- Enter **show macfilter** to verify that MAC addresses are assigned to the WLAN.

Configuring a Timeout for Disabled Clients

You can configure a timeout for disabled clients. Clients who fail to authenticate three times when attempting to associate are automatically disabled from further association attempts. After the timeout period expires, the client is allowed to retry authentication until it associates or fails authentication and is excluded again. Use these commands to configure a timeout for disabled clients:

- Enter **config wlan exclusionlist** *wlan_id timeout* to configure the timeout for disabled clients. Enter a timeout from **1** to **65535** seconds, or enter **0** to permanently disable the client.
- Use the **show wlan** command to verify the current timeout.

Assigning WLANs to Interfaces

Use these commands to assign a WLAN to an interface:

- Enter this command to assign a WLAN to an interface:

config wlan interface {*wlan_id* | **foreignAp**} *interface_id*

- Use the *interface_id* option to assign the WLAN to a specific interface.
- Use the **foreignAp** option to use a third-party access point.

- Enter **show wlan summary** to verify the interface assignment status.

Configuring the DTIM Period

In 802.11a/n and 802.11b/g/n networks, lightweight access points broadcast a beacon at regular intervals, which coincides with the Delivery Traffic Indication Map (DTIM). After the access point broadcasts the beacon, it transmits any buffered broadcast and multicast frames based on the value set for the DTIM period. This feature allows power-saving clients to wake up at the appropriate time if they are expecting broadcast or multicast data.

Normally, the DTIM value is set to 1 (transmit broadcast and multicast frames after every beacon) or 2 (transmit after every other beacon). For instance, if the beacon period of the 802.11a/n or 802.11b/g/n network is 100 ms and the DTIM value is set to 1, the access point transmits buffered broadcast and multicast frames 10 times per second. If the beacon period is 100 ms and the DTIM value is set to 2, the access point transmits buffered broadcast and multicast frames 5 times per second. Either of these settings may be suitable for applications, including VoIP, that expect frequent broadcast and multicast frames.

However, the DTIM value can be set as high as 255 (transmit broadcast and multicast frames after every 255th beacon) if all 802.11a/n or 802.11b/g/n clients have power save enabled. Because the clients have to listen only when the DTIM period is reached, they can be set to listen for broadcasts and multicasts less frequently, resulting in longer battery life. For instance, if the beacon period is 100 ms and the DTIM value is set to 100, the access point transmits buffered broadcast and multicast frames once every 10 seconds, allowing the power-saving clients to sleep longer before they have to wake up and listen for broadcasts and multicasts, resulting in longer battery life.

Many applications cannot tolerate a long time between broadcast and multicast messages, resulting in poor protocol and application performance. Cisco recommends a low DTIM value for 802.11a/n and 802.11b/g/n networks that support such clients.

In controller software release 5.0 or later, you can configure the DTIM period for the 802.11a/n and 802.11b/g/n radio networks on specific WLANs. In previous software releases, the DTIM period was configured per radio network only, not per WLAN. The benefit of this change is that now you can configure a different DTIM period for each WLAN. For example, you might want to set different DTIM values for voice and data WLANs.

Note When you upgrade the controller software to release 5.0 or later, the DTIM period that was configured for a radio network is copied to all of the existing WLANs on the controller.

Using the GUI to Configure the DTIM Period

Using the GUI, follow these steps to configure the DTIM period for a WLAN.

Step 1 Choose **WLANs** to open the WLANs page.

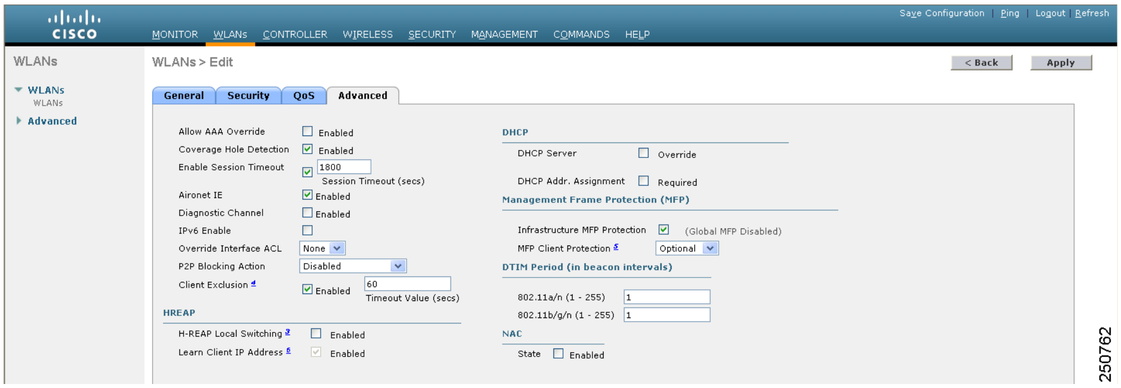
Step 2 Click the ID number of the WLAN for which you want to configure the DTIM period.

Step 3 Uncheck the **Status** check box to disable the WLAN.

Step 4 Click **Apply** to commit your changes.

Step 5 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 6-8).

Figure 6-8 WLANs > Edit (Advanced) Page



Step 6 Under DTIM Period, enter a value between 1 and 255 (inclusive) in the 802.11a/n and 802.11b/g/n fields. The default value is 1 (transmit broadcast and multicast frames after every beacon).

Step 7 Click **Apply** to commit your changes.

Step 8 Choose the **General** tab to open the WLANs > Edit (General) page.

Step 9 Check the **Status** check box to re-enable the WLAN.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Configure the DTIM Period

Using the CLI, follow these steps to configure the DTIM period for a WLAN.

Step 1 To disable the WLAN, enter this command:

config wlan disable *wlan_id*

Step 2 To configure the DTIM period for either the 802.11a/n or 802.11b/g/n radio network on a specific WLAN, enter this command:

config wlan dtim {**802.11a** | **802.11b**} *dtim wlan_id*

where *dtim* is a value between 1 and 255 (inclusive). The default value is 1 (transmit broadcast and multicast frames after every beacon).

Step 3 To re-enable the WLAN, enter this command:

config wlan enable *wlan_id*

Step 4 To save your changes, enter this command:

save config

Step 5 To verify the DTIM period, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

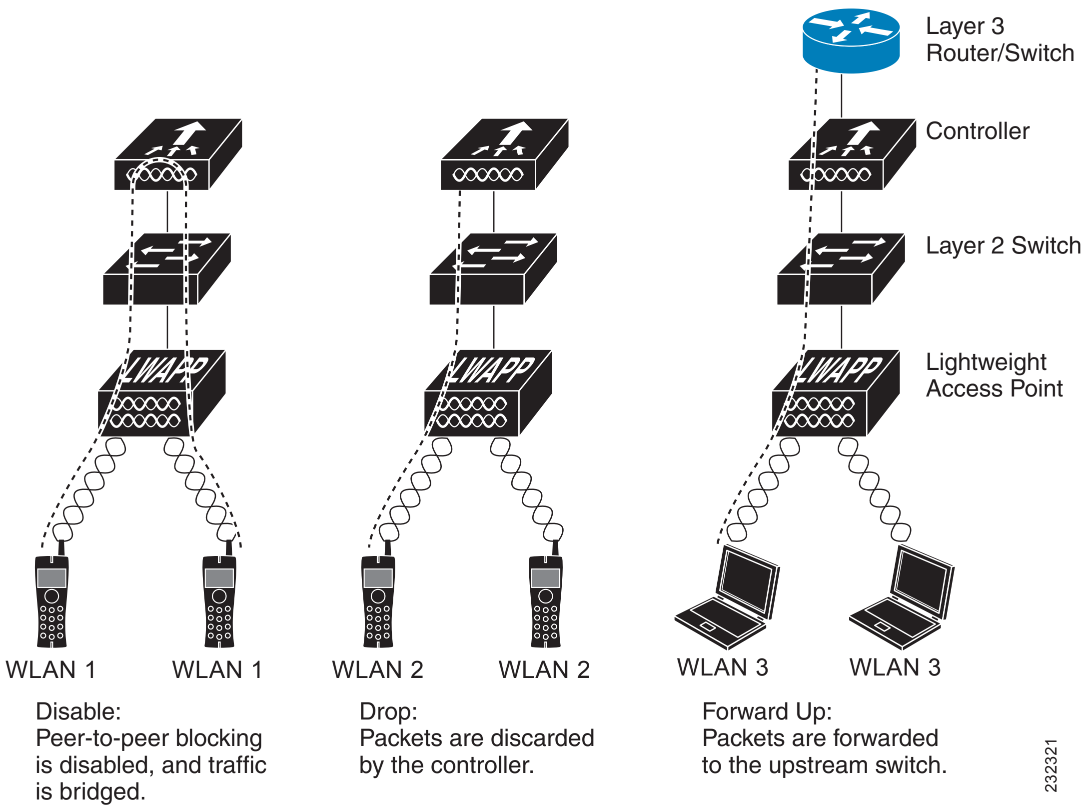
```
WLAN Identifier................................. 1
Profile Name.................................... employee1
Network Name (SSID)............................. employee
Status.......................................... Enabled
...
DTIM period for 802.11a radio................... 1
DTIM period for 802.11b radio................... 1
Local EAP Authentication..................... Disabled
...
```

Configuring Peer-to-Peer Blocking

In controller software releases prior to 4.2, peer-to-peer blocking is applied globally to all clients on all WLANs and causes traffic between two clients on the same VLAN to be transferred to the upstream VLAN rather than being bridged by the controller. This behavior usually results in traffic being dropped at the upstream switch because switches do not forward packets out the same port on which they are received.

In controller software release 4.2 or later, peer-to-peer blocking is applied to individual WLANs, and each client inherits the peer-to-peer blocking setting of the WLAN to which it is associated. In 4.2 or later, you also have more control over how traffic is directed. For example, you can choose to have traffic bridged locally within the controller, dropped by the controller, or forwarded to the upstream VLAN. Figure 6-9 illustrates each option.

Figure 6-9 Peer-to-Peer Blocking Examples



Guidelines for Using Peer-to-Peer Blocking

Follow these guidelines when using peer-to-peer blocking:

- In controller software releases prior to 4.2, the controller forwards Address Resolution Protocol (ARP) requests upstream (just like all other traffic). In controller software release 4.2 or later, ARP requests are directed according to the behavior set for peer-to-peer blocking.
- Peer-to-peer blocking does not apply to multicast traffic.
- Locally switched hybrid-REAP WLANs and hybrid-REAP access points in standalone mode do not support peer-to-peer blocking.
- If you upgrade to controller software release 4.2 or later from a previous release that supports global peer-to-peer blocking, each WLAN is configured with the peer-to-peer blocking action of forwarding traffic to the upstream VLAN.

Using the GUI to Configure Peer-to-Peer Blocking

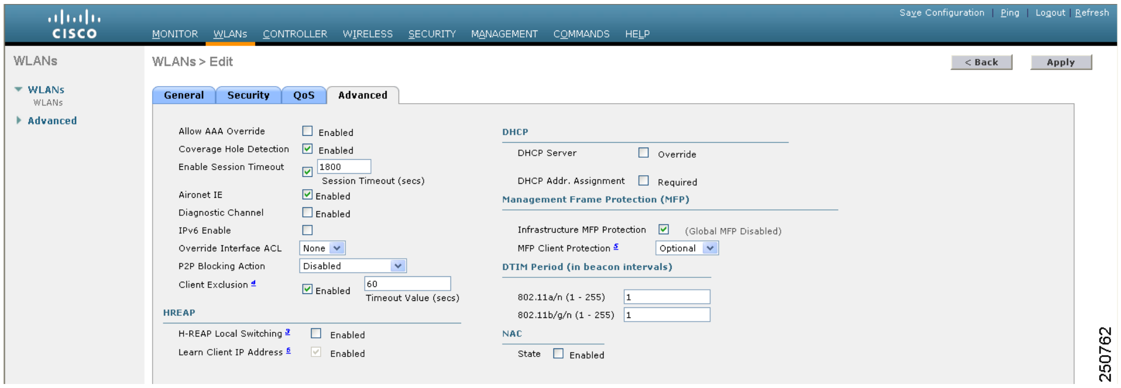
Follow these steps to configure a WLAN for peer-to-peer blocking using the GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure peer-to-peer blocking.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 6-10).

Figure 6-10 WLANs > Edit (Advanced) Page



Step 4 Choose one of the following options from the P2P Blocking drop-down box:

- **Disabled**—Disables peer-to-peer blocking and bridges traffic locally within the controller whenever possible. This is the default value.

Note Traffic is never bridged across VLANs in the controller.

- **Drop**—Causes the controller to discard the packets.
- **Forward-UpStream**—Causes the packets to be forwarded on the upstream VLAN. The device above the controller decides what action to take regarding the packets.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure Peer-to-Peer Blocking

Follow these steps to configure a WLAN for peer-to-peer blocking using the CLI.

Step 1 To configure a WLAN for peer-to-peer blocking, enter this command:

config wlan peer-blocking {**disable** | **drop** | **forward-upstream**} *wlan_id*

Note See the description of each parameter in the "Using the GUI to Configure Peer-to-Peer Blocking" section above.

Step 2 To save your changes, enter this command:

save config

Step 3 To see the status of peer-to-peer blocking for a WLAN, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... test
Network Name (SSID).............................. test
Status........................................... Enabled
...
...
...
Peer-to-Peer Blocking Action..................... Disabled
Radio Policy..................................... All
Local EAP Authentication..................... Disabled
```

Configuring Layer 2 Security

This section explains how to assign Layer 2 security settings to WLANs.

Static WEP Keys

Controllers can control static WEP keys across access points. Use these commands to configure static WEP for WLANs:

- Enter this command to disable 802.1X encryption:

  config wlan security 802.1X disable *wlan_id*

- Enter this command to configure 40/64-bit or 104/128-bit WEP keys:

  config wlan security static-wep-key encryption *wlan_id* {**40** | **104**} {**hex** | **ascii**} *key key_index*

  – Use the **40** or **104** option to specify 40/64-bit or 104/128-bit encryption. The default setting is 104/128.

  – Use the **hex** or **ascii** option to specify the character format for the WEP key.

  – Enter 10 hexadecimal digits (any combination of 0-9, a-f, or A-F) or five printable ASCII characters for 40-bit/64-bit WEP keys or enter 26 hexadecimal or 13 ASCII characters for 104-bit/128-bit keys.

  – Enter a key index (sometimes called a *key slot*) of **1** through **4**.

Dynamic 802.1X Keys and Authorization

Controllers can control 802.1X dynamic WEP keys using Extensible Authentication Protocol (EAP) across access points and support 802.1X dynamic key settings for WLANs.

Note To use LEAP with lightweight access points and wireless clients, make sure to choose **Cisco-Aironet** as the RADIUS server type when configuring the CiscoSecure Access Control Server (ACS).

- Enter **show wlan** *wlan_id* to check the security settings of each WLAN. The default security setting for new WLANs is 802.1X with dynamic keys enabled. To maintain robust Layer 2 security, leave 802.1X configured on your WLANs.

- To disable or enable the 802.1X authentication, use this command:

  config wlan security 802.1X {**enable** | **disable**} *wlan_id*

  After you enable 802.1X authentication, the controller sends EAP authentication packets between the wireless client and the authentication server. This command allows all EAP-type packets to be sent to and from the controller.

- If you want to change the 802.1X encryption level for a WLAN, use this command:

  config wlan security 802.1X encryption *wlan_id* [**0** | **40** | **104**]

  – Use the 0 option to specify no 802.1X encryption.

  – Use the 40 option to specify 40/64-bit encryption.

  – Use the 104 option to specify 104/128-bit encryption. (This is the default encryption setting.)

Configuring a WLAN for Both Static and Dynamic WEP

You can configure up to four WLANs to support static WEP keys, and you can also configure dynamic WEP on any of these static-WEP WLANs. Follow these guidelines when configuring a WLAN for both static and dynamic WEP:

- The static WEP key and the dynamic WEP key must be the same length.
- When you configure both static and dynamic WEP as the Layer 2 security policy, no other security policies can be specified. That is, you cannot configure web authentication. However, when you configure either static or dynamic WEP as the Layer 2 security policy, you can configure web authentication.

WPA1 and WPA2

Wi-Fi Protected Access (WPA or WPA1) and WPA2 are standards-based security solutions from the Wi-Fi Alliance that provide data protection and access control for wireless LAN systems. WPA1 is compatible with the IEEE 802.11i standard but was implemented prior to the standard's ratification; WPA2 is the Wi-Fi Alliance's implementation of the ratified IEEE 802.11i standard.

The following are some of the Layer 2 Security methods that a client can use to log on to a wireless system:

- 801X—This includes:
  - Original 802.1x authentication method
  - No rekeying method; wireless clients must authenticate to the RADIUS server every time they associate to a new AP
  - Dynamic WEP (can be configured with static WEP) for data protection
- WPA1—This includes:
  - 802.1x EAP based authentication method: LEAP, EAP-FAST, PEAP, EAP-TLS
  - PSK, 802.1x, and CCKM rekeying mechanisms
  - Temporal Key Integrity Protocol (TKIP) (dynamic WEP encryption) with message integrity check (MIC) for data protection
- WPA2—This includes:
  - 802.1x EAP based authentication method: LEAP, EAP-FAST, PEAP, EAP-TLS
  - PSK, 802.1x, and CCKM rekeying mechanisms
  - Advanced Encryption Standard encryption algorithm using Counter Mode with Cipher Block Chaining Message Authentication Code Protocol (AES-CCMP) for data protection

The following are the rekeying mechanisms used by both WPA1 and WPA2, with the default being 802.1X:

- **802.1X**—802.11i International Engineering Task Force (IETF) standard rekeying mechanism. We recommend this mechanism for non-Cisco hardware clients.
- **PSK**—When you choose PSK (also known as *WPA pre-shared key* or *WPA passphrase*), you need to configure a pre-shared key (or a passphrase). This key is used as the pairwise master key (PMK) between the clients and the authentication server.
- **CCKM**—Cisco Centralized Key Management (CCKM) uses a fast rekeying technique that enables clients to roam from one access point to another without going through the controller, typically in under 150 milliseconds (ms). CCKM reduces the time required by the client to mutually authenticate with the new access point and derive a new session key during reassociation. CCKM fast secure roaming ensures that there is no perceptible delay in time-sensitive applications such as wireless Voice over IP (VoIP), enterprise resource planning (ERP), or Citrix-based solutions. CCKM is a CCXv4-compliant feature. If CCKM is selected, only CCKM clients are supported.

Note The 4.2 or later release of controller software supports CCX versions 1 through 5. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. The controller stores the CCX version of the client in its client database and uses it to limit client functionality. Clients must support CCXv4 or v5 in order to use CCKM. See the "Configuring Cisco Client Extensions" section on page 6-49 for more information on CCX.

- **802.1X+CCKM**—During normal operation, 802.1X-enabled clients mutually authenticate with a new access point by performing a complete 802.1X authentication, including communication with the main RADIUS server. However, when you configure your WLAN for 802.1X and CCKM fast secure roaming, CCKM-enabled clients securely roam from one access point to another without the need to reauthenticate to the RADIUS server. 802.1X+CCKM is considered optional CCKM because both CCKM and non-CCKM clients are supported when this option is selected.

Note When the AP advertises its security capabilities via the Robust Security Network Information Element (RSNIE) in the beacons and probe responses of the access point, CCKM rekeying capability is communicated by a MAC organizationally unique identifier (OUI) value of 00:40:96 and a type value of 0 in the Authenticated Key Management (AKM) suite selector of the RSNIE. 802.1x rekeying mechanism uses the MAC OUI of 00:0f:ac and a type value of 1 in the AKM suite selector of the RSNIE. The PSK uses a MAC OUI of 00:0F:AC with a type value of 6 in the AKM suite selector of the RSNIE.

On a single WLAN, you can allow WPA1, WPA2, and 802.1X/PSK/CCKM/802.1X+CCKM clients to join. All of the access points on such a WLAN advertise WPA1, WPA2, and 802.1X/PSK/CCKM/802.1X+CCKM information elements in their beacons and probe responses. When you enable WPA1 and/or WPA2, you can also enable one or two *ciphers*, or cryptographic algorithms, designed to protect data traffic. Specifically, you can enable AES and/or TKIP data encryption for WPA1 and/or WPA2. TKIP is the default value for WPA1, and AES is the default value for WPA2.

Note WLAN should be enabled only after WPA1 and WPA2 ciphers are enabled. You can enable WPA1 and WPA2 using the **`config wlan security wpa {wpa1/wpa2} enable`** command. You can not enable ciphers from the GUI unless WPA1 and WPA 2 are enabled.

Using the GUI to Configure WPA1+WPA2

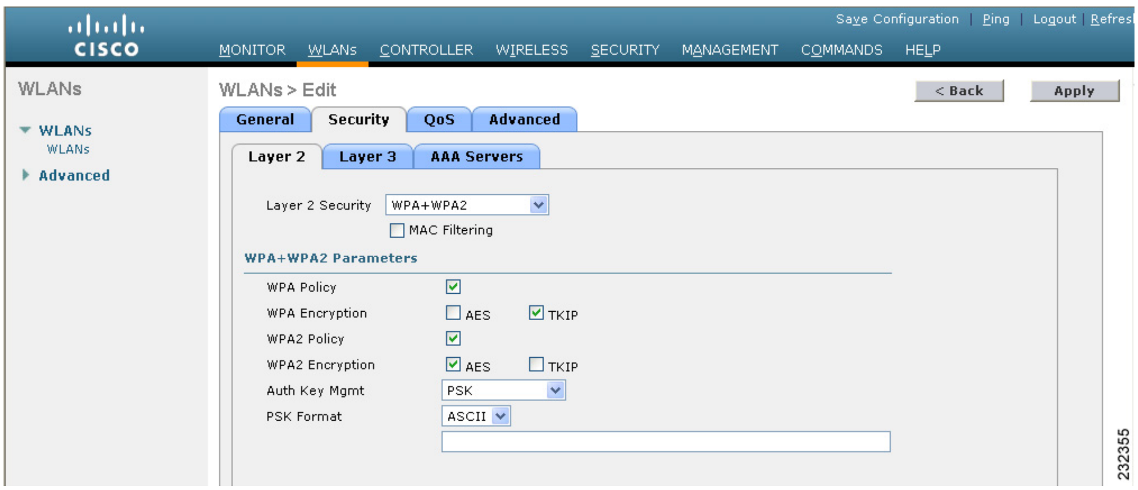
Follow these steps to configure a WLAN for WPA1+WPA2 using the controller GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Security** and **Layer 2** tabs to open the WLANs > Edit (Security > Layer 2) page (see Figure 6-11).

Figure 6-11 WLANs > Edit (Security > Layer 2) Page



Step 4 Choose **WPA+WPA2** from the Layer 2 Security drop-down box.

Step 5 Under WPA+WPA2 Parameters, check the **WPA Policy** check box to enable WPA1, check the **WPA2 Policy** check box to enable WPA2, or check both check boxes to enable both WPA1 and WPA2.

Note The default value is disabled for both WPA1 and WPA2. If you leave both WPA1 and WPA2 disabled, the access points advertise in their beacons and probe responses information elements only for the authentication key management method you choose in Step 7.

Step 6 Check the **AES** check box to enable AES data encryption or the **TKIP** check box to enable TKIP data encryption for WPA1, WPA2, or both. The default values are TKIP for WPA1 and AES for WPA2.

Step 7 Choose one of the following key management methods from the Auth Key Mgmt drop-down box: **802.1X**, **CCKM**, **PSK**, or **802.1X+CCKM**.

Step 8 If you chose PSK in Step 7, choose **ASCII** or **HEX** from the PSK Format drop-down box and then enter a pre-shared key in the blank field. WPA pre-shared keys must contain 8 to 63 ASCII text characters or 64 hexadecimal characters.

Step 9 Click **Apply** to commit your changes.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Configure WPA1+WPA2

Follow these steps to configure a WLAN for WPA1+WPA2 using the controller CLI.

Step 1 Enter this command to disable the WLAN:

config wlan disable *wlan_id*

Step 2 Enter this command to enable or disable WPA for the WLAN:

config wlan security wpa {**enable** | **disable**} *wlan_id*

Step 3 Enter this command to enable or disable WPA1 for the WLAN:

config wlan security wpa wpa1 {**enable** | **disable**} *wlan_id*

Step 4 Enter this command to enable or disable WPA2 for the WLAN:

config wlan security wpa wpa2 {**enable** | **disable**} *wlan_id*

Step 5 Enter these commands to enable or disable AES or TKIP data encryption for WPA1 or WPA2:

- **config wlan security wpa wpa1 ciphers** {**aes** | **tkip**} {**enable** | **disable**} *wlan_id*
- **config wlan security wpa wpa2 ciphers** {**aes** | **tkip**} {**enable** | **disable**} *wlan_id*

The default values are TKIP for WPA1 and AES for WPA2.

Step 6 Enter this command to enable or disable 802.1X, PSK, or CCKM authenticated key management:

config wlan security wpa akm {**802.1X** | **psk** | **cckm**} {**enable** | **disable**} *wlan_id*

The default value is 802.1X.

Step 7 If you enabled PSK in Step 6, enter this command to specify a pre-shared key:

config wlan security wpa akm psk set-key {**ascii** | **hex**} *psk-key wlan_id*

WPA pre-shared keys must contain 8 to 63 ASCII text characters or 64 hexadecimal characters.

Step 8 If you enabled WPA2 with 802.1X authenticated key management or WPA1 or WPA2 with CCKM authenticated key management, the PMK cache lifetime timer is used to trigger reauthentication with the client when necessary. The timer is based on the timeout value received from the AAA server or the WLAN session timeout setting. To see the amount of time remaining before the timer expires, enter this command:

show pmk-cache all

Information similar to the following appears:

```
PMK-CCKM Cache
                            Entry
Type        Station         Lifetime   VLAN Override        IP Override
------  -------------------  --------   ------------------   ---------------
CCKM    00:07:0e:b9:3a:1b   150                           0.0.0.0
```

If you enabled WPA2 with 802.1X authenticated key management, the controller supports opportunistic PMKID caching but not sticky (or non-opportunistic) PMKID caching. In sticky PMKID caching, the client stores multiple PMKIDs. This approach is not practical because it requires full authentication for each new access point and is not guaranteed to work in all conditions. In contrast, opportunistic PMKID caching stores only one PMKID per client and is not subject to the limitations of sticky PMK caching.

Step 9 Enter this command to enable the WLAN:

config wlan enable *wlan_id*

Step 10 Enter this command to save your settings:

save config

CKIP

Cisco Key Integrity Protocol (CKIP) is a Cisco-proprietary security protocol for encrypting 802.11 media. CKIP improves 802.11 security in infrastructure mode using key permutation, message integrity check (MIC), and message sequence number. Software release 4.0 or later supports CKIP with static key. For this feature to operate correctly, you must enable Aironet information elements (IEs) for the WLAN.

A lightweight access point advertises support for CKIP in beacon and probe response packets by adding an Aironet IE and setting one or both of the CKIP negotiation bits [key permutation and multi-modular hash message integrity check (MMH MIC)]. Key permutation is a data encryption technique that uses the basic encryption key and the current initialization vector (IV) to create a new key. MMH MIC prevents bit-flip attacks on encrypted packets by using a hash function to compute message integrity code.

The CKIP settings specified in a WLAN are mandatory for any client attempting to associate. If the WLAN is configured for both CKIP key permutation and MMH MIC, the client must support both. If the WLAN is configured for only one of these features, the client must support only this CKIP feature.

CKIP requires that 5-byte and 13-byte encryption keys be expanded to 16-byte keys. The algorithm to perform key expansion happens at the access point. The key is appended to itself repeatedly until the length reaches 16 bytes. All lightweight access points support CKIP.

You can configure CKIP through either the GUI or the CLI.

Using the GUI to Configure CKIP

Follow these steps to configure a WLAN for CKIP using the controller GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Advanced** tab.

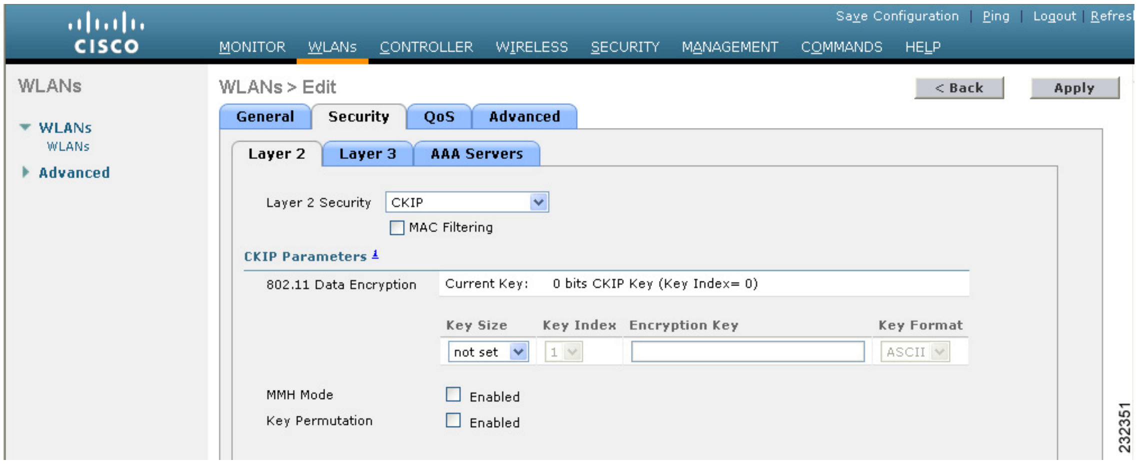
Step 4 Check the **Aironet IE** check box to enable Aironet IEs for this WLAN and click **Apply**.

Step 5 Choose the **General** tab.

Step 6 Uncheck the **Status** check box, if checked, to disable this WLAN and click **Apply**.

Step 7 Choose the **Security** and **Layer 2** tabs to open the WLANs > Edit (Security > Layer 2) page (see Figure 6-12).

Figure 6-12 WLANs > Edit (Security > Layer 2) Page



Step 8 Choose **CKIP** from the Layer 2 Security drop-down box.

Step 9 Under CKIP Parameters, choose the length of the CKIP encryption key from the Key Size drop-down box.

Range: Not Set, 40 bits, or 104 bits

Default: Not Set

Step 10 Choose the number to be assigned to this key from the Key Index drop-down box. You can configure up to four keys.

Step 11 Choose **ASCII** or **HEX** from the Key Format drop-down box and then enter an encryption key in the Encryption Key field. 40-bit keys must contain 5 ASCII text characters or 10 hexadecimal characters. 104-bit keys must contain 13 ASCII text characters or 26 hexadecimal characters.

Step 12 Check the **MMH Mode** check box to enable MMH MIC data protection for this WLAN. The default value is disabled (or unchecked).

Step 13 Check the **Key Permutation** check box to enable this form of CKIP data protection. The default value is disabled (or unchecked).

Step 14 Click **Apply** to commit your changes.

Step 15 Choose the **General** tab.

Step 16 Check the **Status** check box to enable this WLAN.

Step 17 Click **Apply** to commit your changes.

Step 18 Click **Save Configuration** to save your changes.

Using the CLI to Configure CKIP

Follow these steps to configure a WLAN for CKIP using the controller CLI.

Step 1 Enter this command to disable the WLAN:

config wlan disable *wlan_id*

Step 2 Enter this command to enable Aironet IEs for this WLAN:

config wlan ccx aironet-ie enable *wlan_id*

Step 3 Enter this command to enable or disable CKIP for the WLAN:

config wlan security ckip {**enable** | **disable**} *wlan_id*

Step 4 Enter this command to specify a CKIP encryption key for the WLAN:

config wlan security ckip akm psk set-key *wlan_id* {**40** | **104**} {**hex** | **ascii**} *key key_index*

Step 5 Enter this command to enable or disable CKIP MMH MIC for the WLAN:

config wlan security ckip mmh-mic {**enable** | **disable**} *wlan_id*

Step 6 Enter this command to enable or disable CKIP key permutation for the WLAN:

config wlan security ckip kp {**enable** | **disable**} *wlan_id*

Step 7 Enter this command to enable the WLAN:

config wlan enable *wlan_id*

Step 8 Enter this command to save your settings:

save config

Configuring a Session Timeout

Using the controller GUI or CLI, you can configure a session timeout for wireless clients on a WLAN. The session timeout is the maximum time for a client session to remain active before requiring reauthorization.

Using the GUI to Configure a Session Timeout

Using the controller GUI, follow these steps to configure a session timeout for wireless clients on a WLAN.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to assign a session timeout.

Step 3 When the WLANs > Edit page appears, choose the **Advanced** tab. The WLANs > Edit (Advanced) page appears.

Step 4 To configure a session timeout for this WLAN, check the **Enable Session Timeout** check box. Otherwise, uncheck the check box. The default value is checked.

Step 5 In the Session Timeout field, enter a value between 300 and 86400 seconds to specify the duration of the client session. The default value is 1800 seconds for the following Layer 2 security types: 802.1X; Static WEP+802.1X; and WPA+WPA2 with 802.1X, CCKM, or 802.1X+CCKM authentication key management and 0 seconds for all other Layer 2 security types. A value of 0 is equivalent to no timeout.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure a Session Timeout

Using the controller CLI, follow these steps to configure a session timeout for wireless clients on a WLAN.

Step 1 To configure a session timeout for wireless clients on a WLAN, enter this command:

config wlan session-timeout *wlan_id timeout*

The default value is 1800 seconds for the following Layer 2 security types: 802.1X; Static WEP+802.1X; and WPA+WPA2 with 802.1X, CCKM, or 802.1X+CCKM authentication key management and 0 seconds for all other Layer 2 security types. A value of 0 is equivalent to no timeout.

Step 2 To save your changes, enter this command:

save config

Step 3 To see the current session timeout value for a WLAN, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 9
Profile Name..................................... test12
Network Name (SSID).......................... test12
...
Number of Active Clients........................ 0
Exclusionlist Timeout........................... 60 seconds
Session Timeout.............................. 1800 seconds
...
```

Configuring Layer 3 Security

This section explains how to configure Layer 3 security settings for a WLAN on the controller.

Note

- Layer 2 Tunnel Protocol (L2TP) and IPSec are not supported on controllers running software release 4.0 or later.
- The Layer 3 securities are not supported when Client IP Address is disabled on a WLAN.

VPN Passthrough

The controller supports VPN passthrough, or the "passing through" of packets that originate from VPN clients. An example of VPN passthrough is your laptop trying to connect to the VPN server at your corporate office.

Note The VPN Passthrough option is not available on 5500 series and 2100 series controllers. However, you can replicate this functionality on a 5500 or 2100 series controller by creating an open WLAN using an ACL.

Using the GUI to Configure VPN Passthrough

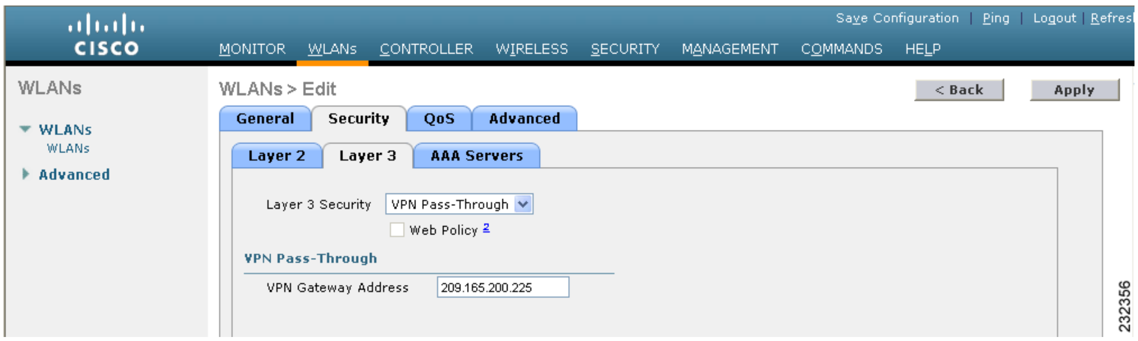
Follow these steps to configure a WLAN for VPN passthrough using the controller GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure VPN passthrough. The WLANs > Edit page appears.

Step 3 Choose the **Security** and **Layer 3** tabs to open the WLANs > Edit (Security > Layer 3) page (see Figure 6-13).

Figure 6-13 WLANs > Edit (Security > Layer 3) Page



Step 4 Choose **VPN Pass-Through** from the Layer 3 Security drop-down box.

Step 5 In the VPN Gateway Address field, enter the IP address of the gateway router that is terminating the VPN tunnels initiated by the client and passed through the controller.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your settings.

Using the CLI to Configure VPN Passthrough

Enter these commands to configure a WLAN for VPN passthrough using the controller CLI:

- **config wlan security passthru** {**enable** | **disable**} *wlan_id gateway*

  For *gateway*, enter the IP address of the router that is terminating the VPN tunnel.

- Enter **show wlan** to verify that the passthrough is enabled.

Web Authentication

WLANs can use web authentication only if VPN passthrough is not enabled on the controller. Web authentication is simple to set up and use and can be used with SSL to improve the overall security of the WLAN.

Note Web authentication is supported only with these Layer 2 security policies: open authentication, open authentication+WEP, and WPA-PSK. It is not supported for use with 802.1X.

Note The controller supports web authentication redirects only to HTTP (HTTP over TCP) servers. It does not support web authentication redirects to HTTPS (HTTP over SSL) servers.

Note Before enabling web authentication, make sure that all proxy servers are configured for ports other than port 53.

Note When you enable web authentication for a WLAN, a message appears indicating that the controller forwards DNS traffic to and from wireless clients prior to authentication. Cisco recommends that you have a firewall or intrusion detection system (IDS) behind your guest VLAN to regulate DNS traffic and to prevent and detect any DNS tunneling attacks.

Using the GUI to Configure Web Authentication

Using the controller GUI, follow these steps to configure a WLAN for web authentication.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure web authentication. The WLANs > Edit page appears.

Step 3 Choose the **Security** and **Layer 3** tabs to open the WLANs > Edit (Security > Layer 3) page.

Step 4 Check the **Web Policy** check box.

Step 5 Make sure that the **Authentication** option is selected.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your settings.

Step 8 Refer to the *Managing User Accounts* chapter for more information on using web authentication.

Using the CLI to Configure Web Authentication

Using the controller CLI, follow these steps to configure a WLAN for web authentication.

Step 1 To enable or disable web authentication on a particular WLAN, enter this command:

config wlan security web-auth {**enable** | **disable**} *wlan_id*

Step 2 To release the guest user IP address when the web authentication policy timer expires and prevent the guest user from acquiring an IP address for 3 minutes, enter this command:

config wlan webauth-exclude *wlan_id* {**enable** | **disable**}

The default value is disabled. This command is applicable when you configure the internal DHCP scope on the controller. By default, when the web authentication timer expires for a guest user, the user can immediately reassociate to the same IP address before another guest user can acquire it. If there are many guest users or limited IP addresses in the DHCP pool, some guest users might not be able to acquire an IP address.

When you enable this feature on the guest WLAN, the guest user's IP address is released when the web authentication policy timer expires and the guest user is excluded from acquiring an IP address for 3 minutes. The IP address is available for another guest user to use. After 3 minutes, the excluded guest user can reassociate and acquire an IP address, if available.

Step 3 To see the status of web authentication, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... cjtalwar
Network Name (SSID).............................. cjtalwar
Status........................................... Disabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Network Admission Control

  NAC-State...................................... Disabled
  Quarantine VLAN................................ 0
Number of Active Clients......................... 0
Exclusionlist Timeout............................ 60 seconds
Session Timeout.................................. 1800 seconds
CHD per WLAN................................. Enabled
Webauth DHCP exclusion........................... Disabled
Interface........................................ management
WLAN ACL......................................... unconfigured
DHCP Server...................................... Default
DHCP Address Assignment Required............. Disabled
...
Web Based Authentication......................... Disabled
Web-Passthrough.............................. Disabled
...
```

Step 4 For more information on using web authentication, refer to the *Managing User Accounts* chapter.

Assigning a QoS Profile to a WLAN

Cisco UWN Solution WLANs support four levels of QoS: Platinum/Voice, Gold/Video, Silver/Best Effort (default), and Bronze/Background. You can configure the voice traffic WLAN to use Platinum QoS, assign the low-bandwidth WLAN to use Bronze QoS, and assign all other traffic between the remaining QoS levels.

The WLAN QoS level defines a specific 802.11e user priority (UP) for over-the-air traffic. This UP is used to derive the over-the-wire priorities for non-WMM traffic, and it also acts as the ceiling when managing WMM traffic with various levels of priorities. The access point uses this QoS-profile-specific UP in accordance with the values in Table 6-1 to derive the IP DSCP value that is visible on the wired LAN.

Table 6-1 Access Point QoS Translation Values

AVVID Traffic Type	AVVID IP DSCP	QoS Profile	AVVID 802.1p	IEEE 802.11e UP
Network control	56 (CS7)	Platinum	7	7
Inter-network control (CAPWAP control, 802.11 management)	48 (CS6)	Platinum	6	7
Voice	46 (EF)	Platinum	5	6
Interactive video	34 (AF41)	Gold	4	5
Mission critical	26 (AF31)	Gold	3	4
Transactional	18 (AF21)	Silver	2	3
Bulk data	10 (AF11)	Bronze	1	2
Best effort	0 (BE)	Silver	0	0
Scavenger	2	Bronze	0	1

Note The IEEE 802.11e UP value for DSCP values that are not mentioned in the table is calculated by considering 3 MSB bits of DSCP.
For example, the IEEE 802.11e UP value for DSCP 32 (100 000 in binary), would be the decimal converted value of the MSB (100) which is 4. The 802.11e UP value of DSCP 32 is 4.

You can assign a QoS profile to a WLAN using the controller GUI or CLI.

Using the GUI to Assign a QoS Profile to a WLAN

Using the controller GUI, follow these steps to assign a QoS profile to a WLAN.

Step 1 If you have not already done so, configure one or more QoS profiles using the instructions in the "Using the GUI to Configure QoS Profiles" section on page 4-67.

Step 2 Choose **WLANs** to open the WLANs page.

Step 3 Click the ID number of the WLAN to which you want to assign a QoS profile.

Step 4 When the WLANs > Edit page appears, choose the **QoS** tab.

Step 5 From the Quality of Service (QoS) drop-down box, choose one of the following:

- Platinum (voice)
- Gold (video)
- Silver (best effort)
- Bronze (background)

Note Silver (best effort) is the default value.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Assign a QoS Profile to a WLAN

Using the controller CLI, follow these steps to assign a QoS profile to a WLAN.

Step 1 If you have not already done so, configure one or more QoS profiles using the instructions in the "Using the CLI to Configure QoS Profiles" section on page 4-69.

Step 2 To assign a QoS profile to a WLAN, enter this command:

config wlan qos *wlan_id* {**bronze** | **silver** | **gold** | **platinum**}

Silver is the default value.

Step 3 To save your changes, enter this command:

save config

Step 4 To verify that you have properly assigned the QoS profile to the WLAN, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... test
Network Name (SSID).............................. test
Status........................................... Enabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Number of Active Clients......................... 0
Exclusionlist.................................... Disabled
Session Timeout.................................. 0
Interface........................................ management
WLAN ACL......................................... unconfigured
DHCP Server...................................... 1.100.163.24
DHCP Address Assignment Required................. Disabled
Quality of Service............................... Silver (best effort)
WMM.............................................. Disabled
...
```

Configuring QoS Enhanced BSS

The QoS Enhanced Basis Service Set (QBSS) information element (IE) enables the access points to communicate their channel usage to wireless devices. Because access points with high channel usage might not be able to handle real-time traffic effectively, the 7921 or 7920 phone uses the QBSS value to determine if they should associate to another access point. You can enable QBSS in these two modes:

- Wi-Fi Multimedia (WMM) mode, which supports devices that meet the 802.11E QBSS standard (such as Cisco 7921 IP Phones)
- 7920 support mode, which supports Cisco 7920 IP Phones on your 802.11b/g network

  The 7920 support mode has two options:
  - Support for 7920 phones that require call admission control (CAC) to be configured on and advertised by the client device (these are typically older 7920 phones)
  - Support for 7920 phones that require CAC to be configured on and advertised by the access point (these are typically newer 7920 phones)

    When access point-controlled CAC is enabled, the access point sends out a Cisco proprietary CAC Information Element (IE) and does not send out the standard QBSS IE.

You can use the controller GUI or CLI to configure QBSS. QBSS is disabled by default.

Guidelines for Configuring QBSS

Follow these guidelines when configuring QBSS on a WLAN:

- 7920 phones are non-WMM phones with limited CAC functionality. The phones look at the channel utilization of the access point to which they are associated and compare that to a threshold that is beaconed by the access point. If the channel utilization is less than the threshold, the 7920 places a call. In contrast, 7921 phones are full-fledged WMM phones that use traffic specifications (TSPECs) to gain access to the voice queue before placing a phone call. The 7921 phones work well with load-based CAC, which uses the percentage of the channel set aside for voice and tries to limit the calls accordingly.

  Because 7921 phones support WMM and 7920 phones do not, capacity and voice quality problems can arise if you do not properly configure both phones when they are used in a mixed environment. To enable both 7921 and 7920 phones to co-exist on the same network, make sure that load-based CAC and 7920 AP CAC are both enabled on the controller and the WMM Policy is set to Allowed. This becomes particularly important if you have many more 7920 users than 7921 users.

Note Refer to the *Configuring Controller Settings* chapter for more information and configuration instructions for load-based CAC.

Additional Guidelines for Using 7921 and 7920 Wireless IP Phones

Follow these guidelines to use Cisco 7921 and 7920 Wireless IP Phones with controllers:

- Aggressive load balancing must be disabled for each controller. Otherwise, the initial roam attempt by the phone may fail, causing a disruption in the audio path.
- The Dynamic Transmit Power Control (DTPC) information element (IE) must be enabled using the **config 802.11b dtpc enable** command. The DTPC IE is a beacon and probe information element that allows the access point to broadcast information on its transmit power. The 7921 or 7920 phone uses this information to automatically adjust its transmit power to the same level as the access point to which it is associated. In this manner, both devices are transmitting at the same level.
- Both the 7921 and 7920 phones and the controllers support Cisco Centralized Key Management (CCKM) fast roaming.
- When configuring WEP, there is a difference in nomenclature for the controller and the 7921 or 7920 phone. Configure the controller for 104 bits when using 128-bit WEP for the 7921 or 7920.

- For standalone 7921 phones, load-based CAC must be enabled, and the WMM Policy must be set to Required on the WLAN.
- The controller supports traffic classification (TCLAS) coming from 7921 phones using firmware version 1.1.1. This feature ensures proper classification of voice streams to the 7921 phones.
- When using a 7921 phone with the 802.11a radio of a 1242 series access point, set the 24-Mbps data rate to Supported and choose a lower Mandatory data rate (such as 12 Mbps). Otherwise, the phone might experience poor voice quality.

Using the GUI to Configure QBSS

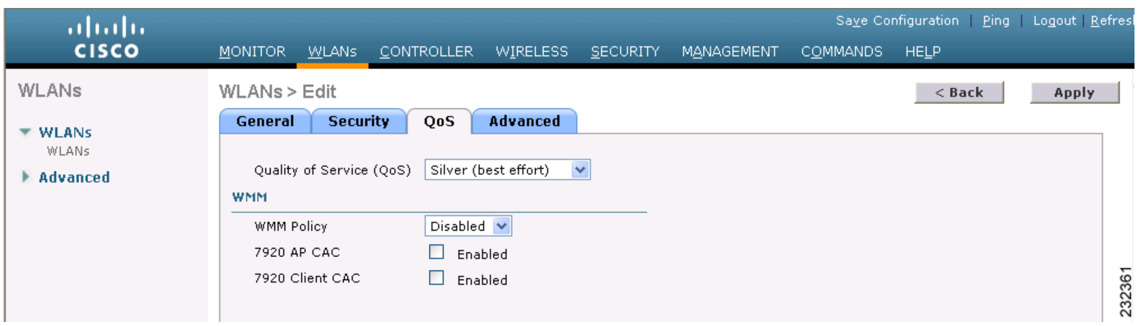
Using the controller GUI, follow these steps to configure QBSS.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure WMM mode.

Step 3 When the WLANs > Edit page appears, choose the **QoS** tab to open the WLANs > Edit (Qos) page (see Figure 6-14).

Figure 6-14 WLANs > Edit (QoS) Page



Step 4 From the WMM Policy drop-down box, choose one of the following options, depending on whether you want to enable WMM mode for 7921 phones and other devices that meet the WMM standard:

- **Disabled**—Disables WMM on the WLAN. This is the default value.
- **Allowed**—Allows client devices to use WMM on the WLAN.
- **Required**—Requires client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

Step 5 Check the **7920 AP CAC** check box if you want to enable 7920 support mode for phones that require access point-controlled CAC. The default value is unchecked.

Step 6 Check the **7920 Client CAC** check box if you want to enable 7920 support mode for phones that require client-controlled CAC. The default value is unchecked.

Note You cannot enable both WMM mode and client-controlled CAC mode on the same WLAN.

Step 7 Click **Apply** to commit your changes.

Step 8 Click **Save Configuration** to save your changes.

Using the CLI to Configure QBSS

Using the controller CLI, follow these steps to configure QBSS.

Step 1 To determine the ID number of the WLAN to which you want to add QBSS support, enter this command:

show wlan summary

Step 2 To disable the WLAN, enter this command:

config wlan disable *wlan_id*

Step 3 To configure WMM mode for 7921 phones and other devices that meet the WMM standard, enter this command:

config wlan wmm {**disabled** | **allowed** | **required**} *wlan_id*

where

- The **disabled** parameter disables WMM mode on the WLAN.
- The **allowed** parameter allows client devices to use WMM on the WLAN.
- The **required** parameter requires client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

Step 4 To enable or disable 7920 support mode for phones that require client-controlled CAC, enter this command:

config wlan 7920-support client-cac-limit {**enable** | **disable**} *wlan_id*

Note You cannot enable both WMM mode and client-controlled CAC mode on the same WLAN.

Step 5 To enable or disable 7920 support mode for phones that require access point-controlled CAC, enter this command:

config wlan 7920-support ap-cac-limit {**enable** | **disable**} *wlan_id*

Step 6 To re-enable the WLAN, enter this command:

config wlan enable *wlan_id*

Step 7 To save your changes, enter this command:

save config

Step 8 To verify that the WLAN is enabled and the Dot11-Phone Mode (7920) field is configured for compat mode, enter this command:

show wlan *wlan_id*

Configuring VoIP Snooping

Controller software release 6.0 supports Voice over IP (VoIP) Media Session Aware (MSA) snooping and reporting. This feature enables access points to detect the establishment, termination, and failure of Session Initiation Protocol (SIP) voice calls and then report them to the controller and WCS. It can be enabled or disabled for each WLAN.

When VoIP MSA snooping is enabled, the access point radios that advertise this WLAN look for SIP voice packets that comply with SIP RFC-3261. They do not look for non-RFC-3261-compliant SIP voice packets or Skinny Call Control Protocol (SCCP) voice packets. Any SIP packets destined to or originating from port number 5060 (the standard SIP signaling port) are considered for further inspection. The access points track when Wi-Fi Multimedia (WMM) and non-WMM clients are establishing a call, are already on an active call, or are in the process of ending a call. Upstream packet classification for both client types occurs at the access point whereas downstream packet classification happens at the controller for WMM clients and at the access point for non-WMM clients. The access points notify the controller and WCS of any major call events, such as call establishment, termination, and failure.

The controller provides detailed information for VoIP MSA calls. For failed calls, the controller generates a trap log with a timestamp and the reason for failure (in the GUI) and an error code (in the CLI) to aid in troubleshooting. For successful calls, the controller shows the number and duration of calls for usage tracking purposes. WCS displays failed VoIP call information in the Events window.

Using the GUI to Configure VoIP Snooping

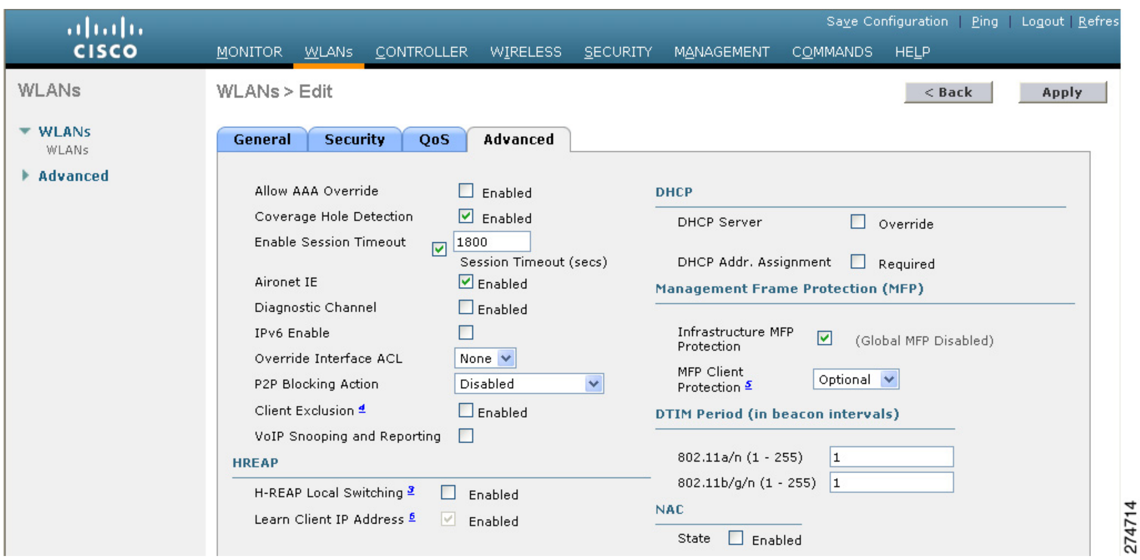
Using the controller GUI, follow these steps to configure VoIP snooping.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure VoIP snooping.

Step 3 When the WLANs > Edit page appears, choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 6-15).

Figure 6-15 WLANs > Edit (Advanced) Page



Step 4 Check the **VoIP Snooping and Reporting** check box to enable VoIP snooping or uncheck it to disable this feature. The default value is unchecked.

Step 5 Click **Apply** to commit your changes.

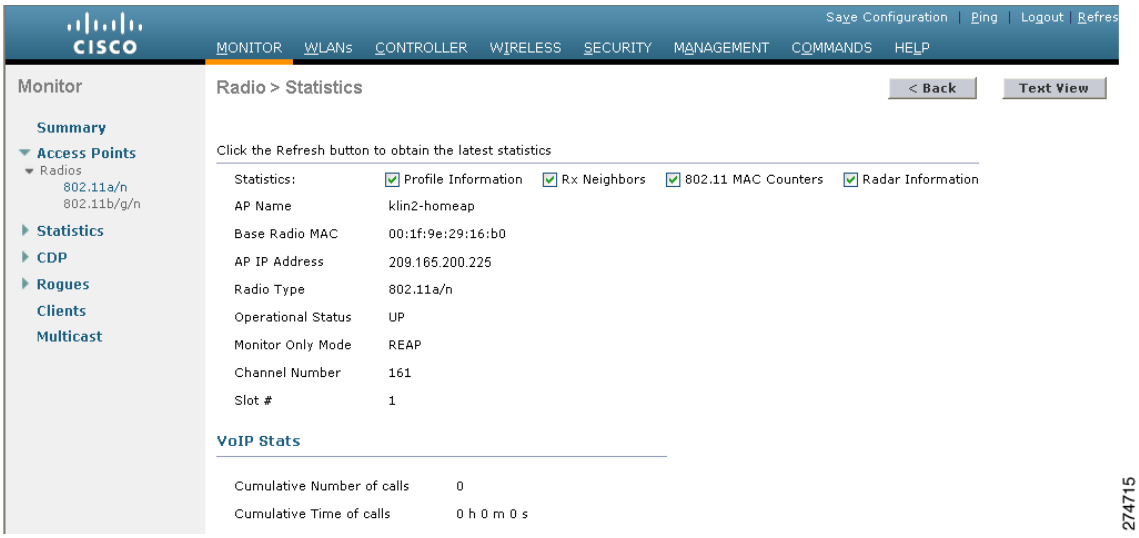
Step 6 Click **Save Configuration** to save your changes.

Step 7 To see the VoIP statistics for your access point radios, follow these steps:

a. Choose **Monitor** > **Access Points** > **Radios** > **802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

b. Scroll to the right and click the **Detail** link for the access point for which you want to view VoIP statistics. The Radio > Statistics page appears (see Figure 6-16).

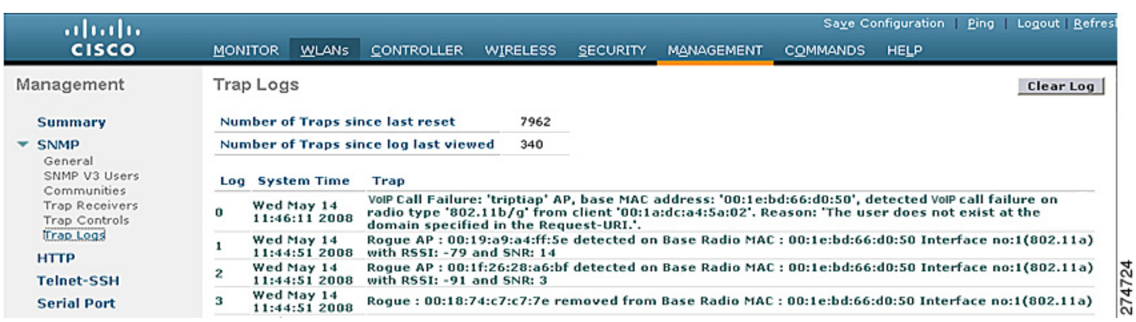
Figure 6-16 Radio > Statistics Page



The VoIP Stats section shows the cumulative number and length of voice calls for this access point radio. Entries are added automatically when voice calls are successfully placed and deleted when the access point disassociates from the controller.

Step 8 To see the traps generated for failed calls, choose **Management** > **SNMP** > **Trap Logs**. The Trap Logs page appears (Figure 6-17).

Figure 6-17 Trap Logs Page



For example, log 0 in Figure 6-17 shows that a call failed. The log provides the date and time of the call, a description of the failure, and the reason why the failure occurred.

Using the CLI to Configure VoIP Snooping

Using the controller CLI, follow these steps to configure VoIP snooping.

Step 1 To enable or disable VoIP snooping for a particular WLAN, enter this command:

config wlan call-snoop {**enable** | **disable**} *wlan_id*

Step 2 To save your changes, enter this command:

save config

Step 3 To see the status of VoIP snooping on a particular WLAN, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... wpa2-psk
Network Name (SSID).............................. wpa2-psk
Status........................................... Enabled
...
    H-REAP Local Switching........................ Disabled
    H-REAP Learn IP Address....................... Enabled
    Infrastructure MFP protection............. Enabled (Global Infrastructure MFP
Disabled)
    Client MFP.................................... Optional
    Tkip MIC Countermeasure Hold-down Timer....... 60
Call Snooping.................................. Enabled
```

Step 4 To see call information for an MSA client when VoIP snooping is enabled and the call is active, enter this command:

show call-control client callInfo *client_MAC_address*

Information similar to the following appears:

```
Uplink IP/port...................................... 192.11.1.71 / 23870
Downlonk IP/port.................................... 192.12.1.47 / 2070
UP.................................................. 6
Calling Party....................................... sip:1054
Called Party........................................ sip:1000
Call ID............................................. 58635b00-850161b7-14853-1501a8
Number of calls for given client is............. 1
```

Step 5 To see the metrics for successful calls or the traps generated for failed calls, enter this command:

show call-control ap {**802.11a** | **802.11b**} *Cisco_AP* {**metrics** | **traps**}

Information similar to the following appears when you enter **show call-control ap** {**802.11a** | **802.11b**} *Cisco_AP* **metrics**:

```
Total Call Duration in Seconds.................. 120
Number of Calls................................. 10
```

Information similar to the following appears when you enter **show call-control ap** {**802.11a** | **802.11b**} *Cisco_AP* **traps**:

```
Number of traps sent in one min................. 2
Last SIP error code............................. 404
Last sent trap timestamp..................... Jun 20 10:05:06
```

To aid in troubleshooting, the output of this command shows an error code for any failed calls. Table 6-2 explains the possible error codes for failed calls.

Table 6-2 Error Codes for Failed VoIP Calls

Error Code	Integer	Description
1	unknown	Unknown error.
400	badRequest	The request could not be understood because of malformed syntax.
401	unauthorized	The request requires user authentication.
402	paymentRequired	Reserved for future use.
403	forbidden	The server understood the request but refuses to fulfill it.
404	notFound	The server has information that the user does not exist at the domain specified in the Request-URI.
405	methodNotallowed	The method specified in the Request-Line is understood but not allowed for the address identified by the Request-URI.
406	notAcceptable	The resource identified by the request is only capable of generating response entities with content characteristics that are not acceptable according to the Accept header field sent in the request.
407	proxyAuthenticationRequired	The client must first authenticate with the proxy.
408	requestTimeout	The server could not produce a response within a suitable amount of time, if it could not determine the location of the user in time.
409	conflict	The request could not be completed due to a conflict with the current state of the resource.
410	gone	The requested resource is no longer available at the server, and no forwarding address is known.
411	lengthRequired	The server is refusing to process a request because the request entity-body is larger than the server is willing or able to process.
413	requestEntityTooLarge	The server is refusing to process a request because the request entity-body is larger than the server is willing or able to process.
414	requestURITooLarge	The server is refusing to service the request because the Request-URI is longer than the server is willing to interpret.
415	unsupportedMediaType	The server is refusing to service the request because the message body of the request is in a format not supported by the server for the requested method.
420	badExtension	The server did not understand the protocol extension specified in a Proxy-Require or Require header field.
480	temporarilyNotAvailable	The callee's end system was contacted successfully, but the callee is currently unavailable.

Table 6-2 Error Codes for Failed VoIP Calls (continued)

Error Code	Integer	Description
481	callLegDoesNotExist	The UAS received a request that does not match any existing dialog or transaction.
482	loopDetected	The server has detected a loop.
483	tooManyHops	The server received a request that contains a Max-Forwards header field with the value zero.
484	addressIncomplete	The server received a request with a Request-URI that was incomplete.
485	ambiguous	The Request-URI was ambiguous.
486	busy	The callee's end system was contacted successfully, but the callee is currently not willing or able to take additional calls at this end system.
500	internalServerError	The server encountered an unexpected condition that prevented it from fulfilling the request.
501	notImplemented	The server does not support the functionality required to fulfill the request.
502	badGateway	The server, while acting as a gateway or proxy, received an invalid response from the downstream server it accessed in attempting to fulfill the request.
503	serviceUnavailable	The server is temporarily unable to process the request because of a temporary overloading or maintenance of the server.
504	serverTimeout	The server did not receive a timely response from an external server it accessed in attempting to process the request.
505	versionNotSupported	The server does not support or refuses to support the SIP protocol version that was used in the request.
600	busyEverywhere	The callee's end system was contacted successfully, but the callee is busy or does not want to take the call at this time.
603	decline	The callee's machine was contacted successfully, but the user does not want to or cannot participate.
604	doesNotExistAnywhere	The server has information that the user indicated in the Request-URI does not exist anywhere.
606	notAcceptable	The user's agent was contacted successfully, but some aspects of the session description (such as the requested media, bandwidth, or addressing style) were not acceptable.

Note If you experience any problems with VoIP snooping, enter this command to debug all VoIP messages or events: **debug call-control** {**all** | **event**} {**enable** | **disable**}.

Configuring IPv6 Bridging

Internet Protocol version 6 (IPv6) is the next-generation network layer Internet protocol intended to replace version 4 (IPv4) in the TCP/IP suite of protocols. This new version increases Internet global address space to accommodate users and applications that require unique global IP addresses. IPv6 incorporates 128-bit source and destination addresses, providing significantly more addresses than the 32-bit IPv4 addresses. Follow the instructions in this section to configure a WLAN for IPv6 bridging using either the controller GUI or CLI.

Guidelines for Using IPv6 Bridging

Follow these guidelines when using IPv6 bridging:

- To use IPv6 bridging, multicast must be enabled on the controller.
- Hybrid-REAP with central switching is supported for use with IPv6 bridging. Hybrid-REAP with local switching is not supported.
- Auto-anchor mobility is not supported for use with IPv6 bridging.
- If symmetric mobility tunneling is enabled, all IPv4 traffic is bidirectionally tunneled to and from the client, but the IPv6 client traffic is bridged locally.
- Clients must support IPv6 with either static stateless auto-configuration (such as Windows XP clients) or stateful DHCPv6 IP addressing (such as Windows Vista clients).

  Note Currently, DHCPv6 is supported for use only with Windows Vista clients. For these clients, you must manually renew the DHCPv6 IP address after the client changes VLANs.

  Note Dynamic VLAN function on IPV6 bridging environment is not supported in this release.

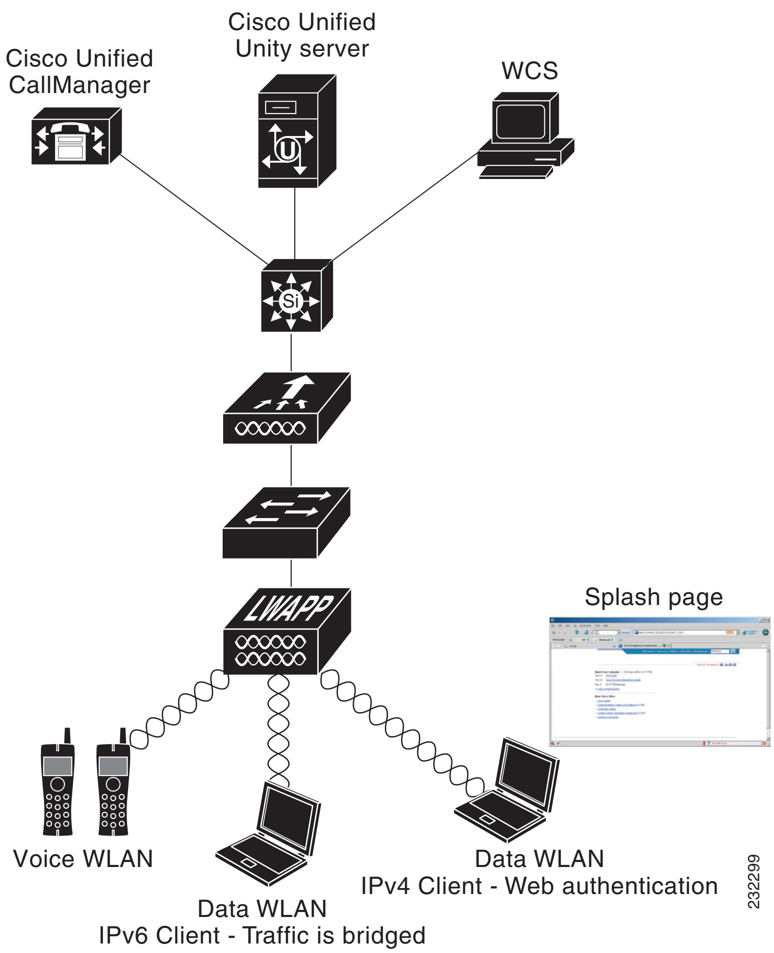
- For stateful DHCPv6 IP addressing to operate properly, you need a switch or router that supports the DHCP for IPv6 feature (such as the Cisco Catalyst 3750 switch) and is configured to act like a DHCPv6 server, or you need a dedicated server such as a Windows 2008 server with a built-in DHCPv6 server.

  Note To load the SDM IPv6 template in the Cisco Catalyst 3750 switch, enter this command and then reset the switch: **sdm prefer dual-ipv4-and-v6 default**. For more information, refer to the Cisco Catalyst 3750 switch configuration guide for Cisco IOS Release 12.2(46)SE.

- In controller software release 4.2 or later, you can enable IPv6 bridging and IPv4 web authentication on the same WLAN, a combination that previously was not supported. The controller bridges IPv6 traffic from all clients on the WLAN while IPv4 traffic goes through the normal web authentication process. The controller begins bridging IPv6 as soon as the client associates and even before web authentication for IPv4 clients is complete. No other Layer 2 or Layer 3 security policy configuration is supported on the WLAN when both IPv6 bridging and web authentication are enabled. Figure 6-18 illustrates how IPv6 bridging and IPv4 web authentication can be used on the same WLAN.

- In controller software release 6.0, all Layer 2 security policies are supported and can be configured when you enable IPv6 bridging on a WLAN.

Figure 6-18 IPv6 Bridging and IPv4 Web Authentication



Note The Security Policy Completed field in both the controller GUI and CLI shows “No for IPv4 (bridging allowed for IPv6)” until web authentication is completed. You can view this field from the Clients > Detail page on the GUI or from the **show client detail** CLI command.

Using the GUI to Configure IPv6 Bridging

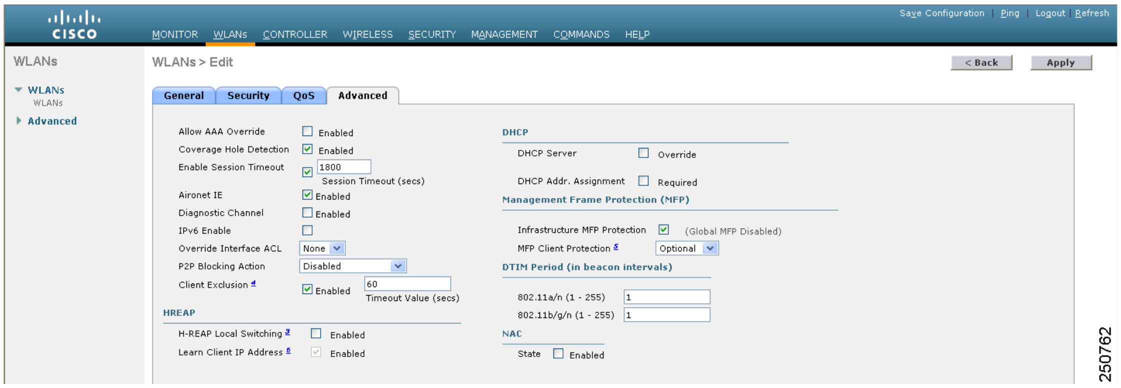
Follow these steps to configure a WLAN for IPv6 bridging using the GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced tab) page (see Figure 6-19).

Figure 6-19 WLANs > Edit (Advanced) Page



Step 4 Check the **IPv6 Enable** check box if you want to enable clients that connect to this WLAN to accept IPv6 packets. Otherwise, leave the check box unchecked, which is the default value.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure IPv6 Bridging

To configure a WLAN for IPv6 bridging using the CLI, enter this command:

config wlan IPv6support {**enable** | **disable**} *wlan_id*

The default value is disabled.

Configuring Cisco Client Extensions

Cisco Client Extensions (CCX) software is licensed to manufacturers and vendors of third-party client devices. The CCX code resident on these clients enables them to communicate wirelessly with Cisco access points and to support Cisco features that other client devices do not, including those related to increased security, enhanced performance, fast roaming, and superior power management.

The 4.2 or later release of controller software supports CCX versions 1 through 5, which enables controllers and their access points to communicate wirelessly with third-party client devices that support CCX. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. However, you can configure a specific CCX feature per WLAN. This feature is Aironet information elements (IEs).

If Aironet IE support is enabled, the access point sends an Aironet IE 0x85 (which contains the access point name, load, number of associated clients, and so on) in the beacon and probe responses of this WLAN, and the controller sends Aironet IEs 0x85 and 0x95 (which contains the management IP address of the controller and the IP address of the access point) in the reassociation response if it receives Aironet IE 0x85 in the reassociation request.

Follow the instructions in this section to configure a WLAN for the CCX Aironet IE feature and to see the CCX version supported by specific client devices using either the GUI or the CLI.

Using the GUI to Configure CCX Aironet IEs

Follow these steps to configure a WLAN for CCX Aironet IEs using the GUI.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced tab) page (see Figure 6-19).

Step 4 Check the **Aironet IE** check box if you want to enable support for Aironet IEs for this WLAN. Otherwise, uncheck this check box. The default value is enabled (or checked).

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

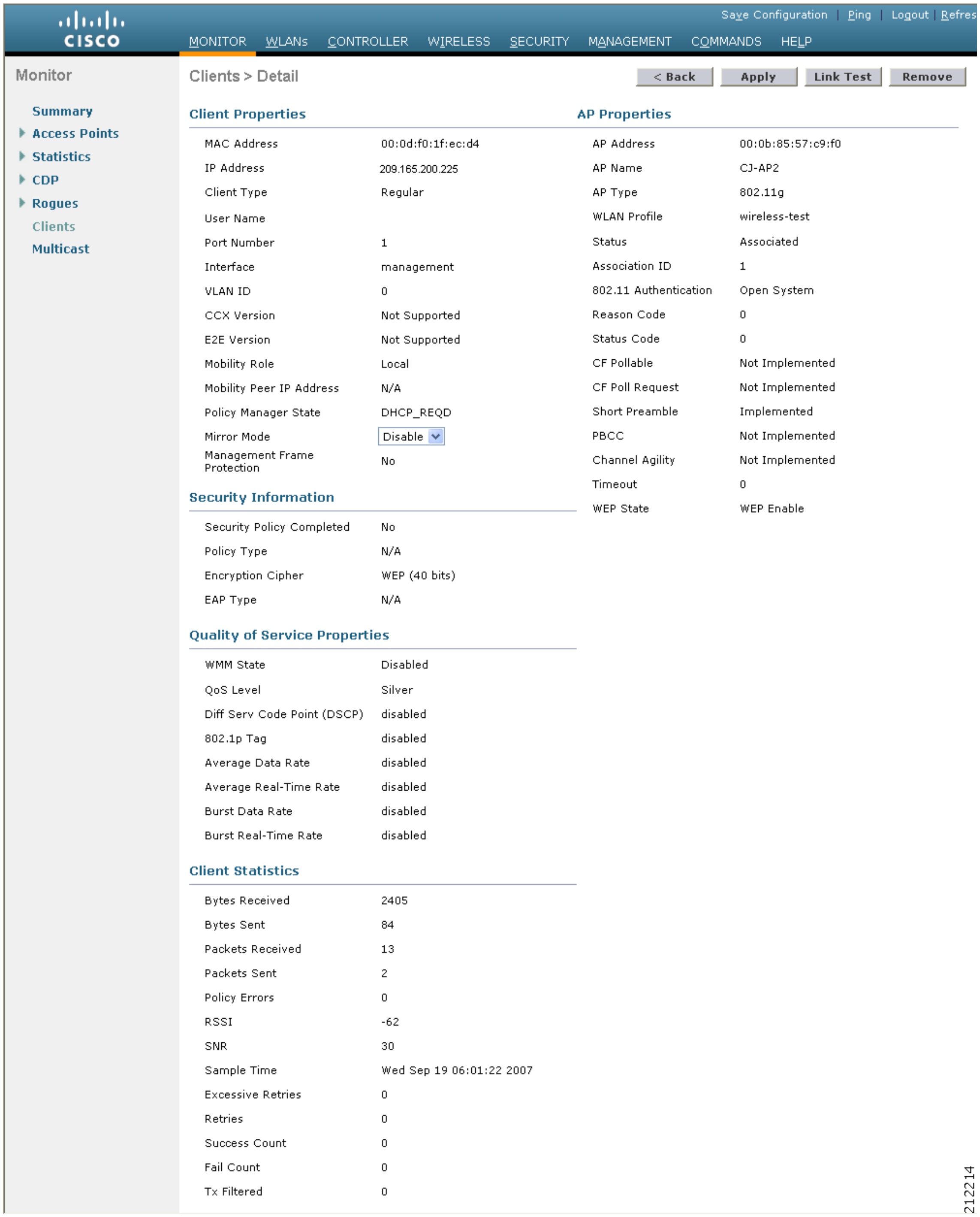
Using the GUI to View a Client's CCX Version

A client device sends its CCX version in association request packets to the access point. The controller then stores the client's CCX version in its database and uses it to limit the features for this client. For example, if a client supports CCX version 2, the controller does not allow the client to use CCX version 4 features. Follow these steps to see the CCX version supported by a particular client device using the GUI.

Step 1 Choose **Monitor** > **Clients** to open the Clients page.

Step 2 Click the MAC address of the desired client device to open the Clients > Detail page (see Figure 6-20).

Figure 6-20 Clients > Detail Page



The CCX Version field shows the CCX version supported by this client device. *Not Supported* appears if the client does not support CCX.

Step 3 Click **Back** to return to the previous screen.

Step 4 Repeat this procedure to view the CCX version supported by any other client devices.

Using the CLI to Configure CCX Aironet IEs

To enable or disable support for Aironet IEs for a particular WLAN, enter this command:

config wlan ccx aironet-ie {**enable** | **disable**} *wlan_id*

The default value is enabled.

Using the CLI to View a Client's CCX Version

To see the CCX version supported by a particular client device, enter this command:

show client detail *client_mac*

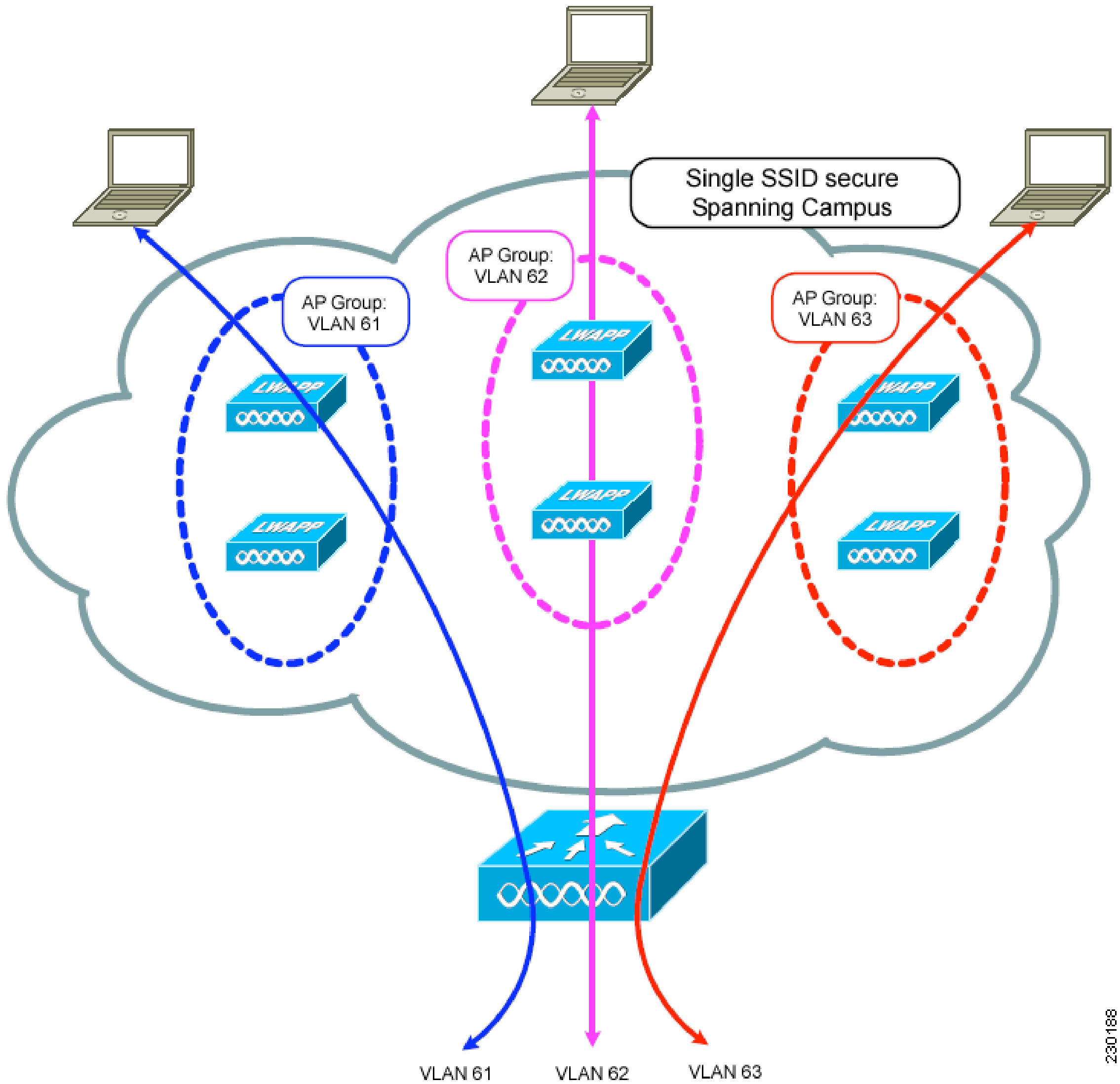
Configuring Access Point Groups

After you create up to 512 WLANs on the controller, you can selectively publish them (using access point groups) to different access points to better manage your wireless network. In a typical deployment, all users on a WLAN are mapped to a single interface on the controller. Therefore, all users associated with that WLAN are on the same subnet or VLAN. However, you can choose to distribute the load among several interfaces or to a group of users based on specific criteria such as individual departments (such as Marketing) by creating access point groups. Additionally, these access point groups can be configured in separate VLANs to simplify network administration, as illustrated in Figure 6-21.

Note The required access control list (ACL) must be defined on the router that serves the VLAN or subnet.

Note Multicast traffic is supported with access point group VLANs. However, if the client roams from one access point to another, the client might stop receiving multicast traffic, unless IGMP snooping is enabled.

Figure 6-21 Access Point Groups



In Figure 6-21, three configured dynamic interfaces are mapped to three different VLANs (VLAN 61, VLAN 62, and VLAN 63). Three access point groups are defined, and each is a member of a different VLAN, but all are members of the same SSID. A client within the wireless SSID is assigned an IP address from the VLAN subnet on which its access point is a member. For example, any user that associates with an access point that is a member of access point group VLAN 61 is assigned an IP address from that subnet.

In the example in Figure 6-21, the controller internally treats roaming between access points as a Layer 3 roaming event. In this way, WLAN clients maintain their original IP addresses.

Note Suppose the interface mapping for a WLAN in the AP group table is the same as the WLAN interface. If the WLAN interface is changed, then the interface mapping for the WLAN in the AP group table will also change to the new WLAN interface.

Suppose the interface mapping for a WLAN in the AP group table is different from the one defined for the WLAN. If the WLAN interface is changed, then the interface mapping for the WLAN in the AP group table will not be changed to the new WLAN interface.

To configure access point groups, follow these top-level steps:

1. Configure the appropriate dynamic interfaces and map them to the desired VLANs.

   For example, to implement the network in Figure 6-21, create dynamic interfaces for VLANs 61, 62, and 63 on the controller. Refer to the *Configuring Ports and Interfaces* chapter for information on how to configure dynamic interfaces.

2. Create the access point groups. Refer to the "Creating Access Point Groups" section below.
3. Assign access points to the appropriate access point groups. Refer to the "Creating Access Point Groups" section below.

Creating Access Point Groups

After all access points have joined the controller, you can create access point groups and assign up to 16 WLANs to each group. Each access point advertises only the enabled WLANs that belong to its access point group. The access point does not advertise disabled WLANs in its access point group or WLANs that belong to another group.

You can create up to 50 access point groups for 2100 series controllers and controller network modules and up to 192 access point groups for 4400 series controllers, 5500 series controllers, the Cisco WiSM, and the 3750G wireless LAN controller switch.

Note All OfficeExtend access points should be in the same access point group, and that group should contain no more than 15 WLANs. A controller with OfficeExtend access points in an access point group publishes only up to 15 WLANs to each connected OfficeExtend access point because it reserves one WLAN for the personal SSID.

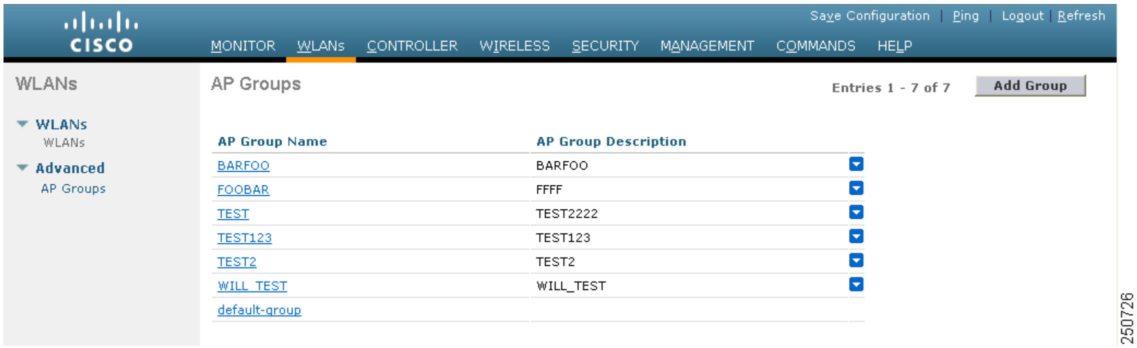
Note If you clear the configuration on the controller, all of the access point groups disappear except for the default access point group "default-group," which is created automatically.

Using the GUI to Create Access Point Groups

Using the controller GUI, follow these steps to create an access point group.

Step 1 Choose **WLANs** > **Advanced** > **AP Groups** to open the AP Groups page (see Figure 6-22).

Figure 6-22 AP Groups Page



This page lists all the access point groups currently created on the controller. By default, all access points belong to the default access point group "default-group," unless you assign them to other access point groups.

Note When you upgrade to controller software release 5.2 or later, the controller creates the default-group access point group and automatically populates it with the first 16 WLANs (WLANs with IDs 1 through 16, or fewer if 16 WLANs are not configured). This default group cannot be modified (you cannot add WLANs to it nor delete WLANs from it). It is dynamically updated whenever the first 16 WLANs are added or deleted. If an access point does not belong to an access point group, it is assigned to the default group and uses the WLANs in that group. If an access point joins the controller with an undefined access point group name, the access point keeps its group name but uses the WLANs in the default-group access point group.

Step 2 Click **Add Group** to create a new access point group. The Add New AP Group section appears at the top of the page.

Step 3 In the AP Group Name field, enter the group's name.

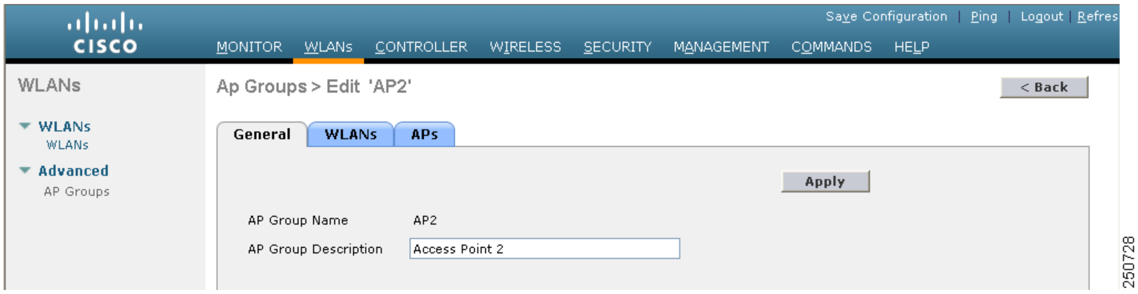
Step 4 In the Description field, enter the group's description.

Step 5 Click **Add**. The newly created access point group appears in the list of access point groups on the AP Groups page.

Note If you ever want to delete this group, hover your cursor over the blue drop-down arrow for the group and choose **Remove**. An error message appears if you try to delete an access point group that is used by at least one access point. Before deleting an access point group in controller software release 6.0, move all access points in the group to another group. The access points are not moved to the default-group access point group as in previous releases.

Step 6 To edit this new group, click the name of the group. The AP Groups > Edit (General) page appears (see Figure 6-23).

Figure 6-23 AP Groups > Edit (General) Page

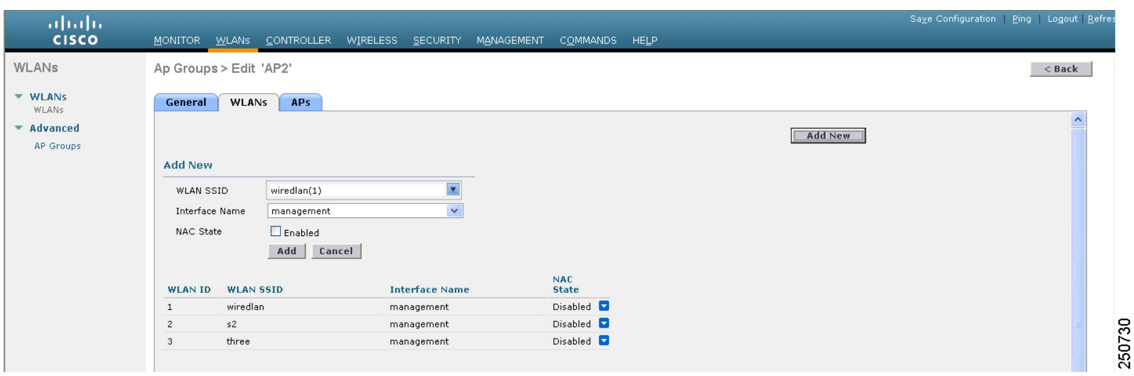


Step 7 To change the description of this access point group, enter the new text in the AP Group Description field and click **Apply**.

Step 8 Choose the **WLANs** tab to open the AP Groups > Edit (WLANs) page. This page lists the WLANs that are currently assigned to this access point group.

Step 9 Click **Add New** to assign a WLAN to this access point group. The Add New section appears at the top of the page (see Figure 6-24).

Figure 6-24 AP Groups > Edit (WLANs) Page



Step 10 From the WLAN SSID drop-down box, choose the SSID of the WLAN.

Step 11 From the Interface Name drop-down box, choose the interface to which you want to map the access point group. Choose the quarantine VLAN if you plan to enable network admission control (NAC) out-of-band support.

Note The interface name in the default-group access point group matches the WLAN interface.

Step 12 To enable NAC out-of-band support for this access point group, check the **NAC State** check box. To disable NAC out-of-band support, leave the check box unchecked, which is the default value. Refer to the "Configuring NAC Out-of-Band Integration" section on page 6-66 for more information on NAC.

Step 13 Click **Add** to add this WLAN to the access point group. This WLAN appears in the list of WLANs that are assigned to this access point group.

Note If you ever want to remove this WLAN from the access point group, hover your cursor over the blue drop-down arrow for the WLAN and choose **Remove**.

Step 14 Repeat Step 9 through Step 13 to add any additional WLANs to this access point group.

Step 15 Choose the **APs** tab to assign access points to this access point group. The AP Groups > Edit (APs) page lists the access points that are currently assigned to this group as well as any access points that are available to be added to the group. If an access point is not currently assigned to a group, its group name appears as "default-group" (see Figure 6-25).

Figure 6-25 AP Groups > Edit (APs) Page

250727

Step 16 To add an access point to this access point group, check the check box to the left of the access point name and click **Add APs**. The access point now appears in the list of access points currently in this access point group.

Note To select all of the available access points at once, check the **AP Name** check box. All of the access points are then selected.

Note If you ever want to remove an access point from the group, check the check box to the left of the access point name and click **Remove APs**. To select all of the access points at once, check the **AP Name** check box. All of the access points are then removed from this group.

Note If you ever want to change the access point group to which an access point belongs, choose **Wireless** > **Access Points** > **All APs** > *ap_name* > **Advanced** tab, choose the name of another access point group from the **AP Group Name** drop-down box, and click **Apply**.

Step 17 Click **Save Configuration** to save your changes.

Using the CLI to Create Access Point Groups

Using the controller CLI, follow these steps to create access point groups.

Step 1 To create an access point group, enter this command:

config wlan apgroup add *group_name*

> **Note** To delete an access point group, enter this command: **config wlan apgroup delete** *group_name*. An error message appears if you try to delete an access point group that is used by at least one access point. Before deleting an access point group in controller software release 6.0, move all access points in the group to another group. The access points are not moved to the default-group access point group as in previous releases. To see the access points in a group, enter **show wlan apgroups**. To move the access points to another group, enter **config ap group-name** *group_name Cisco_AP*.

Step 2 To add a description to an access point group, enter this command:

config wlan apgroup description *group_name description*

Step 3 To assign a WLAN to an access point group, enter this command:

config wlan apgroup interface-mapping add *group_name wlan_id interface_name*

> **Note** To remove a WLAN from an access point group, enter this command: **config wlan apgroup interface-mapping delete** *group_name wlan_id*.

Step 4 To enable or disable NAC out-of-band support for this access point group, enter this command:

config wlan apgroup nac {**enable** | **disable**} *group_name wlan_id*

Step 5 To configure a WLAN radio policy on the access point group, enter this command:

config wlan apgroup radio-policy *apgroup_name wlan-id* {**802.11a-only** | **802.11bg** | **802.11g-only** | **all**}

Step 6 To assign an access point to an access point group, enter this command:

config ap group-name *group_name Cisco_AP*

Note To remove an access point from an access point group, re-enter this command and assign the access point to another group.

Step 7 To save your changes, enter this command:

save config

Using the CLI to View Access Point Groups

Use these CLI commands to view information about or to troubleshoot access point groups.

1. To see a list of all access point groups on the controller, enter this command:

   show wlan apgroups

   Information similar to the following appears:

```
Site Name....................................... AP2
Site Description................................ Access Point 2

WLAN ID          Interface          Network Admission Control
-------         -----------        --------------------------
 1              management           Disabled
 2              management           Disabled
 3              management           Disabled
 4              management           Disabled
 9              management           Disabled
 10             management           Disabled
 11             management           Disabled
 12             management           Disabled
 13             management           Disabled
 14             management           Disabled
 15             management           Disabled
 16             management           Disabled
 18             management           Disabled

AP Name Slots AP Model      Ethernet MAC   Location Port Country Priority GroupName
------- ---- -------------- ----------------- ------- ---- ------- -------- ---------
AP1242   2   AP1242AG-A-K9 00:14:1c:ed:23:9a default  1    US       1       AP2
...
```

2. To see the BSSIDs for each WLAN assigned to an access point group, enter this command:

   show ap wlan {**802.11a** | **802.11b**} *Cisco_AP*

   Information similar to the following appears:

```
Site Name....................................... AP3
Site Description................................ Access Point 3

WLAN ID          Interface          BSSID
-------         ------------  -------------------
 10             management     00:14:1b:58:14:df
```

3. To see the number of WLANs enabled for an access point group, enter this command:

   show ap config {**802.11a** | **802.11b**} *Cisco_AP*

   Information similar to the following appears:

```
Cisco AP Identifier............................. 166
Cisco AP Name................................ AP2
...
Station Configuration
      Configuration ............................ AUTOMATIC
      Number Of WLANs .......................... 2
...
```

4. To enable or disable debugging of access point groups, enter this command:

   debug group {**enable** | **disable**}

Configuring Web Redirect with 802.1X Authentication

You can configure a WLAN to redirect a user to a particular web page after 802.1X authentication has completed successfully. You can configure the web redirect to give the user partial or full access to the network.

Conditional Web Redirect

If you enable conditional web redirect, the user can be conditionally redirected to a particular web page after 802.1X authentication has completed successfully. You can specify the redirect page and the conditions under which the redirect occurs on your RADIUS server. Conditions might include the user's password reaching expiration or the user needing to pay his or her bill for continued usage.

If the RADIUS server returns the Cisco AV-pair "url-redirect," then the user is redirected to the specified URL upon opening a browser. If the server also returns the Cisco AV-pair "url-redirect-acl," the specified access control list (ACL) is installed as a preauthentication ACL for this client. The client is not considered fully authorized at this point and can only pass traffic allowed by the preauthentication ACL.

After the client completes a particular operation at the specified URL (for example, changing a password or paying a bill), the client must reauthenticate. When the RADIUS server does not return a "url-redirect," the client is considered fully authorized and allowed to pass traffic.

Note The conditional web redirect feature is available only for WLANs that are configured for 802.1X or WPA+WPA2 Layer 2 security.

After you configure the RADIUS server, you can then configure the conditional web redirect on the controller using either the controller GUI or CLI.

Splash Page Web Redirect

If you enable splash page web redirect, the user is redirected to a particular web page after 802.1X authentication has completed successfully. After the redirect, the user has full access to the network. You can specify the redirect page on your RADIUS server. If the RADIUS server returns the Cisco AV-pair "url-redirect," then the user is redirected to the specified URL upon opening a browser. The client is considered fully authorized at this point and is allowed to pass traffic, even if the RADIUS server does not return a "url-redirect."

Note The splash page web redirect feature is available only for WLANs that are configured for 802.1X or WPA+WPA2 Layer 2 security with 802.1x key management. Preshared key management is not supported with any Layer 2 security method.

After you configure the RADIUS server, you can then configure the splash page web redirect on the controller using either the controller GUI or CLI.

Configuring the RADIUS Server

Follow these steps to configure your RADIUS server.

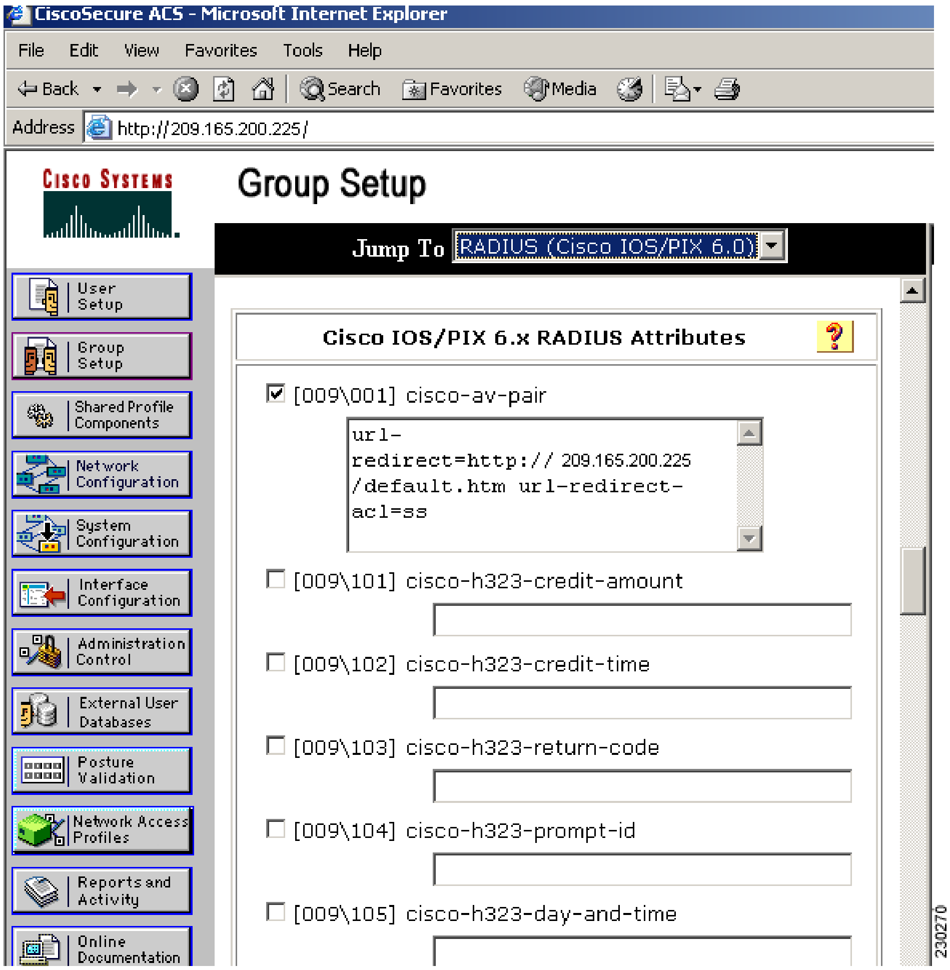
Note These instructions are specific to the CiscoSecure ACS; however, they should be similar to those for other RADIUS servers.

Step 1 From the CiscoSecure ACS main menu, choose **Group Setup**.

Step 2 Click **Edit Settings**.

Step 3 From the Jump To drop-down menu, choose **RADIUS (Cisco IOS/PIX 6.0)**. The window shown in Figure 6-26 appears.

Figure 6-26 ACS Server Configuration



Step 4 Check the **[009\001] cisco-av-pair** check box.

Step 5 Enter the following Cisco AV-pairs in the [009\001] cisco-av-pair edit box to specify the URL to which the user is redirected and, if configuring conditional web redirect, the conditions under which the redirect takes place, respectively:

url-redirect=http://*url*

url-redirect-acl=*acl_name*

Using the GUI to Configure Web Redirect

Using the controller GUI, follow these steps to configure conditional or splash page web redirect.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN. The WLANs > Edit page appears.

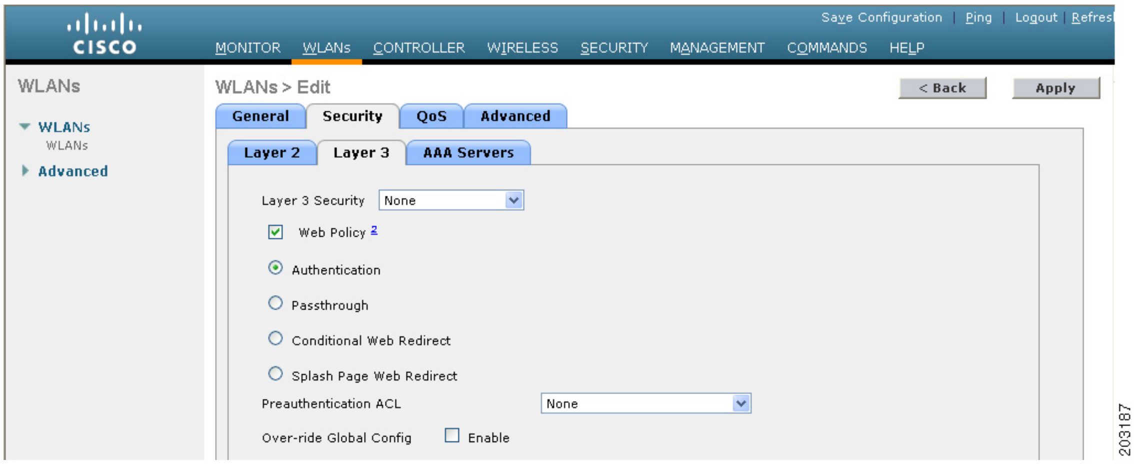
Step 3 Choose the **Security** and **Layer 2** tabs to open the WLANs > Edit (Security > Layer 2) page.

Step 4 Choose **802.1X** or **WPA+WPA2** from the Layer 2 Security drop-down box.

Step 5 Set any additional parameters for 802.1X or WPA+WPA2.

Step 6 Choose the **Layer 3** tab to open the WLANs > Edit (Security > Layer 3) page (see Figure 6-27).

Figure 6-27 WLANs > Edit (Security > Layer 3) Page



Step 7 Choose **None** from the Layer 3 Security drop-down box.

Step 8 Check the **Web Policy** check box.

Step 9 Choose one of the following options to enable conditional or splash page web redirect: **Conditional Web Redirect** or **Splash Page Web Redirect**. The default value is disabled for both parameters.

Step 10 If the user is to be redirected to a site external to the controller, choose the ACL that was configured on your RADIUS server from the Preauthentication ACL drop-down list.

Step 11 Click **Apply** to commit your changes.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure Web Redirect

Using the controller CLI, follow these steps to configure conditional or splash page web redirect.

Step 1 To enable or disable conditional web redirect, enter this command:

config wlan security cond-web-redir {**enable** | **disable**} *wlan_id*

Step 2 To enable or disable splash page web redirect, enter this command:

config wlan security splash-page-web-redir {**enable** | **disable**} *wlan_id*

Step 3 To save your settings, enter this command:

save config

Step 4 To see the status of the web redirect features for a particular WLAN, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... test
Network Name (SSID).............................. test
...
Web Based Authentication......................... Disabled
Web-Passthrough.................................. Disabled
Conditional Web Redirect......................... Disabled
Splash-Page Web Redirect......................... Enabled
...
```

Disabling Accounting Servers per WLAN

This section provides instructions for disabling all accounting servers on a WLAN. Disabling accounting servers disables all accounting operations and prevents the controller from falling back to the default RADIUS server for the WLAN.

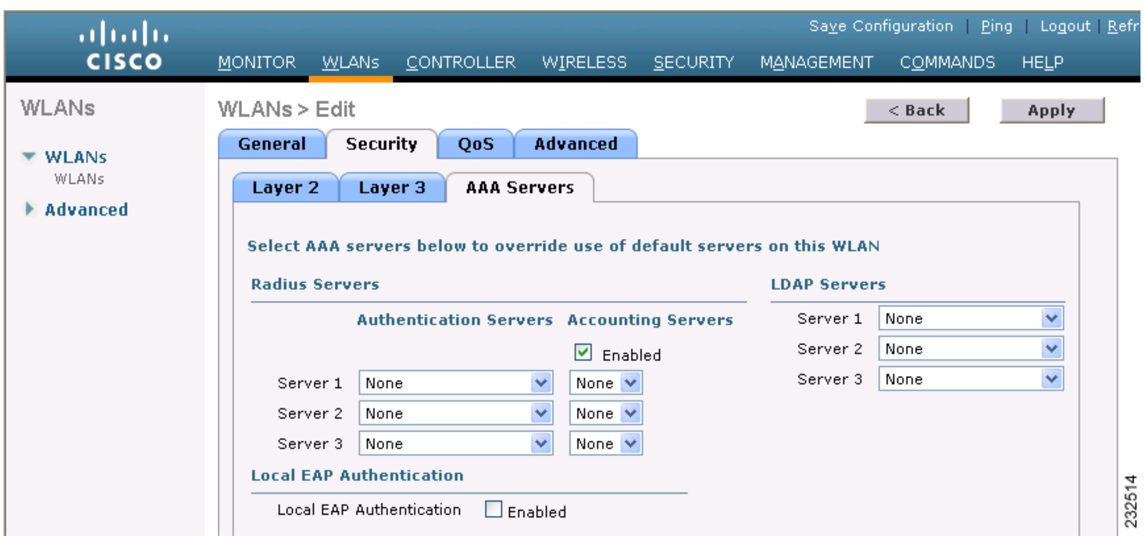
Follow these steps to disable all accounting servers for a RADIUS authentication server.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN to be modified. The WLANs > Edit page appears.

Step 3 Choose the **Security** and **AAA Servers** tabs to open the WLANs > Edit (Security > AAA Servers) page (see Figure 6-28).

Figure 6-28 WLANs > Edit (Security > AAA Servers) Page



Step 4 Uncheck the **Enabled** check box for the Accounting Servers.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Disabling Coverage Hole Detection per WLAN

This section provides instructions for disabling coverage hole detection on a WLAN.

Coverage hole detection is enabled globally on the controller. See the "Coverage Hole Detection and Correction" section on page 11-4 and the "Using the GUI to Configure Coverage Hole Detection" section on page 11-17 for more information.

In software release 5.2 or later, you can disable coverage hole detection on a per-WLAN basis. When you disable coverage hole detection on a WLAN, a coverage hole alert is still sent to the controller, but no other processing is done to mitigate the coverage hole. This feature is useful for guest WLANs where guests are connected to your network for short periods of time and are likely to be highly mobile.

Using the GUI to Disable Coverage Hole Detection on a WLAN

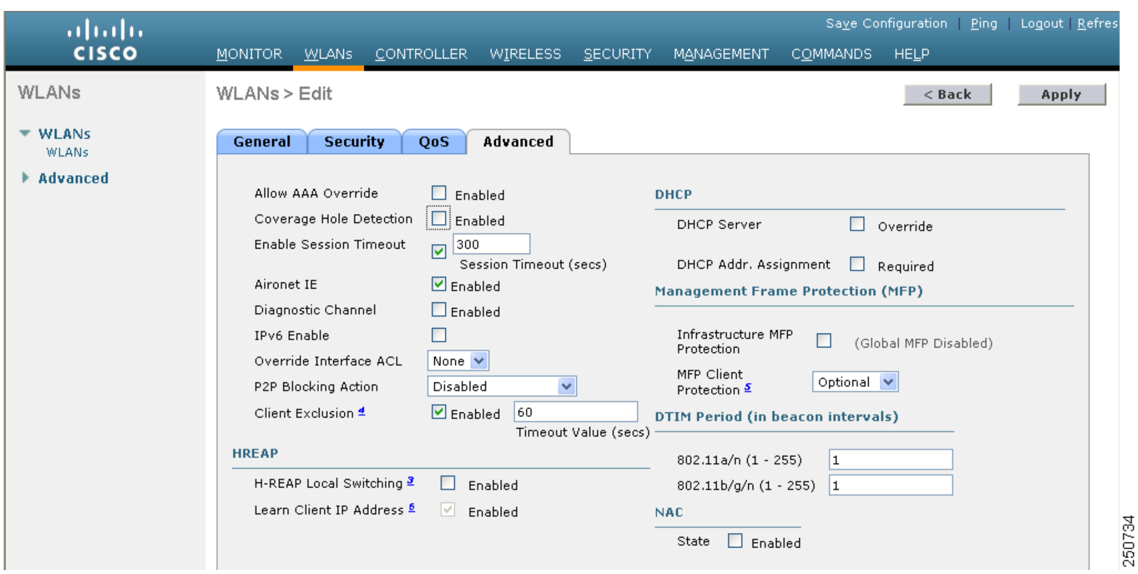
Using the controller GUI, follow these steps to disable coverage hole detection on a WLAN.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the profile name of the WLAN to be modified. The WLANs > Edit page appears.

Step 3 Choose the **Advanced** tab to display the WLANs > Edit (Advanced) page (see Figure 6-29).

Figure 6-29 WLANs > Edit (Advanced) Page



Step 4 Uncheck the **Coverage Hole Detection Enabled** check box.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Disable Coverage Hole Detection on a WLAN

Using the controller CLI, follow these steps to disable coverage hole detection on a WLAN.

Step 1 To disable coverage hole detection on a WLAN, enter this command:

config wlan chd *wlan_id* **disable**

Step 2 To save your settings, enter this command:

save config

Step 3 To see the coverage hole detection status for a particular WLAN, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 2
Profile Name..................................... wlan2
Network Name (SSID).............................. 2
. . .
CHD per WLAN................................. Disabled
```

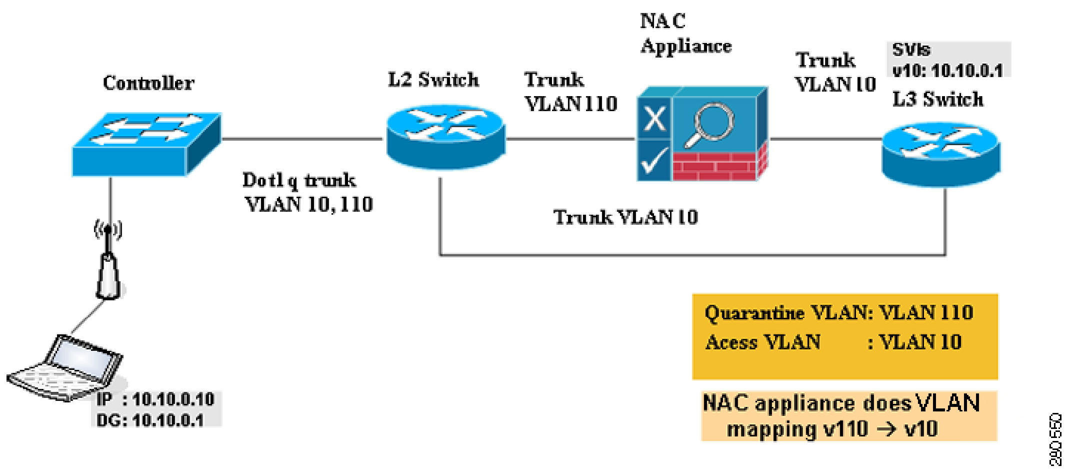
Configuring NAC Out-of-Band Integration

The Cisco NAC Appliance, also known as Cisco Clean Access (CCA), is a network admission control (NAC) product that allows network administrators to authenticate, authorize, evaluate, and remediate wired, wireless, and remote users and their machines prior to allowing users onto the network. It identifies whether machines are compliant with security policies and repairs vulnerabilities before permitting access to the network. The NAC appliance is available in two modes: in-band and out-of-band. Customers can deploy both modes if desired, each geared toward certain types of access (in-band for supporting wireless users and out-of-band for supporting wired users, for example).

In controller software releases prior to 5.1, the controller integrates with the NAC appliance only in in-band mode, where the NAC appliance must remain in the data path. For in-band mode, a NAC appliance is required at each authentication location (such as at each branch or for each controller), and all traffic must traverse the NAC enforcement point. In controller software release 5.1 or later, the controller can integrate with the NAC appliance in out-of-band mode, where the NAC appliance remains in the data path only until clients have been analyzed and cleaned. Out-of-band mode reduces the traffic load on the NAC appliance and enables centralized NAC processing.

To implement the NAC out-of-band feature on the controller, you need to enable NAC support on the WLAN or guest LAN and then map this WLAN or guest LAN to an interface that is configured with a quarantine VLAN (untrusted VLAN) and an access VLAN (trusted VLAN). When a client associates and completes Layer 2 authentication, the client obtains an IP address from the access VLAN subnet, but the client state is Quarantine. While deploying the NAC out-of-band feature, be sure that the quarantine VLAN is allowed only between the Layer 2 switch on which the controller is connected and the NAC appliance and that the NAC appliance is configured with a unique quarantine-to-access VLAN mapping. Client traffic passes into the quarantine VLAN, which is trunked to the NAC appliance. After posture validation is completed, the client is prompted to take action for remediation. After cleaning is completed, the NAC appliance updates the controller to change the client state from Quarantine to Access. Figure 6-30 provides an example of NAC out-of-band integration.

Figure 6-30 NAC Out-of-Band Integration



In Figure 6-30, the link between the controller and the switch is configured as a trunk, enabling the quarantine VLAN (110) and the access VLAN (10). On the Layer 2 switch, the quarantine traffic is trunked to the NAC appliance while the access VLAN traffic goes directly to the Layer 3 switch. Traffic that reaches the quarantine VLAN on the NAC appliance is mapped to the access VLAN based on a static mapping configuration.

Follow the instructions in this section to configure NAC out-of-band integration using either the controller GUI or CLI.

Guidelines for Using NAC Out-of-Band Integration

Follow these guidelines when using NAC out-of-band integration:

- The NAC appliance supports up to 3500 users, and the controller supports up to 5000 users. Therefore, multiple NAC appliances might need to be deployed.
- CCA software release 4.5 or later is required for NAC out-of-band integration.
- Because the NAC appliance supports static VLAN mapping, you must configure a unique quarantine VLAN for each interface configured on the controller. For example, you might configure a quarantine VLAN of 110 on controller 1 and a quarantine VLAN of 120 on controller 2. However, if two WLANs or guest LANs use the same distribution system interface, they must use the same quarantine VLAN, provided they have one NAC appliance deployed in the network. The NAC appliance supports unique quarantine-to-access VLAN mapping.
- For posture reassessment based on session expiry, you must configure the session timeout on both the NAC appliance and the WLAN, making sure that the session expiry on the WLAN is greater than that on the NAC appliance.
- When a session timeout is configured on an open WLAN, the timing out of clients in the Quarantine state is determined by the timer on the NAC appliance. Once the session timeout expires for WLANs using web authentication, clients deauthenticate from the controller and must perform posture validation again.

- NAC out-of-band integration is supported only on WLANs configured for hybrid-REAP central switching. It is not supported for use on WLANs configured for hybrid-REAP local switching.

Note Refer to the *Configuring Hybrid REAP* chapter for more information on hybrid REAP.

- If you want to enable NAC on an access point group VLAN, you must first enable NAC on the WLAN. Then you can enable or disable NAC on the access point group VLAN. If you ever decide to disable NAC on the WLAN, be sure to disable it on the access point group VLAN as well.
- NAC out-of-band integration is not supported for use with the WLAN AAA override feature.
- All Layer 2 and Layer 3 authentication occurs in the quarantine VLAN. To use external web authentication, you must configure the NAC appliance to allow HTTP traffic to and from external web servers and to allow the redirect URL in the quarantine VLAN.

Note Refer to the Cisco NAC appliance configuration guides for configuration instructions: http://www.cisco.com/c/en/us/support/security/nac-appliance-clean-access/products-installation-and-configuration-guides-list.html

Using the GUI to Configure NAC Out-of-Band Integration

Using the controller GUI, follow these steps to configure NAC out-of-band integration.

Step 1 To configure the quarantine VLAN for a dynamic interface, follow these steps:

a. Choose **Controller** > **Interfaces** to open the Interfaces page.

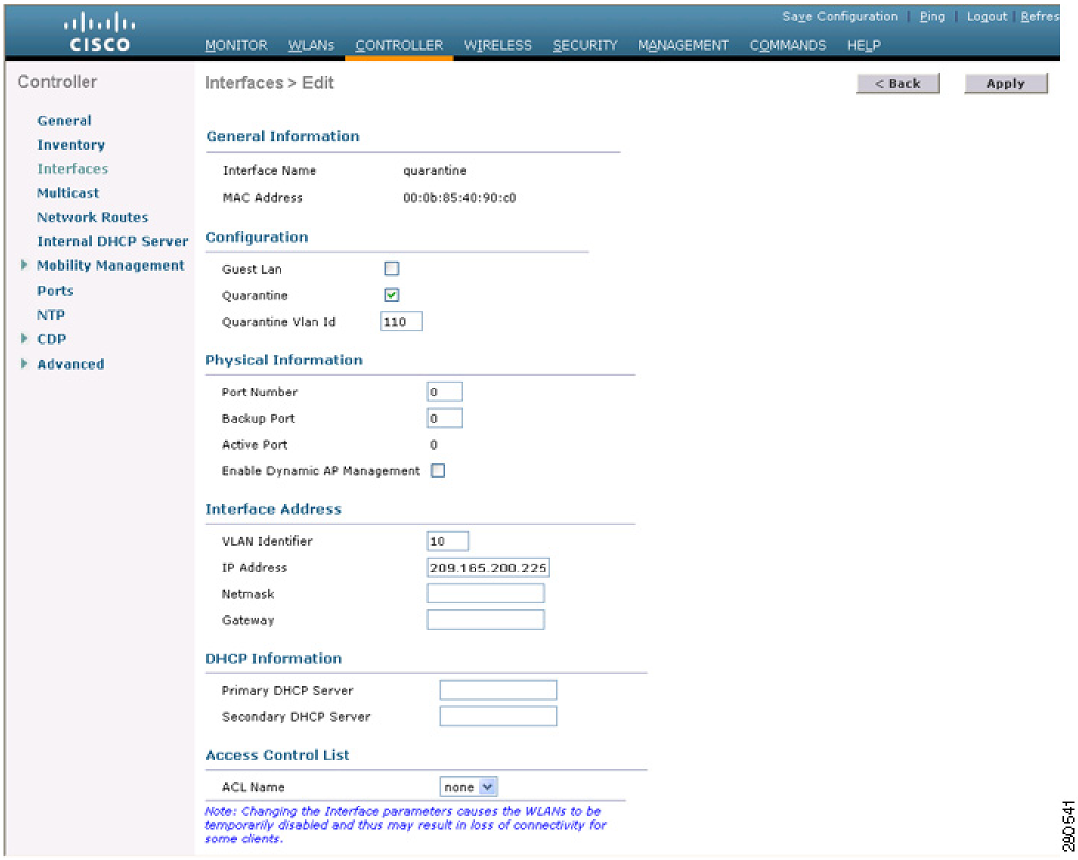
b. Click **New** to create a new dynamic interface.

c. In the Interface Name field, enter a name for this interface, such as “quarantine.”

d. In the VLAN ID field, enter a non-zero value for the access VLAN ID, such as “10.”

e. Click **Apply** to commit your changes. The Interfaces > Edit page appears (see Figure 6-31).

Figure 6-31 Interfaces > Edit Page



f. Check the **Quarantine** check box and enter a non-zero value for the quarantine VLAN ID, such as "110."

Note Cisco recommends that you configure unique quarantine VLANs throughout your network. If multiple controllers are configured in the same mobility group and access interfaces on all controllers are in the same subnet, it is mandatory to have the same quarantine VLAN if there is only one NAC appliance in the network. If multiple controllers are configured in the same mobility group and access interfaces on all controllers are in different subnets, it is mandatory to have different quarantine VLANs if there is only one NAC appliance in the network.

g. Configure any remaining fields for this interface, such as the IP address, netmask, and default gateway.

h. Click **Apply** to save your changes.

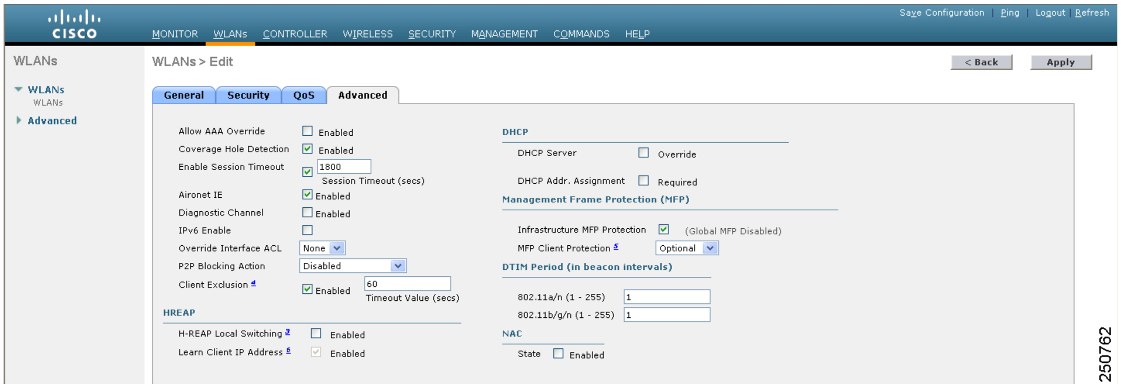
Step 2 To configure NAC out-of-band support on a WLAN or guest LAN, follow these steps:

a. Choose **WLANs** to open the WLANs page.

b. Click the ID number of the desired WLAN or guest LAN. The WLANs > Edit page appears.

c. Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 6-32).

Figure 6-32 WLANs > Edit (Advanced) Page



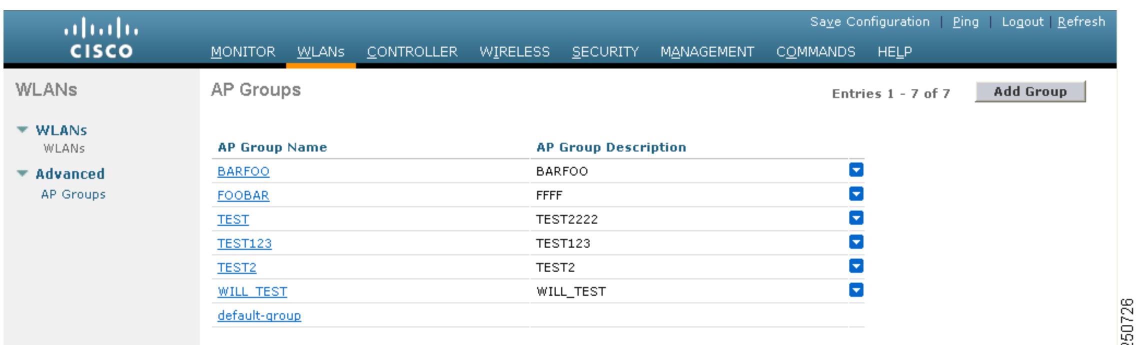
d. To configure NAC out-of-band support for this WLAN or guest LAN, check the **NAC State** check box. To disable NAC out-of-band support, leave the check box unchecked, which is the default value.

e. Click **Apply** to commit your changes.

Step 3 To configure NAC out-of-band support for a specific access point group, follow these steps:

a. Choose **WLANs** > **Advanced** > **AP Groups** to open the AP Groups page (see Figure 6-33).

Figure 6-33 AP Groups Page

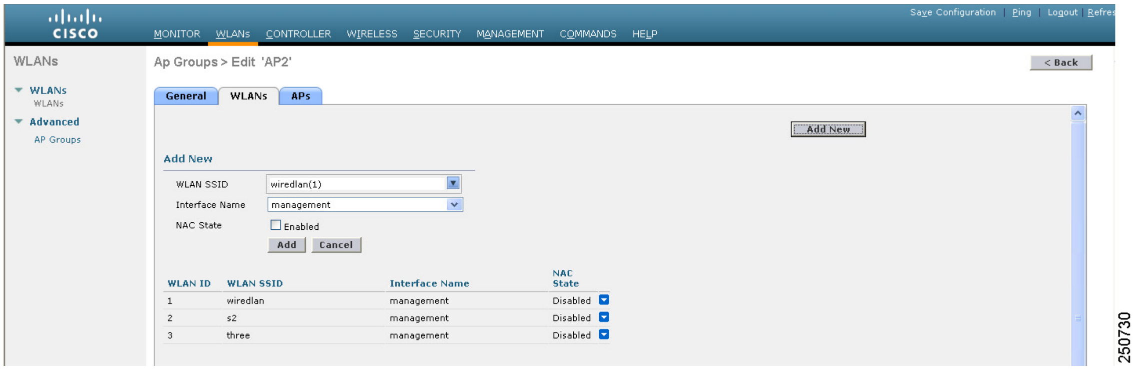


b. Click the name of the desired access point group.

c. Choose the **WLANs** tab to open the AP Groups > Edit (WLANs) page.

d. Click **Add New** to assign a WLAN to this access point group. The Add New section appears at the top of the page (see Figure 6-34).

Figure 6-34 AP Groups > Edit (WLANs) Page



e. From the WLAN SSID drop-down box, choose the SSID of the WLAN.

f. From the Interface Name drop-down box, choose the interface to which you want to map the access point group. Choose the quarantine VLAN if you plan to enable NAC out-of-band support.

g. To enable NAC out-of-band support for this access point group, check the **NAC State** check box. To disable NAC out-of-band support, leave the check box unchecked, which is the default value.

h. Click **Add** to add this WLAN to the access point group. This WLAN appears in the list of WLANs assigned to this access point group.

Note If you ever want to remove this WLAN from the access point group, hover your cursor over the blue drop-down arrow for the WLAN and choose **Remove**.

Step 4 Click **Save Configuration** to save your changes.

Step 5 To see the current state of the client (either Quarantine or Access), follow these steps:

a. Choose **Monitor** > **Clients** to open the Clients page.

b. Click the MAC address of the desired client to open the Clients > Detail page. The NAC state appears under the Security Information section.

Note The client state appears as "Invalid" if the client is probing, has not yet associated to a WLAN, or cannot complete Layer 2 authentication.

Using the CLI to Configure NAC Out-of-Band Integration

Using the controller CLI, follow these steps to configure NAC out-of-band integration.

Step 1 To configure the quarantine VLAN for a dynamic interface, enter this command:

config interface quarantine vlan *interface_name vlan_id*

Note You must configure a unique quarantine VLAN for each interface on the controller.

Note To disable the quarantine VLAN on an interface, enter **0** for the VLAN ID.

Step 2 To enable or disable NAC out-of-band support for a WLAN or guest LAN, enter this command:

config {**wlan** | **guest-lan**} **nac** {**enable** | **disable**} {*wlan_id* | *guest_lan_id*}

Step 3 To enable or disable NAC out-of-band support for a specific access point group, enter this command:

config wlan apgroup nac {**enable** | **disable**} *group_name wlan_id*

Step 4 To save your changes, enter this command:

save config

Step 5 To see the configuration of a WLAN or guest LAN, including the NAC state, enter this command:

show {**wlan** *wlan_ id* | **guest-lan** *guest_lan_id*}

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... wlan
Network Name (SSID).............................. wlan
Status........................................... Disabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Network Admission Control

  NAC-State...................................... Enabled
  Quarantine VLAN............................. 110
...
```

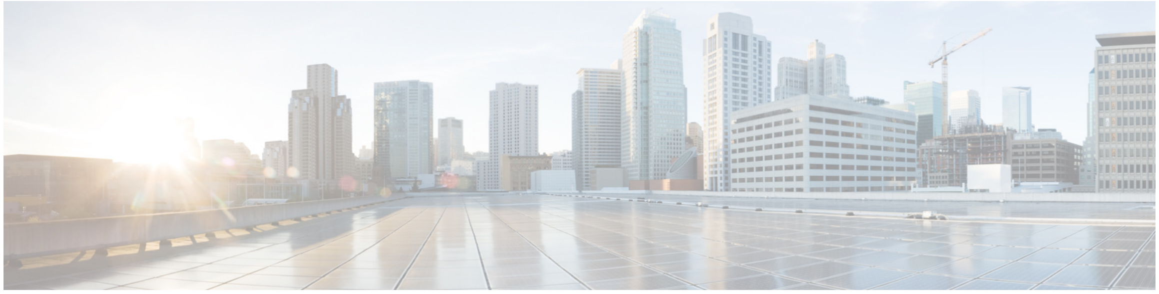
Step 6 To see the current state of the client (either Quarantine or Access), enter this command:

show client detailed *client_mac*

Information similar to the following appears:

```
Client's NAC state.................................. QUARANTINE
```

Note The client state appears as "Invalid" if the client is probing, has not yet associated to a WLAN, or cannot complete Layer 2 authentication.



7

Controlling Lightweight Access Points

This chapter describes the Cisco lightweight access points and explains how to connect them to the controller and manage access point settings. It contains these sections:

Americas Headquarters:
Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA

Access Point Communication Protocols

In controller software release 5.2 or later, Cisco lightweight access points use the IETF standard Control and Provisioning of Wireless Access Points Protocol (CAPWAP) to communicate with the controller and other lightweight access points on the network. Controller software releases prior to 5.2 use the Lightweight Access Point Protocol (LWAPP) for these communications.

CAPWAP, which is based on LWAPP, is a standard, interoperable protocol that enables a controller to manage a collection of wireless access points. CAPWAP is being implemented in controller software release 5.2 and later for these reasons:

- To provide an upgrade path from Cisco products that use LWAPP to next-generation Cisco products that use CAPWAP
- To manage RFID readers and similar devices
- To enable controllers to interoperate with third-party access points in the future

LWAPP-enabled access points can discover and join a CAPWAP controller, and conversion to a CAPWAP controller is seamless. For example, the controller discovery process and the firmware downloading process when using CAPWAP are the same as when using LWAPP. The one exception is for Layer 2 deployments, which are not supported by CAPWAP.

You can deploy CAPWAP controllers and LWAPP controllers on the same network. The CAPWAP-enabled software allows access points to join either a controller running CAPWAP or LWAPP. The only exception is the Cisco Aironet 1140 Series Access Point, which supports only CAPWAP and therefore joins only controllers running CAPWAP. For example, an 1130 series access point can join a controller running either CAPWAP or LWAPP whereas an 1140 series access point can join only a controller running CAPWAP.

Note The 5500 series controllers only support CAPWAP because 6.0 is the first software release for these controllers.

Guidelines for Using CAPWAP

Follow these guidelines when using CAPWAP:

- If your firewall is currently configured to allow traffic only from access points using LWAPP, you must change the rules of the firewall to allow traffic from access points using CAPWAP.
- Make sure that the CAPWAP UDP ports 5246 and 5247 (similar to the LWAPP UDP ports 12222 and 12223) are enabled and are not blocked by an intermediate device that could prevent an access point from joining the controller.
- If access control lists (ACLs) are in the control path between the controller and its access points, you need to open new protocol ports to prevent access points from being stranded.

Configuring Data Encryption

Cisco 5500 series controllers enable you to encrypt CAPWAP control packets (and optionally CAPWAP data packets) that are sent between the access point and the controller using Datagram Transport Layer Security (DTLS). DTLS is a standards-track Internet Engineering Task Force (IETF) protocol based on TLS. CAPWAP control packets are management packets exchanged between a controller and an access point while CAPWAP data packets encapsulate forwarded wireless frames. CAPWAP control and data packets are sent over separate UDP ports: 5246 (control) and 5247 (data). If an access point does not support DTLS data encryption, DTLS is enabled only for the control plane, and a DTLS session for the data plane is not established.

Note Only 5500 series controllers support data encryption. This feature is not available on other controller platforms. If an access point with data encryption enabled tries to join any other controller, the access point joins the controller, but data packets are sent unencrypted.

Note Cisco 1130 and 1240 series access points support DTLS data encryption with software-based encryption, and 1140 and 1250 series access points support DTLS data encryption with hardware-based encryption. Data-encrypted access points can join a 5500 series controller only if the wplus license is installed on the controller. If the wplus license is not installed, the access points cannot join the controller.

DTLS data encryption is enabled automatically for OfficeExtend access points but disabled by default for all other access points. Most access points are deployed in a secure network within a company building, so data encryption is not necessary. In contrast, the traffic between an OfficeExtend access point and the controller travels through an unsecure public network, so data encryption is more important for these access points. When data encryption is enabled, traffic is encrypted at the access point before it is sent to the controller and at the controller before it is sent to the client.

Note Encryption limits throughput at both the controller and the access point, and maximum throughput is desired for most enterprise networks.

Caution In a Cisco unified local wireless network environment, do not enable DTLS on the Cisco 1130 and 1240 access points, as it may result in severe throughput degradation and may render the APs unusable.

Note Refer to the "OfficeExtend Access Points" section on page 51 for more information on OfficeExtend access points.

You can use the controller GUI or CLI to enable or disable DTLS data encryption for a specific access point or for all access points.

Using the GUI to Configure Data Encryption

Using the controller GUI, follow these steps to enable DTLS data encryption for access points on the controller.

Step 1 Make sure that the wplus license is installed on the 5500 series controller. Once the license is installed, you can enable data encryption for the access points.

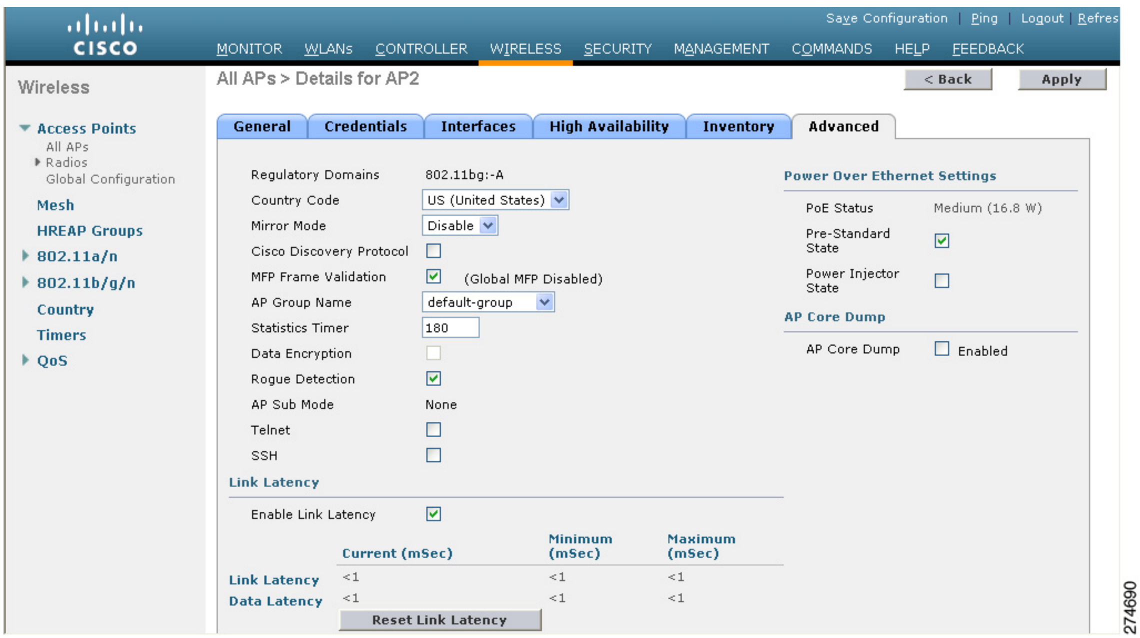
> **Note** Note Refer to the *Configuring Controller Settings* chapter for information on obtaining and installing licenses.

Step 2 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 3 Click the name of the access point for which you want to enable data encryption.

Step 4 Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 1).

Figure 1 All APs > Details for (Advanced) Page



Step 5 Check the **Data Encryption** check box to enable data encryption for this access point or uncheck it to disable this feature. The default value is unchecked.

> **Note** Changing the data encryption mode requires the access points to rejoin the controller.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure Data Encryption

Using the controller CLI, follow these steps to enable DTLS data encryption for access points on the controller.

Step 1 To enable or disable data encryption for all access points or a specific access point, enter this command:

config ap link-encryption {**enable** | **disable**} {**all** | *Cisco_AP*}

The default value is disabled.

> **Note** Changing the data encryption mode requires the access points to rejoin the controller.

Step 2 When prompted to confirm that you want to disconnect the access point(s) and attached client(s), enter **Y**.

Step 3 To save your changes, enter this command:

save config

Step 4 To see the encryption state of all access points or a specific access point, enter this command:

show ap link-encryption {**all** | *Cisco_AP*}

Information similar to the following appears:

```
               Encryption  Dnstream  Upstream Last
AP Name        State       Count     Count    Update
-------------- ---------- --------  --------  --------
AP1130         En          112       1303      23:49
AP1140         En          232      2146      23:49
            auth err: 198 replay err: 0
AP1250         En          0        0          Never
AP1240         En          6191    15011      22:13
```

This command also shows authentication errors, which tracks the number of integrity check failures, and replay errors, which tracks the number of times that the access point receives the same packet.

Step 5 To see a summary of all active DTLS connections, enter this command:

show dtls connections

Information similar to the following appears:

```
AP Name        Local Port       Peer IP       Peer Port             Ciphersuite
------------- ------------- ----------------  ------------- ----------------------------
AP1130         Capwap_Ctrl    172.20.225.163      62369     TLS_RSA_WITH_AES_128_CBC_SHA
AP1250         Capwap_Ctrl    172.20.225.166      19917     TLS_RSA_WITH_AES_128_CBC_SHA
AP1140         Capwap_Ctrl    172.20.225.165       1904     TLS_RSA_WITH_AES_128_CBC_SHA
AP1140         Capwap_Data    172.20.225.165       1904     TLS_RSA_WITH_AES_128_CBC_SHA
AP1130         Capwap_Data    172.20.225.163      62369     TLS_RSA_WITH_AES_128_CBC_SHA
AP1250         Capwap_Data   172.20.225.166     19917    TLS_RSA_WITH_AES_128_CBC_SHA
```

> **Note** If you experience any problems with DTLS data encryption, enter this command to debug all DTLS messages, events, traces, or packets: **debug dtls** {**all** | **event** | **trace** | **packet**} {**enable** | **disable**}.

Viewing CAPWAP MTU Information

To view the maximum transmission unit (MTU) for the CAPWAP path on the controller, enter this command. The MTU specifies the maximum size of any packet (in bytes) in a transmission.

show ap config general *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier............................. 9
Cisco AP Name................................... Maria-1250
Country code.................................... US  - United States
Regulatory Domain allowed by Country............ 802.11bg:-A     802.11a:-A
AP Country code................................. US  - United States
AP Regulatory Domain............................ 802.11bg:-A    802.11a:-A
Switch Port Number ............................. 1
MAC Address..................................... 00:1f:ca:bd:bc:7c
IP Address Configuration........................ DHCP
IP Address...................................... 1.100.163.193
IP NetMask...................................... 255.255.255.0
CAPWAP Path MTU.............................. 1485
...
```

Debugging CAPWAP

Use these CLI commands to obtain CAPWAP debug information:

- **debug capwap events** {**enable** | **disable**}—Enables or disables debugging of CAPWAP events.
- **debug capwap errors** {**enable** | **disable**}—Enables or disables debugging of CAPWAP errors.
- **debug capwap detail** {**enable** | **disable**}—Enables or disables debugging of CAPWAP details.
- **debug capwap info** {**enable** | **disable**}—Enables or disables debugging of CAPWAP information.
- **debug capwap packet** {**enable** | **disable**}—Enables or disables debugging of CAPWAP packets.
- **debug capwap payload** {**enable** | **disable**}—Enables or disables debugging of CAPWAP payloads.
- **debug capwap hexdump** {**enable** | **disable**}—Enables or disables debugging of the CAPWAP hexadecimal dump.
- **debug capwap dtls-keepalive** {**enable** | **disable**}—Enables or disables debugging of CAPWAP DTLS data keepalive packets.

The Controller Discovery Process

In a CAPWAP environment, a lightweight access point discovers a controller by using CAPWAP discovery mechanisms and then sends the controller a CAPWAP join request. The controller sends the access point a CAPWAP join response allowing the access point to join the controller. When the access point joins the controller, the controller manages its configuration, firmware, control transactions, and data transactions.

Upgrade and downgrade paths from LWAPP to CAPWAP or from CAPWAP to LWAPP are supported. An access point with an LWAPP image starts the discovery process in LWAPP. If it finds an LWAPP controller, it starts the LWAPP discovery process to join the controller. If it does not find a LWAPP controller, it starts the discovery in CAPWAP. If the number of times that the discovery process starts with one discovery type (CAPWAP or LWAPP) exceeds the maximum discovery count and the access point does not receive a discovery response, the discovery type changes to the other type. For example, if the access point does not discover the controller in LWAPP, it starts the discovery process in CAPWAP.

Note If an access point is in the UP state and its IP address changes, the access point tears down the existing CAPWAP tunnel and rejoins the controller. In previous software releases, the access point notifies the controller, and the session continues with the changed IP address without tearing down the session.

Note You must install software release 4.0.155.0 or later on the controller before connecting 1100 and 1300 series access points to the controller. The 1120 and 1310 access points were not supported prior to software release 4.0.155.0.

Note During the discovery process, the 1140 series access point will only query for Cisco CAPWAP Controllers. It will not query for LWAPP controllers. If you want this access point to query for both LWAPP and CAPWAP controllers then you need to update the DNS.

Note The Cisco controllers cannot edit or query any access point information using the CLI if the name of the access point contains a space.

Note Make sure that the controller is set to the current time. If the controller is set to a time that has already occurred, the access point might not join the controller because its certificate may not be valid for that time.

Access points must be discovered by a controller before they can become an active part of the network. The lightweight access points support these controller discovery processes:

- **Layer 3 CAPWAP or LWAPP discovery**—Can occur on different subnets from the access point and uses IP addresses and UDP packets rather the MAC addresses used by Layer 2 discovery.
- **Over-the-air provisioning (OTAP)**—This feature is supported by Cisco 5500 and 4400 series controllers. If this feature is enabled on the controller (on the controller General page or through the **config network otap-mode** {**enable** | **disable**} CLI command), all associated access points transmit wireless CAPWAP or LWAPP neighbor messages, and new access points receive the controller IP address from these messages. This feature is disabled by default and should remain disabled when all access points are installed.

  Note Disabling OTAP on the controller does not disable it on the access point. OTAP cannot be disabled on the access point.

  Note For more information about OTAP, see http://www.cisco.com/c/en/us/support/docs/wireless/4400-series-wireless-lan-controllers/100516-ustnd-otap.html

- **Locally stored controller IP address discovery**—If the access point was previously associated to a controller, the IP addresses of the primary, secondary, and tertiary controllers are stored in the access point's non-volatile memory. This process of storing controller IP addresses on an access point for later deployment is called *priming the access point*.
- **DHCP server discovery**—This feature uses DHCP option 43 to provide controller IP addresses to the access points. Cisco switches support a DHCP server option that is typically used for this capability. For more information about DHCP option 43, see the "Using DHCP Option 43 and DHCP Option 60" section on page 36.

- **DNS discovery**—The access point can discover controllers through your domain name server (DNS). For the access point to do so, you must configure your DNS to return controller IP addresses in response to CISCO-LWAPP-CONTROLLER.*localdomain*, where *localdomain* is the access point domain name. When an access point receives an IP address and DNS information from a DHCP server, it contacts the DNS to resolve CISCO-LWAPP-CONTROLLER.*localdomain*. When the DNS sends a list of controller IP addresses, the access point sends discovery requests to the controllers.

Verifying that Access Points Join the Controller

When replacing a controller, you need to make sure that access points join the new controller.

Using the GUI to Verify that Access Points Join the Controller

Follow these steps to ensure that access points join the new controller.

Step 1 Follow these steps to configure the new controller as a master controller.

a. Choose **Controller** > **Advanced** > **Master Controller Mode** to open the Master Controller Configuration page.

b. Check the **Master Controller Mode** check box.

c. Click **Apply** to commit your changes.

d. Click **Save Configuration** to save your changes.

Step 2 (Optional) Flush the ARP and MAC address tables within the network infrastructure. Ask your network administrator for more information about this step.

Step 3 Restart the access points.

Step 4 Once all the access points have joined the new controller, configure the controller not to be a master controller by unchecking the **Master Controller Mode** check box on the Master Controller Configuration page.

Using the CLI to Verify that Access Points Join the Controller

Follow these steps to ensure that access points join the new controller.

Step 1 To configure the new controller as a master controller, enter this command:

config network master-base enable

Step 2 (Optional) Flush the ARP and MAC address tables within the network infrastructure. Ask your network administrator for more information about this step.

Step 3 Restart the access points.

Step 4 To configure the controller not to be a master controller once all the access points have joined the new controller, enter this command:

config network master-base disable

All APs

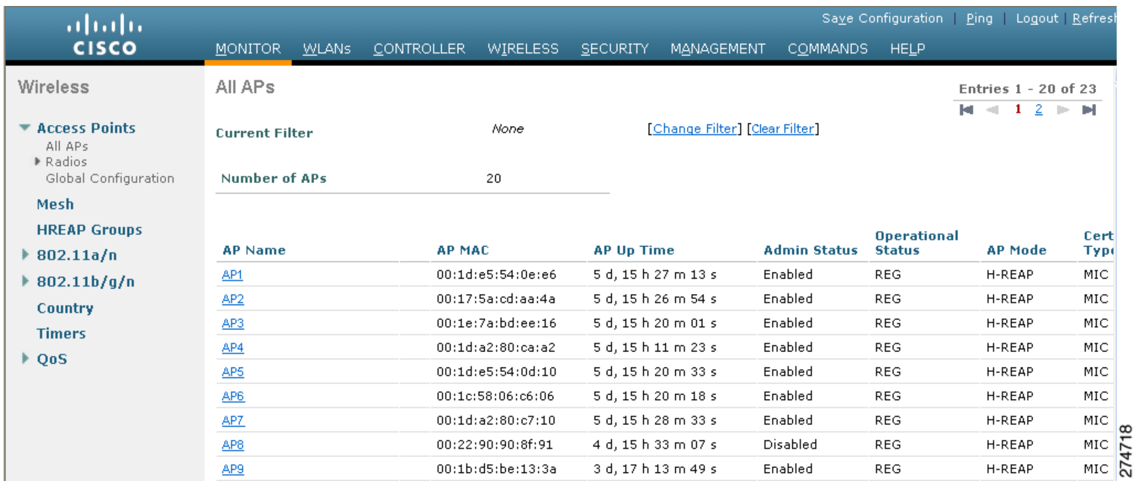
You can search for specific access points in the list of access points on the All APs page. To do so, you create a filter to display only access points that meet certain criteria (such as MAC address, status, access point mode, and certificate type). This feature is especially useful if your list of access points spans multiple pages, preventing you from viewing them all at once.

Using the GUI to Search the AP Filter

To search for access points using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Access Point Summary**> **All APs** > **Details** to open the All APs page (see Figure 2).

Figure 2 All APs Page

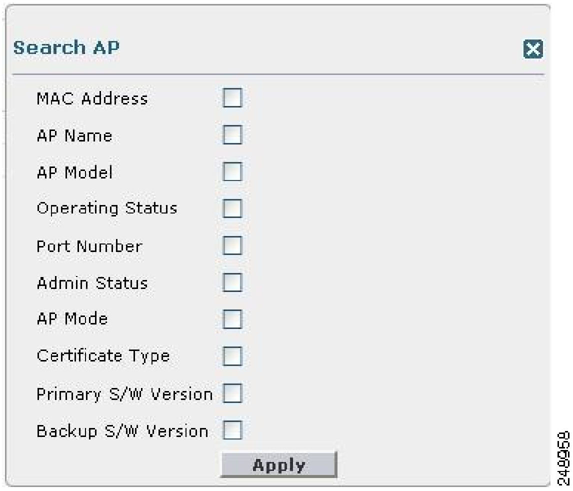


This page lists all of the access points joined to the controller. For each access point, you can see its name, MAC address, uptime, status, operating mode, certificates, OfficeExtend access point status, and access point submode.

The total number of access points appears in the upper right-hand corner of the page. If the list of access points spans multiple pages, you can access these pages by clicking the page number links. Each page shows up to 20 access points.

Step 2 Click **Change Filter** to open the Search AP dialog box (see Figure 3).

Figure 3 Search AP Dialog Box



Step 3 Select one or more of the following check boxes to specify the criteria used when displaying access points:

- **MAC Address**—Enter the MAC address of an access point.

Note When you enable the MAC Address filter, the other filters are disabled automatically. When you enable any of the other filters, the MAC Address filter is disabled automatically.

- **AP Name**—Enter the name of an access point.
- **AP Model**—Enter the model name of an access point.
- **Operating Status**—Select one or more of the following check boxes to specify the operating status of the access points:
  - **UP**—The access point is up and running.
  - **DOWN**—The access point is not operational.
  - **REG**—The access point is registered to the controller.
  - **DEREG**—The access point is not registered to the controller.
  - **DOWNLOAD**—The controller is downloading its software image to the access point.
- **Port Number**—Enter the controller port number to which the access point is connected.
- **Admin Status**—Choose **Enabled** or **Disabled** to specify whether the access points are enabled or disabled on the controller.
- **AP Mode**—Select one or more of the following options to specify the operating mode of the access points:
  - **Local**—The default option.

Note The 600 OEAP series access point uses only local mode.

When an access point in local mode connects to a Cisco Flex 7500 Series Controller, it does not serve clients. The access point details are available in the controller. To enable an access point to serve clients or perform monitoring-related tasks when connected to the Cisco Flex 7500

Series Controller, the access point mode must be in hybrid-REAP or monitor mode. Use the following command to automatically convert access points to a hybrid-REAP mode or monitor mode on joining the controller:

config ap autoconvert {hreap | monitor | disable}

All access points that connect to the controller will either be converted to hybrid-REAP mode or monitor mode depending on the configuration provided.

- **HREAP (hybrid Remote Edge lightweight Access Point)**—This mode is used for 1040, 1130AG, 1140, 1240AG, 1250, 1260, 3500, AP801, and AP802 access points.
- **REAP**—This mode is the remote edge lightweight access point.
- **Monitor**—This mode is the monitor-only mode.
- **Rogue Detector**—This mode monitors the rogue APs on wire. It does not transmit or receive frames over the air or contain rogue AP**s.**

  For more information on Rogue detection, see http://www.cisco.com/c/en/us/support/docs/wireless-mobility/wireless-lan-wlan/70987-rogue-detect.html
- **Sniffer**—The access point starts sniffing the air on a given channel. It captures and forwards all the packets from the clients on that channel to a remote machine that runs Airopeek or Wireshark (packet analyzers for IEEE 802.11 wireless LANs). It includes information on the time stamp, signal strength, packet size, and so on.

Note The Bridge option is displayed only if the AP is bridge capable.

Note If the AP mode is set to "Bridge" and the AP is not REAP capable, an error appears.

- **Bridge—**This mode sets the AP mode to "Bridge" if you are connecting a Root AP.
- **SE-Connect—**This mode allows you to connect to spectrum expert and it allows the access point to perform spectrum intelligence.

Note The AP3500 supports the spectrum intelligence and AP1260 does not support the spectrum intelligence.

Note When an access point is configured in SE-Connect mode, the access point reboots and rejoins the controller. Access points that are configured in this mode do not serve the client.

- **Certificate Type—**Select one or more of the following check boxes to specify the types of certificates installed on the access points:
  - **MIC**—Manufactured-installed certificate
  - **SSC**—Self-signed certificate
  - **LSC**—Local significant certificate

> **Note** See the "Authorizing Access Points" section on page 28 for more information on these certificate types.

- **Primary S/W Version**—Select this check box to enter the primary software version number
- **Backup S/W Version**—Select this check box to enter the secondary software version number.

Step 4 Click **Apply** to commit your changes. Only the access points that match your search criteria appear on the All APs page, and the Current Filter parameter at the top of the page specifies the filter used to generate the list (for example, MAC Address:00:1d:e5:54:0e:e6, AP Name:pmsk-ap, Operational Status: UP, Status: Enabled, and so on).

> **Note** If you want to remove the filters and display the entire access point list, click **Clear Filter**.

Searching Access Point Radios

You can search for specific access point radios in the list of radios on the 802.11a/n Radios page or the 802.11b/g/n Radios page. You can access these pages from the Monitor Menu when viewing access point radios or from the Wireless Menu when configuring access point radios. To search for specific access point radios, you create a filter to display only radios that meet certain criteria (such as radio MAC address or access point name). This feature is especially useful if your list of access point radios spans multiple pages, preventing you from viewing them all at once.

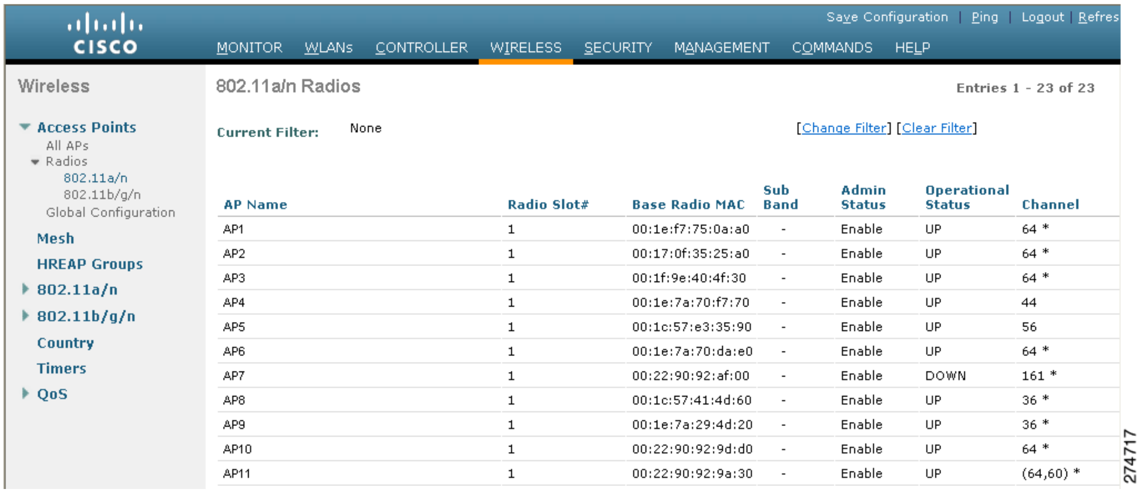
Follow these steps to search for access point radios using the controller GUI.

Step 1 Perform one of the following:

- Choose **Monitor** > **Access Points** > **Radios** > **802.11a/n** (or **802.11b/g/n**) to open the 802.11a/n (or 802.11b/g/n) Radios page (see Figure 4).
- Choose **Wireless** > **Access Points** > **Radios** > **802.11a/n** (or **802.11b/g/n**) to open the 802.11a/n (or 802.11b/g/n) Radios page (see Figure 5).

Figure 4 802.11a/n Radios Page (from Monitor Menu)

Figure 5 802.11a/n Radios Page (from Wireless Menu)

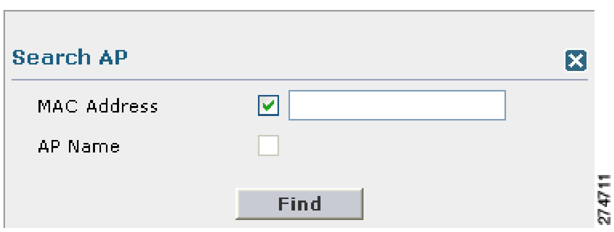


These pages show all of the 802.11a/n or 802.11b/g/n access point radios that are joined to the controller and their current settings.

The total number of access point radios appears in the upper right-hand corner of the page. If the list of radios spans multiple pages, you can access these pages by clicking the page number links. Each page shows up to 25 access point radios.

Step 2 Click **Change Filter** to open the Search AP window (see Figure 6).

Figure 6 Search AP Window



Step 3 Check one of the following check boxes to specify the criteria used when displaying access point radios:

- **MAC Address**—Enter the base radio MAC address of an access point radio.
- **AP Name**—Enter the name of an access point.

Note When you enable one of these filters, the other filter is disabled automatically.

Step 4 Click **Find** to commit your changes. Only the access point radios that match your search criteria appear on the 802.11a/n Radios page or the 802.11b/g/n Radios page, and the Current Filter parameter at the top of the page specifies the filter used to generate the list (for example, MAC Address:00:1e:f7:75:0a:a0 or AP Name:pmsk-ap).

Note If you want to remove the filter and display the entire access point radio list, click **Clear Filter**.

Configuring Global Credentials for Access Points

Cisco IOS access points are shipped from the factory with *Cisco* as the default enable password. This password allows users to log into the non-privileged mode and execute **show** and **debug** commands, posing a security threat. The default enable password must be changed to prevent unauthorized access and to enable users to execute configuration commands from the access point's console port.

In controller software releases prior to 5.0, you can set the access point enable password only for access points that are currently connected to the controller. In controller software release 5.0 or later, you can set a global username, password, and enable password that all access points inherit as they join the controller. This includes all access points that are currently joined to the controller and any that join in the future. If desired, you can override the global credentials and assign a unique username, password, and enable password for a specific access point.

Also in controller software release 5.0 or later, after an access point joins the controller, the access point enables console port security, and you are prompted for your username and password whenever you log into the access point's console port. When you log in, you are in non-privileged mode, and you must enter the enable password in order to use the privileged mode.

Note These controller software release 5.0(or later) features are supported on all access points that have been converted to lightweight mode, except the 1100 series. VxWorks access points are not supported.

The global credentials that you configure on the controller are retained across controller and access point reboots. They are overwritten only if the access point joins a new controller that is configured with a global username and password. If the new controller is not configured with global credentials, the access point retains the global username and password configured for the first controller.

Note You need to keep careful track of the credentials used by the access points. Otherwise, you might not be able to log into an access point's console port. If you ever need to return the access points to the default *Cisco*/*Cisco* username and password, you must clear the controller's configuration and the access point's configuration to return them to factory default settings. To clear the controller's configuration, choose **Commands** > **Reset to Factory Default** > **Reset** on the controller GUI, or enter **clear config** on the controller CLI. To clear the access point's configuration, enter **clear ap config** *Cisco_AP* on the controller CLI. Entering this command does not clear the static IP address of the access point. Once the access point rejoins a controller, it adopts the default *Cisco*/*Cisco* username and password.

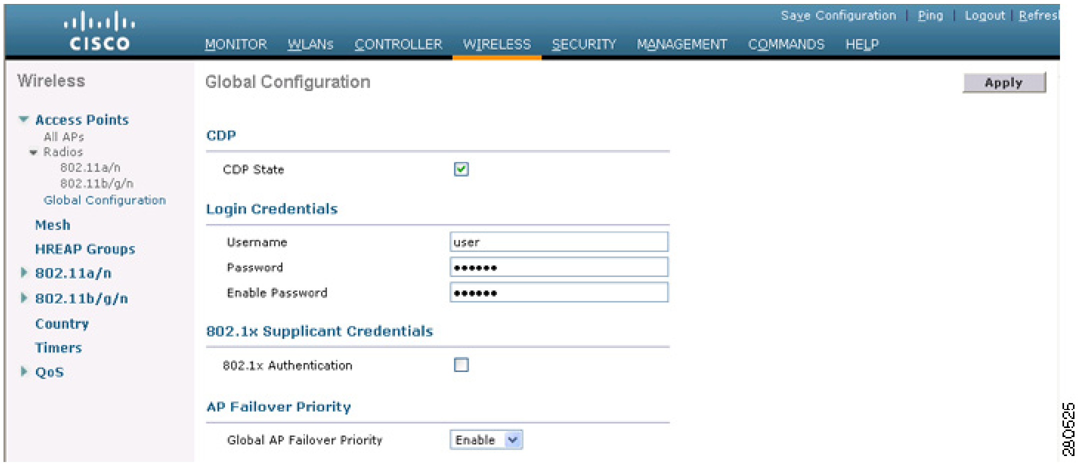
You can use the controller GUI or CLI to configure global credentials for access points that join the controller.

Using the GUI to Configure Global Credentials for Access Points

Using the controller GUI, follow these steps to configure global credentials for access points that join the controller.

Step 1 Choose **Wireless** > **Access Points** > **Global Configuration** to open the Global Configuration page (see Figure 7).

Figure 7 Global Configuration Page



Step 2 In the Username field, enter the username that is to be inherited by all access points that join the controller.

Step 3 In the Password field, enter the password that is to be inherited by all access points that join the controller.

Step 4 In the Enable Password field, enter the enable password that is to be inherited by all access points that join the controller.

Step 5 Click **Apply** to send the global username, password, and enable password to all access points that are currently joined to the controller or that join the controller in the future.

Step 6 Click **Save Configuration** to save your changes.

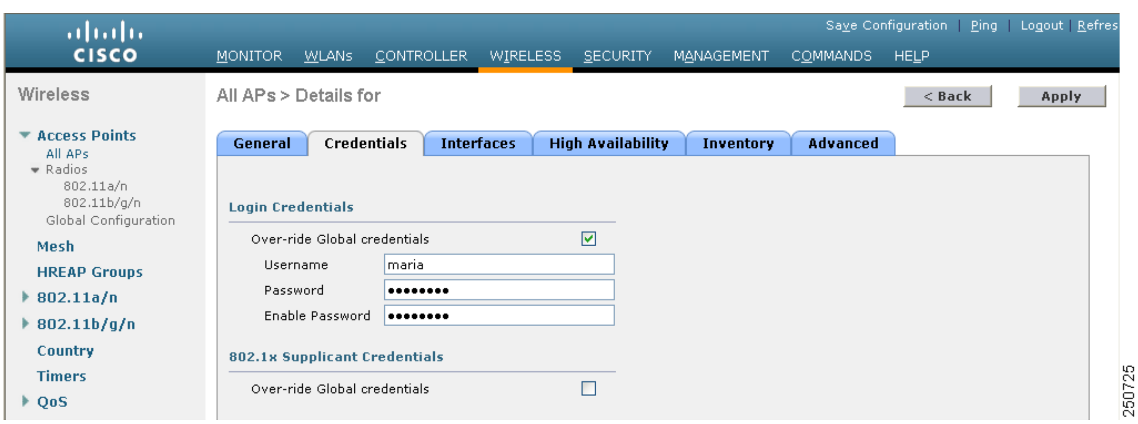
Step 7 If desired, you can choose to override the global credentials for a specific access point and assign a unique username, password, and enable password to this access point. Follow these steps to do so:

a. Choose **Access Points** > **All APs** to open the All APs page.

b. Click the name of the access point for which you want to override the global credentials.

c. Choose the **Credentials** tab. The All APs > Details for (Credentials) page appears (see Figure 8).

Figure 8 All APs > Details for (Credentials) Page



d. Check the **Over-ride Global Credentials** check box to prevent this access point from inheriting the global username, password, and enable password from the controller. The default value is unchecked.

e. In the Username, Password, and Enable Password fields, enter the unique username, password, and enable password that you want to assign to this access point.

Note The information that you enter is retained across controller and access point reboots and if the access point joins a new controller.

f. Click **Apply** to commit your changes.

g. Click **Save Configuration** to save your changes.

Note If you ever want to force this access point to use the controller's global credentials, simply uncheck the **Over-ride Global Credentials** check box.

Using the CLI to Configure Global Credentials for Access Points

Using the controller CLI, follow these steps to configure global credentials for access points that join the controller.

Step 1 To configure the global username, password, and enable password for all access points currently joined to the controller as well as any access points that join the controller in the future, enter this command:

config ap mgmtuser add username *user* **password** *password* **enablesecret** *enable_password* **all**

Step 2 If desired, you can choose to override the global credentials for a specific access point and assign a unique username, password, and enable password to this access point. To do so, enter this command:

config ap mgmtuser add username *user* **password** *password* **enablesecret** *enable_password Cisco_AP*

The credentials that you enter in this command are retained across controller and access point reboots and if the access point joins a new controller.

Note If you ever want to force this access point to use the controller's global credentials, enter this command: **config ap mgmtuser delete** *Cisco_AP*. The following message appears after you execute this command: "AP reverted to global username configuration."

Step 3 To save your changes, enter this command:

save config

Step 4 To verify that global credentials are configured for all access points that join the controller, enter this command:

show ap summary

Information similar to the following appears:

```
Number of APs.................................. 1
Global AP User Name............................ globalap
```

```
AP Name  Slots  AP Model           Ethernet MAC       Location          Port  Country
-------- ------ ------------------ ------------------ ------------------ ----  -------
HReap      2    AIR-AP1131AG-N-K9 00:13:80:60:48:3e  default location  1     US
```

Note If global credentials are not configured, the Global AP User Name field shows "Not Configured."

Step 5 To see the global credentials configuration for a specific access point, enter this command:

show ap config general *Cisco_AP*

Note The name of the access point is case sensitive.

Information similar to the following appears:

```
Cisco AP Identifier.............................. 0
Cisco AP Name................................. HReap
...
AP User Mode..................................... AUTOMATIC
AP User Name..................................... globalap
```

Note If this access point is configured for global credentials, the AP User Mode fields shows "Automatic." If the global credentials have been overwritten for this access point, the AP User Mode field shows "Customized."

Configuring Authentication for Access Points

You can configure 802.1X authentication between a lightweight access point and a Cisco switch. The access point acts as an 802.1X supplicant and is authenticated by the switch using EAP-FAST with anonymous PAC provisioning.

This feature is supported on the following hardware:

- Cisco Aironet 1130, 1140, 1240, and 1250 series access points
- All controller platforms running in local, hybrid-REAP, monitor, or sniffer mode. Bridge mode is not supported.

  Note In hybrid-REAP mode, you can configure local switching with 802.1X authentication if you have configured a local external RADIUS server configured.

- All Cisco switches that support authentication

  Note Refer to the *Release Notes for Cisco Wireless LAN Controllers and Lightweight Access Points for Release 6.0* for a list of supported switch hardware and minimum supported software.

You can configure global authentication settings that all access points inherit as they join the controller. This includes all access points that are currently joined to the controller and any that join in the future. If desired, you can override the global authentication settings and assign unique authentication settings for a specific access point.

Observe the following flow for configuring authentication for access points:

1. If the access point is new, do the following:
   a. Boot the access point with the installed recovery image.
   b. If you choose not to follow this suggested flow and instead enable 802.1X authentication on the switch port connected to the access point prior to the access point joining the controller, enter the following command:

      lwapp ap dot1x username *username* **password** *password*

      Note If you choose to follow this suggested flow and enable 802.1X authentication on the switch port after the access point has joined the controller and received the configured 802.1X credentials, you do not need to enter this command.

      Note This command is available only for access points that are running the 5.1, 5.2, or 6.0 recovery image.

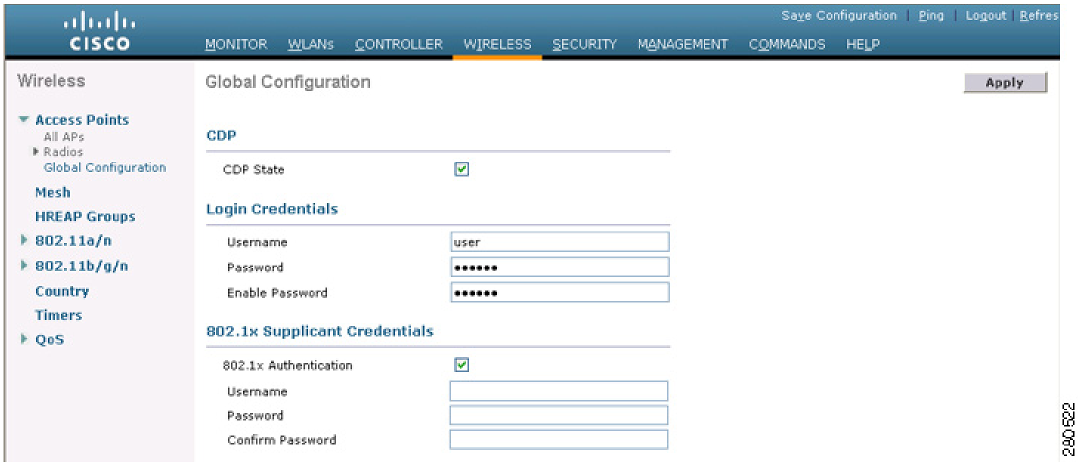
   c. Connect the access point to the switch port.
2. Install the 5.1, 5.2, or 6.0 image on the controller and reboot the controller.
3. Allow all access points to join the controller.
4. Configure authentication on the controller. See the "Using the GUI to Configure Authentication for Access Points" section on page 20 or the "Using the CLI to Configure Authentication for Access Points" section on page 22 for information on configuring authentication on the controller.
5. Configure the switch to allow authentication. See the "Configuring the Switch for Authentication" section on page 24 for information on configuring the switch for authentication.

Using the GUI to Configure Authentication for Access Points

Using the controller GUI, follow these steps to configure authentication for access points that join the controller.

Step 1 Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page (see Figure 9).

Figure 9 Global Configuration Page



Step 2 Under 802.1x Supplicant Credentials, check the **802.1x Authentication** check box.

Step 3 In the Username field, enter the username that is to be inherited by all access points that join the controller.

Step 4 In the Password and Confirm Password fields, enter the password that is to be inherited by all access points that join the controller.

Note You must enter a strong password in these fields. Strong passwords have the following characteristics:
- They are at least eight characters long.
- They contain a combination of upper- and lowercase letters, numbers, and symbols.
- They are not a word in any language.

Step 5 Click **Apply** to send the global authentication username and password to all access points that are currently joined to the controller and to any that join the controller in the future.

Step 6 Click **Save Configuration** to save your changes.

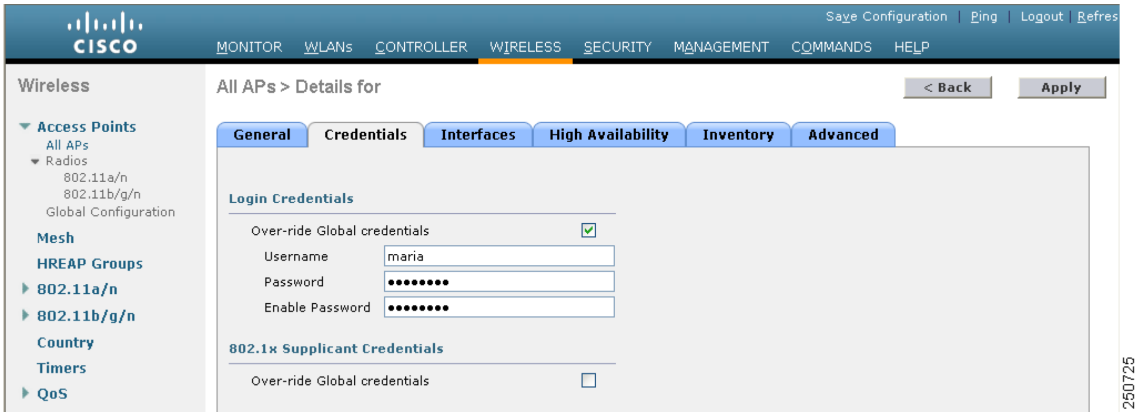
Step 7 If desired, you can choose to override the global authentication settings and assign a unique username and password to a specific access point. Follow these steps to do so:

a. Choose **Access Points** > **All APs** to open the All APs page.

b. Click the name of the access point for which you want to override the authentication settings.

c. Choose the **Credentials** tab to open the All APs > Details for (Credentials) page (see Figure 10).

Figure 10 All APs > Details for (Credentials) Page



d. Under 802.1x Supplicant Credentials, check the **Over-ride Global Credentials** check box to prevent this access point from inheriting the global authentication username and password from the controller. The default value is unchecked.

e. In the Username, Password, and Confirm Password fields, enter the unique username and password that you want to assign to this access point.

Note The information that you enter is retained across controller and access point reboots and whenever the access point joins a new controller.

f. Click **Apply** to commit your changes.

g. Click **Save Configuration** to save your changes.

Note If you ever want to force this access point to use the controller's global authentication settings, simply uncheck the **Over-ride Global Credentials** check box.

Using the CLI to Configure Authentication for Access Points

Using the controller CLI, follow these steps to configure authentication for access points that join the controller.

Step 1 To configure the global authentication username and password for all access points currently joined to the controller as well as any access points that join the controller in the future, enter this command:

config ap dot1xuser add username *user* **password** *password* **all**

Note You must enter a strong password for the *password* parameter. Strong passwords have the following characteristics:
- They are at least eight characters long.
- They contain a combination of upper- and lowercase letters, numbers, and symbols.
- They are not a word in any language.

Step 2 If desired, you can choose to override the global authentication settings and assign a unique username and password to a specific access point. To do so, enter this command:

config ap dot1xuser add username *user* **password** *password Cisco_AP*

Note You must enter a strong password for the *password* parameter. See the note in Step 1 for the characteristics of strong passwords.

The authentication settings that you enter in this command are retained across controller and access point reboots and whenever the access point joins a new controller.

Note If you ever want to force this access point to use the controller's global authentication settings, enter this command: **config ap dot1xuser delete** *Cisco_AP*. The following message appears after you execute this command: "AP reverted to global username configuration."

Step 3 To save your changes, enter this command:

save config

Step 4 If you ever want to disable 802.1X authentication for all access points or for a specific access point, enter this command:

config ap dot1xuser disable {**all** | *Cisco_AP*}

Note You can disable 802.1X authentication for a specific access point only if global 802.1X authentication is not enabled. If global 802.1X authentication is enabled, you can disable 802.1X for all access points only.

Step 5 To view the authentication settings for all access points that join the controller, enter this command:

show ap summary

Information similar to the following appears:

```
Number of APs.................................... 1
Global AP User Name.............................. globalap
Global AP Dot1x User Name........................ globalDot1x
```

Note If global authentication settings are not configured, the Global AP Dot1x User Name field shows "Not Configured."

Step 6 To view the authentication settings for a specific access point, enter this command:

show ap config general *Cisco_AP*

Note The name of the access point is case sensitive.

Information similar to the following appears:

```
Cisco AP Identifier............................. 0
Cisco AP Name................................. HReap
...
AP Dot1x User Mode.............................. AUTOMATIC
AP Dot1x User Name.............................. globalDot1x
...
```

Note If this access point is configured for global authentication, the AP Dot1x User Mode fields shows "Automatic." If the global authentication settings have been overwritten for this access point, the AP Dot1x User Mode field shows "Customized."

Configuring the Switch for Authentication

On the switch CLI, enter these commands to enable 802.1X authentication on a switch port:

Switch# **configure terminal**

Switch(config)# **dot1x system-auth-control**

Switch(config)# **aaa new-model**

Switch(config)# **aaa authentication dot1x default group radius**

Switch(config)# **radius-server host** *ip_addr* **auth-port** *port* **acct-port** *port* **key** *key*

Switch(config)# **interface fastethernet2/1**

Switch(config-if)# **switchport mode access**

Switch(config-if)# **dot1x pae authenticator**

Switch(config-if)# **dot1x port-control auto**

Switch(config-if)# **end**

Embedded Access Points

Controller software release 5.1 or later supports the AP801, which is the integrated access point on the Cisco 800 Series Integrated Services Routers (ISRs). This access point uses a Cisco IOS software image that is separate from the router Cisco IOS software image. It can operate as an autonomous access point that is configured and managed locally, or it can operate as a centrally managed access point utilizing the CAPWAP or LWAPP protocol. The AP801 is preloaded with both an autonomous Cisco IOS release and a recovery image for the unified mode.

Note Before you use an AP801 Series Lightweight Access Point with controller software release 5.2 or later, you must upgrade the software in the Cisco 860 and 880 Series Integrated Services Routers (ISRs) to Cisco IOS 12.4(22)T and the software in the Cisco 890 Series Integrated Services Router to Cisco IOS 12.4(22)YB.

When you want to use the AP801 with a controller, you must enable the recovery image for the unified mode on the access point by entering this CLI command on the router in privileged EXEC mode: **service-module wlan-ap 0 bootimage unified**.

Note If the **service-module wlan-ap 0 bootimage unified** command does not work successfully, make sure that the software license is still eligible.

After enabling the recovery image, enter this CLI command on the router to shut down and reboot the access point: **service-module wlan-ap 0 reload**. After the access point reboots, it discovers the controller, downloads the full CAPWAP or LWAPP software release from the controller, and acts as a lightweight access point.

Note To use the CLI commands mentioned above, the router must be running Cisco IOS Release 12.4(20)T or later. If you experience any problems, refer to the following URL: http://www.cisco.com/c/en/us/td/docs/routers/access/800/software/configuration/guide/SCG800Guide/SCG800_Guide_BookMap_chapter_01001.html

In order to support CAPWAP or LWAPP, the router must be activated with at least the Cisco Advanced IP Services IOS license-grade image. A license is required to upgrade to this IOS image on the router. Refer to this URL for licensing information:

http://www.cisco.com/c/en/us/td/docs/routers/access/sw_activation/SA_on_ISR.html

After the AP801 boots up with the recovery image for the unified mode, it requires an IP address to communicate with the controller and to download its unified image and configuration from the controller. The router can provide DHCP server functionality, the DHCP pool to reach the controller, and setup option 43 for the controller IP address in the DHCP pool configuration. Use the following configuration to perform this task:

ip dhcp pool *pool_name*

network *ip_address subnet_mask*

dns-server *ip_address*

default-router *ip_address*

option 43 hex *controller_ip_address_in_hex*

Example:

```
ip dhcp pool embedded-ap-pool
    network 60.0.0.0 255.255.255.0
   dns-server 171.70.168.183
   default-router 60.0.0.1
   option 43 hex  f104.0a0a.0a0f   /* single WLC IP address(10.10.10.15) in hex format  */
```

The AP801 802.11n radio supports lower power levels than the 802.11n radio in the Cisco Aironet 1250 series access points. The AP801 stores the radio power levels and passes them to the controller when the access point joins the controller. The controller uses the supplied values to limit the user's configuration.

The AP801 can be used in hybrid-REAP mode. Refer to the *Configuring Hybrid REAP* chapter for more information on hybrid REAP.

Note For more information on the AP801, refer to the documentation for the Cisco 800 Series ISRs at this URL:

http://www.cisco.com/c/en/us/support/routers/800-series-routers/tsd-products-support-series-home.html

Autonomous Access Points Converted to Lightweight Mode

You can use an upgrade conversion tool to convert autonomous Cisco Aironet 1100, 1130AG, 1200, 1240AG, and 1300 Series Access Points to lightweight mode. When you upgrade one of these access points to lightweight mode, the access point communicates with a controller and receives a configuration and software image from the controller.

Refer to the *Upgrading Autonomous Cisco Aironet Access Points to Lightweight Mode* document for instructions on upgrading an autonomous access point to lightweight mode. You can find this document at this URL:
http://www.cisco.com/c/en/us/td/docs/wireless/controller/8-0/configuration-guide/b_cg80/b_cg80_chapter_01101010.html

Guidelines for Using Access Points Converted to Lightweight Mode

Keep these guidelines in mind when you use autonomous access points that have been converted to lightweight mode:

- Access points converted to lightweight mode do not support Wireless Domain Services (WDS). Converted access points communicate only with Cisco wireless LAN controllers and cannot communicate with WDS devices. However, the controller provides functionality equivalent to WDS when the access point associates to it.

- In controller software release 4.2 or later, all Cisco lightweight access points support 16 BSSIDs per radio and a total of 16 wireless LANs per access point. In previous releases, they supported only 8 BSSIDs per radio and a total of 8 wireless LANs per access point. When a converted access point associates to a controller, only wireless LANs with IDs 1 through 16 are pushed to the access point.
- Access points converted to lightweight mode must get an IP address and discover the controller using DHCP, DNS, or IP subnet broadcast.
- After you convert an access point to lightweight mode, the console port provides read-only access to the unit.
- The 1130AG and 1240AG access points support hybrid-REAP mode. See the *Configuring Hybrid REAP chapter* for details.
- The upgrade conversion tool adds the self-signed certificate (SSC) key-hash to only one of the controllers on the Cisco WiSM. After the conversion has been completed, add the SSC key-hash to the second controller on the Cisco WiSM by copying the SSC key-hash from the first controller to the second controller. To copy the SSC key-hash, open the AP Policies page of the controller GUI (**Security** > **AAA** > **AP Policies**) and copy the SSC key-hash from the SHA1 Key Hash column under AP Authorization List (see Figure 13). Then, using the second controller's GUI, open the same page and paste the key-hash into the SHA1 Key Hash field under Add AP to Authorization List. If you have more than one Cisco WiSM, use WCS to push the SSC key-hash to all the other controllers.

Reverting from Lightweight Mode to Autonomous Mode

After you use the upgrade tool to convert an autonomous access point to lightweight mode, you can convert the access point from a lightweight unit back to an autonomous unit by loading a Cisco IOS release that supports autonomous mode (Cisco IOS release 12.3(7)JA or earlier). If the access point is associated to a controller, you can use the controller to load the Cisco IOS release. If the access point is not associated to a controller, you can load the Cisco IOS release using TFTP. In either method, the access point must be able to access a TFTP server that contains the Cisco IOS release to be loaded.

Using a Controller to Return to a Previous Release

Follow these steps to revert from lightweight mode to autonomous mode using a wireless LAN controller:

Step 1 Log into the CLI on the controller to which the access point is associated.

Step 2 Enter this command:

config ap tftp-downgrade *tftp-server-ip-address filename access-point-name*

Step 3 Wait until the access point reboots and reconfigure the access point using the CLI or GUI.

Using the MODE Button and a TFTP Server to Return to a Previous Release

Follow these steps to revert from lightweight mode to autonomous mode by using the access point MODE (reset) button to load a Cisco IOS release from a TFTP server:

Step 1 The PC on which your TFTP server software runs must be configured with a static IP address in the range of 10.0.0.2 to 10.0.0.30.

Step 2 Make sure that the PC contains the access point image file (such as *c1200-k9w7-tar.123-7.JA.tar* for a 1200 series access point) in the TFTP server folder and that the TFTP server is activated.

Step 3 Rename the access point image file in the TFTP server folder to **c1200-k9w7-tar.default** for a 1200 series access point.

Step 4 Connect the PC to the access point using a Category 5 (CAT5) Ethernet cable.

Step 5 Disconnect power from the access point.

Step 6 Press and hold the **MODE** button while you reconnect power to the access point.

Note The MODE button on the access point must be enabled. Follow the steps in the "Disabling the Reset Button on Access Points Converted to Lightweight Mode" section on page 48 to check the status of the access point MODE button.

Step 7 Hold the **MODE** button until the status LED turns red (approximately 20 to 30 seconds), and release the MODE button.

Step 8 Wait until the access point reboots as indicated by all LEDs turning green followed by the Status LED blinking green.

Step 9 After the access point reboots, reconfigure the access point using the GUI or the CLI.

Authorizing Access Points

In controller software releases prior to 5.2, the controller may either use self-signed certificates (SSCs) to authenticate access points or send the authorization information to a RADIUS server (if access points have manufactured-installed certificates [MICs]). In controller software release 5.2 or later, you can configure the controller to use a local significant certificate (LSC).

Authorizing Access Points Using SSCs

The Control and Provisioning of Wireless Access Points protocol (CAPWAP) secures the control communication between the access point and controller by means of a secure key distribution requiring X.509 certificates on both the access point and controller. CAPWAP relies on a priori provisioning of the X.509 certificates. Cisco Aironet access points shipped before July 18, 2005 do not have a MIC, so these access points create an SSC when upgraded to operate in lightweight mode. Controllers are programmed to accept local SSCs for authentication of specific access points and do not forward those authentication requests to a RADIUS server. This behavior is acceptable and secure.

Authorizing Access Points Using MICs

You can configure controllers to use RADIUS servers to authorize access points using MICs. The controller uses an access point's MAC address as both the username and password when sending the information to a RADIUS server. For example, if the MAC address of the access point is 000b85229a70, both the username and password used by the controller to authorize the access point are 000b85229a70.

Note The lack of a strong password by the use of the access point's MAC address should not be an issue because the controller uses MIC to authenticate the access point prior to authorizing the access point through the RADIUS server. Using MIC provides strong authentication.

Note If you use the MAC address as the username and password for access point authentication on a RADIUS AAA server, do not use the same AAA server for client authentication.

Authorizing Access Points Using LSCs

You can use an LSC if you want your own public key infrastructure (PKI) to provide better security, to have control of your certificate authority (CA), and to define policies, restrictions, and usages on the generated certificates.

The LSC CA certificate is installed on access points and controllers. You need to provision the device certificate on the access point. The access point gets a signed X.509 certificate by sending a certRequest to the controller. The controller acts as a CA proxy and receives the certRequest signed by the CA for the access point.

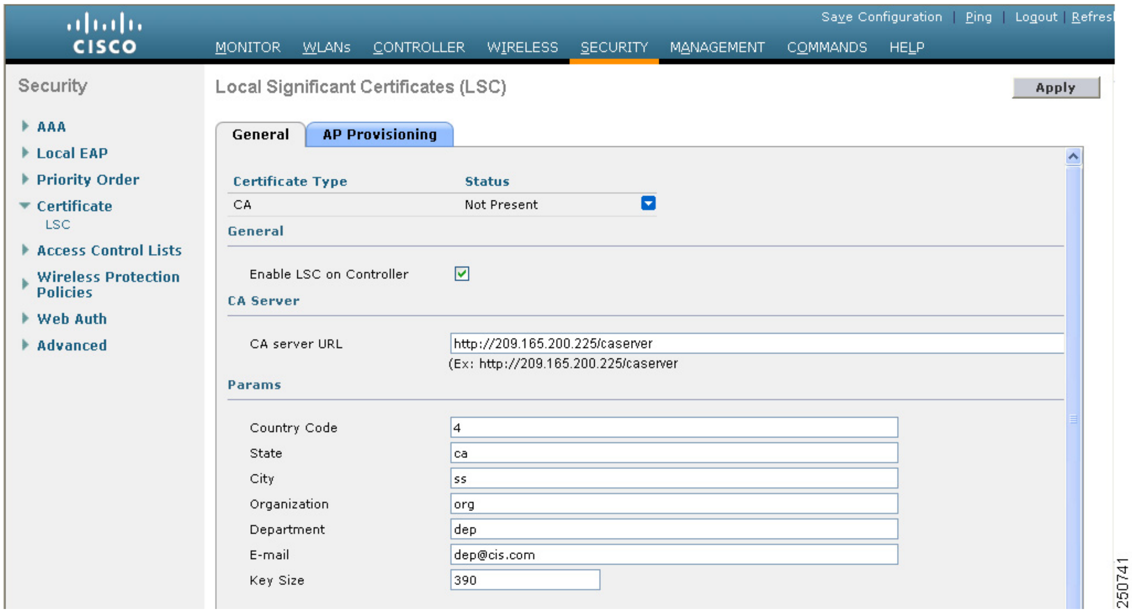
Note Access points that are configured for bridge mode are not supported.

Using the GUI to Configure LSC

Using the controller GUI, follow these steps to enable the use of LSC on the controller.

Step 1 Choose **Security** > **Certificate** > **LSC** to open the Local Significant Certificates (LSC) - General page (see Figure 11).

Figure 11 Local Significant Certificates (LSC) - General Page



Step 2 To enable LSC on the system, check the **Enable LSC on Controller** check box.

Step 3 In the CA Server URL field, enter the URL to the CA server. You can enter either a domain name or an IP address.

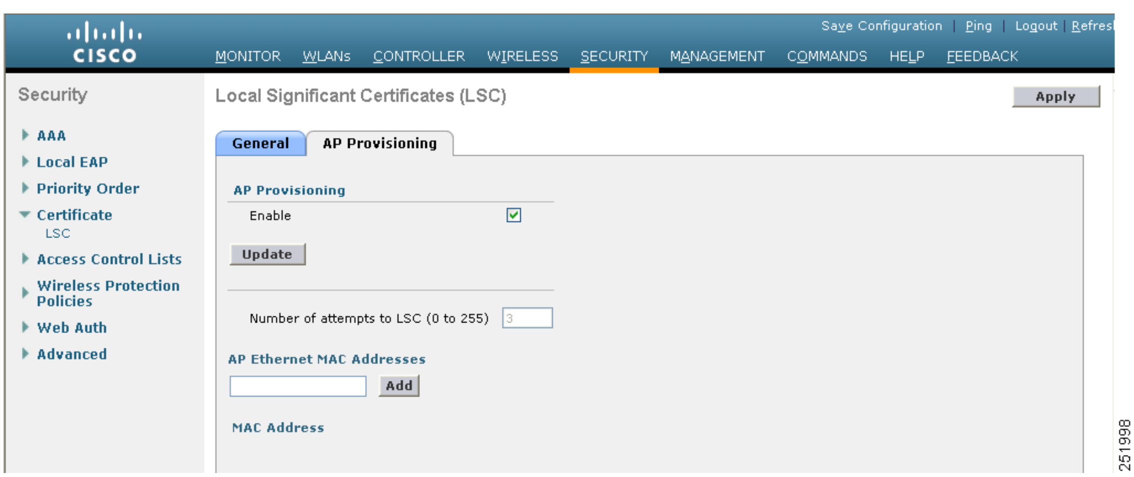
Step 4 In the Params fields, enter the parameters for the device certificate. The key size is a value from 384 to 2048 (in bits), and the default value is 2048.

Step 5 Click **Apply** to commit your changes.

Step 6 To add the CA certificate into the controller's CA certificate database, hover your cursor over the blue drop-down arrow for the certificate type and choose **Add**.

Step 7 Choose the **AP Provisioning** tab to open the Local Significant Certificates (LSC) - AP Provisioning page (see Figure 12).

Figure 12 Local Significant Certificates (LSC) - AP Provisioning Page



Step 8 To provision the LSC on the access point, check the **Enable** check box and click **Update**.

Step 9 When a message appears indicating that the access points will be rebooted, click **OK**.

Step 10 In the Number of Attempts to LSC field, enter the number of times that the access point attempts to join the controller using an LSC before the access point reverts to the default certificate (MIC or SSC). The range is 0 to 255 (inclusive), and the default value is 3.

> **Note** If you set the number of retries to a non-zero value and the access point fails to join the controller using an LSC after the configured number of retries, the access point reverts to the default certificate. If you set the number of retries to 0 and the access point fails to join the controller using an LSC, the access point does not attempt to join the controller using the default certificate.

> **Note** If you are configuring LSC for the first time, Cisco recommends that you configure a non-zero value.

Step 11 To add access points to the provision list, enter the access point MAC address in the AP Ethernet MAC Addresses field and click **Add**.

> **Note** To remove an access point from the provision list, hover your cursor over the blue drop-down arrow for the access point and choose **Remove**.

> **Note** If you configure an access point provision list, only the access points in the provision list are provisioned when you enable AP provisioning. If you do not configure an access point provision list, all access points with a MIC or SSC certificate that join the controller are LSC provisioned.

Step 12 Click **Apply** to commit your changes.

Step 13 Click **Save Configuration** to save your changes.

Using the CLI to Configure LSC

Using the controller CLI, follow these steps to enable the use of LSC on the controller.

Step 1 To enable LSC on the system, enter this command:

config certificate lsc {**enable** | **disable**}

Step 2 To configure the URL to the CA server, enter this command:

config certificate lsc ca-server http://*url:port/path*

where *url* can be either a domain name or IP address.

> **Note** You can configure only one CA server. To configure a different CA server, delete the configured CA server using the **config certificate lsc ca-server delete** command; then configure a different CA server.

Step 3 To add the LSC CA certificate into the controller's CA certificate database, enter this command:

config certificate lsc ca-cert {**add** | **delete**}

Step 4 To configure the parameters for the device certificate, enter this command:

config certificate lsc subject-params *country state city orgn dept email*

> **Note** The common name (CN) is generated automatically on the access point using the current MIC/SSC format C*xxxx-MacAddr*, where *xxxx* is the product number.

Step 5 To configure a key size, enter this command:

config certificate lsc other-params *keysize*

The *keysize* is a value from 384 to 2048 (in bits), and the default value is 2048.

Step 6 To add access points to the provision list, enter this command:

config certificate lsc ap-provision auth-list add *AP_mac_addr*

> **Note** To remove access points from the provision list, enter this command: **config certificate lsc ap-provision auth-list delete** *AP_mac_addr*.

> **Note** If you configure an access point provision list, only the access points in the provision list are provisioned when you enable AP provisioning (in Step 8). If you do not configure an access point provision list, all access points with a MIC or SSC certificate that join the controller are LSC provisioned.

Step 7 To configure the number of times that the access point attempts to join the controller using an LSC before the access point reverts to the default certificate (MIC or SSC), enter this command:

config certificate lsc ap-provision revert-cert *retries*

where *retries* is a value from 0 to 255, and the default value is 3.

> **Note** If you set the number of retries to a non-zero value and the access point fails to join the controller using an LSC after the configured number of retries, the access point reverts to the default certificate. If you set the number of retries to 0 and the access point fails to join the controller using an LSC, the access point does not attempt to join the controller using the default certificate.

> **Note** If you are configuring LSC for the first time, Cisco recommends that you configure a non-zero value.

Step 8 To provision the LSC on the access point, enter this command:

config certificate lsc ap-provision {**enable** | **disable**}

Step 9 To view the LSC summary, enter this command:

show certificate lsc summary

Information similar to the following appears:

```
LSC Enabled.......................................... Yes
LSC CA-Server........................................ http://10.0.0.1:8080/caserver

LSC AP-Provisioning.................................. Yes
    Provision-List................................... Not Configured
    LSC Revert Count in AP reboots................... 3

LSC Params:
    Country.......................................... 4
    State............................................ ca
    City............................................. ss
    Orgn............................................. org
    Dept............................................. dep
    Email............................................ dep@co.com
    KeySize.......................................... 390

LSC Certs:
    CA Cert.......................................... Not Configured
    RA Cert....................................... Not Configured
```

Step 10 To view details about the access points that are provisioned using LSC, enter this command:

show certificate lsc ap-provision

Information similar to the following appears:

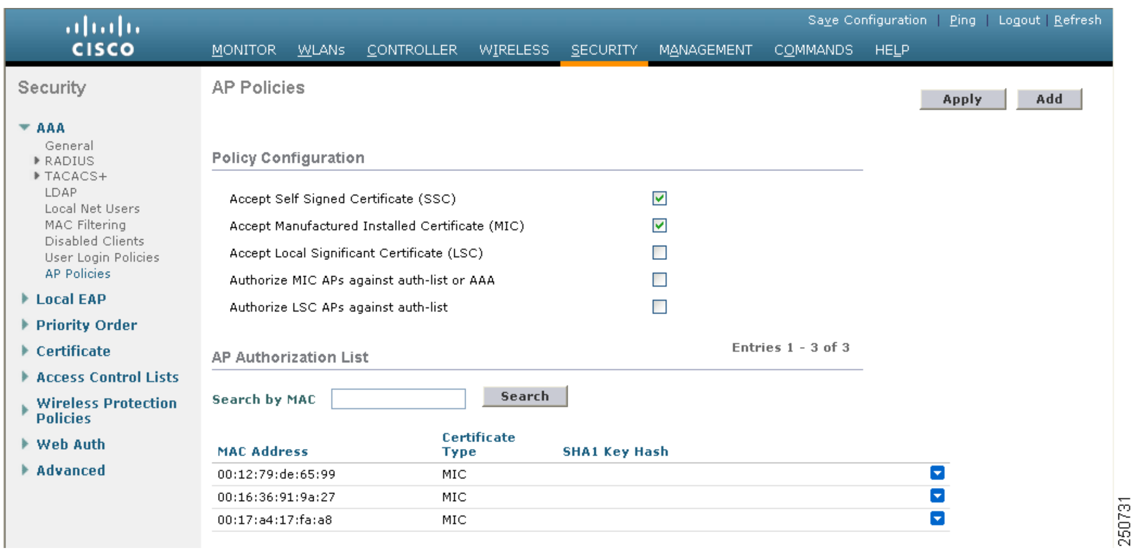
```
LSC AP-Provisioning.......................... Yes
Provision-List............................... Present

Idx     Mac Address
---     ------------
1       00:18:74:c7:c0:90
```

Using the GUI to Authorize Access Points

Using the controller GUI, follow these steps to authorize access points.

Step 1 Choose **Security** > **AAA** > **AP Policies** to open the AP Policies page (see Figure 13).

Figure 13 AP Policies Page



Step 2 If you want the access point to accept self-signed certificates (SSCs), manufactured-installed certificates (MICs), or local significant certificates (LSCs), check the appropriate check box.

Step 3 If you want the access points to be authorized using a AAA RADIUS server, check the **Authorize MIC APs against auth-list or AAA** check box.

Step 4 If you want the access points to be authorized using an LSC, check the **Authorize LSC APs against auth-list** check box.

Step 5 Click **Apply** to commit your changes.

Step 6 Follow these steps to add an access point to the controller's authorization list:

a. Click **Add** to access the Add AP to Authorization List area.

b. In the MAC Address field, enter the MAC address of the access point.

c. From the Certificate Type drop-down box, choose **MIC**, **SSC**, or **LSC**.

d. Click **Add**. The access point appears in the access point authorization list.

Note To remove an access point from the authorization list, hover your cursor over the blue drop-down arrow for the access point and choose **Remove**.

Note To search for a specific access point in the authorization list, enter the MAC address of the access point in the Search by MAC field and click **Search**.

Using the CLI to Authorize Access Points

Using the controller CLI, follow these steps to authorize access points.

Step 1 To configure an access point authorization policy, enter this command:

config auth-list ap-policy {**authorize-ap** {**enable** | **disable**} | **authorize-lsc-ap** {**enable** | **disable**}}

Step 2 To configure an access point to accept manufactured-installed certificates (MICs), self-signed certificates (SSCs), or local significant certificates (LSCs), enter this command:

config auth-list ap-policy {**mic** | **ssc** | **lsc** {**enable** | **disable**}}

Step 3 To add an access point to the authorization list, enter this command:

config auth-list add {**mic** | **ssc** | **lsc**} *ap_mac* [*ap_key*]

where *ap_key* is an optional key hash value equal to 20 bytes or 40 digits.

Note To delete an access point from the authorization list, enter this command: **config auth-list delete** *ap_mac*.

Step 4 To view the access point authorization list, enter this command:

show auth-list

Information similar to the following appears:

```
Authorize MIC APs against AAA ....................... disabled
Authorize LSC APs against Auth-List ................. disabled

Allow APs with MIC - Manufactured Installed C ....... enabled
Allow APs with SSC - Self-Signed Certificate ........ enabled
Allow APs with LSC - Locally Significant Cert ....... enabled

Mac Addr                  Cert Type    Key Hash
-----------------------   ----------   ---------------------------------------------
00:12:79:de:65:99          SSC        ca528236137130d37049a5ef3d1983b30ad7e543
00:16:36:91:9a:27          MIC        593f34e7cb151997a28cc7da2a6cac040b329636
```

Using DHCP Option 43 and DHCP Option 60

Cisco Aironet access points use the type-length-value (TLV) format for DHCP option 43. DHCP servers must be programmed to return the option based on the access point's DHCP Vendor Class Identifier (VCI) string (DHCP option 60). Table 1 lists the VCI strings for Cisco access points capable of operating in lightweight mode.

Table 1 VCI Strings For Lightweight Access Points

Access Point	VCI String
Cisco Aironet 1130 Series	Cisco AP c1130
Cisco Aironet 1140 Series	Cisco AP c1140
Cisco Aironet 1200 Series	Cisco AP c1200
Cisco Aironet 1240 Series	Cisco AP c1240
Cisco Aironet 1250 Series	Cisco AP c1250
Cisco AP801 Embedded Access Point	Cisco AP801

This is the format of the TLV block:

- Type: 0xf1 (decimal 241)
- Length: Number of controller IP addresses * 4
- Value: List of the IP addresses of controller management interfaces

Refer to the product documentation for your DHCP server for instructions on configuring DHCP option 43. The *Upgrading Autonomous Cisco Aironet Access Points to Lightweight Mode* document contains example steps for configuring option 43 on a DHCP server.

Troubleshooting the Access Point Join Process

Access points can fail to join a controller for many reasons: a RADIUS authorization is pending, self-signed certificates are not enabled on the controller, the access point and controller's regulatory domains do not match, and so on.

Note For join information specific to an OfficeExtend access point, refer to the "OfficeExtend Access Points" section on page 51.

Controller software release 5.2 or later enables you to configure the access points to send all CAPWAP-related errors to a syslog server. You do not need to enable any debug commands on the controller because all of the CAPWAP error messages can be viewed from the syslog server itself.

The state of the access point is not maintained on the controller until it receives a CAPWAP join request from the access point. Therefore, it can be difficult to determine why the CAPWAP discovery request from a certain access point was rejected. In order to troubleshoot such joining issues without enabling CAPWAP debug commands on the controller, the controller collects information for all access points that send a discovery message to this controller and maintains information for any access points that have successfully joined this controller.

The controller collects all join-related information for each access point that sends a CAPWAP discovery request to the controller. Collection begins with the first discovery message received from the access point and ends with the last configuration payload sent from the controller to the access point.

You can view join-related information for the following numbers of access points:

- Up to 250 access points for 5500 series controllers
- Up to 300 access points for 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Integrated Wireless LAN Controller Switch
- Up to three times the maximum number of access points supported by the platform for the 2100 series controllers and the Controller Network Module within the Cisco 28/37/38xx Series Integrated Services Routers

When the controller is maintaining join-related information for the maximum number of access points, it does not collect information for any more access points.

An access point sends all syslog messages to IP address 255.255.255.255 by default when any of the following conditions are met:

- An access point running software release 4.2 or later has been newly deployed.
- An existing access point running a software release prior to 4.2 has been upgraded to 4.2 or a later release.
- An existing access point running software release 4.2 or later has been reset after clearing the configuration.

If any of these conditions are met and the access point has not yet joined a controller, you can also configure a DHCP server to return a syslog server IP address to the access point using option 7 on the server. The access point then starts sending all syslog messages to this IP address.

You can also configure the syslog server IP address through the access point CLI, provided the access point is currently not connected to the controller. The relevant command is **lwapp ap log-server** *syslog_server_IP_address*.

When the access point joins a controller for the first time, the controller pushes the global syslog server IP address (the default is 255.255.255.255) to the access point. After that, the access point sends all syslog messages to this IP address, until it is overridden by one of the following scenarios:

- The access point is still connected to the same controller, and the global syslog server IP address configuration on the controller has been changed using the **config ap syslog host global** *syslog_server_IP_address* command. In this case, the controller pushes the new global syslog server IP address to the access point.
- The access point is still connected to the same controller, and a specific syslog server IP address has been configured for the access point on the controller using the **config ap syslog host specific** *Cisco_AP syslog_server_IP_address* command. In this case, the controller pushes the new specific syslog server IP address to the access point.
- The access point gets disconnected from the controller, and the syslog server IP address has been configured from the access point CLI using the **lwapp ap log-server** *syslog_server_IP_address* command. This command works only if the access point is not connected to any controller.
- The access point gets disconnected from the controller and joins another controller. In this case, the new controller pushes its global syslog server IP address to the access point.

Whenever a new syslog server IP address overrides the existing syslog server IP address, the old address is erased from persistent storage, and the new address is stored in its place. The access point also starts sending all syslog messages to the new IP address, provided the access point can reach the syslog server IP address.

You can configure the syslog server for access points using the controller GUI and view the access point join information using the controller GUI or CLI.

Configuring the Syslog Server for Access Points

Follow these steps to configure the syslog server for access points using the controller CLI.

Step 1 Perform one of the following:

- To configure a global syslog server for all access points that join this controller, enter this command:

  config ap syslog host global *syslog_server_IP_address*

  Note By default, the global syslog server IP address for all access points is 255.255.255.255. Make sure that the access points can reach the subnet on which the syslog server resides before configuring the syslog server on the controller. If the access points cannot reach this subnet, the access points are unable to send out syslog messages.

- To configure a syslog server for a specific access point, enter this command:

  config ap syslog host specific *Cisco_AP syslog_server_IP_address*

  Note By default, the syslog server IP address for each access point is 0.0.0.0, indicating that it is not yet set. When the default value is used, the global access point syslog server IP address is pushed to the access point.

Step 2 To save your changes, enter this command:

save config

Step 3 To see the global syslog server settings for all access points that join the controller, enter this command:

show ap config global

Information similar to the following appears:

```
AP global system logging host.................... 255.255.255.255
```

Step 4 To see the syslog server settings for a specific access point, enter this command:

show ap config general *Cisco_AP*

Viewing Access Point Join Information

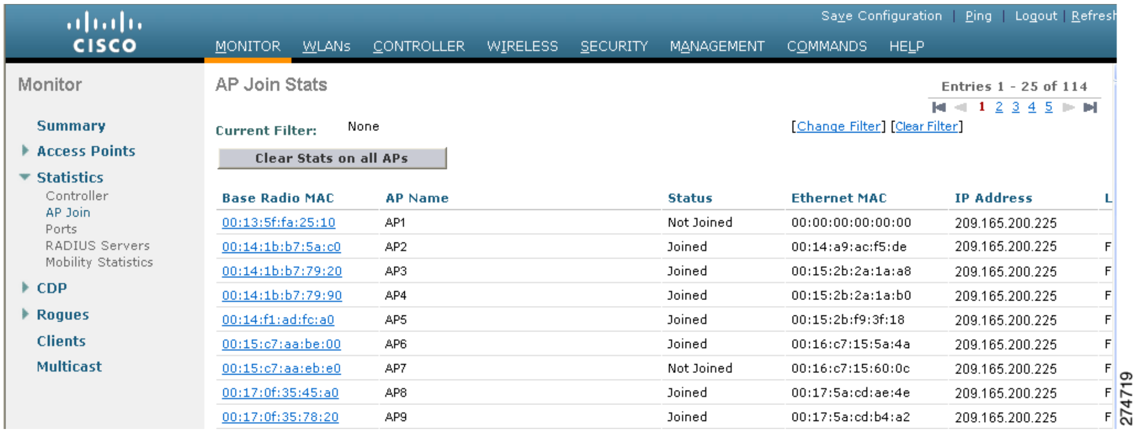
Join statistics for an access point that sends a CAPWAP discovery request to the controller at least once are maintained on the controller even if the access point is rebooted or disconnected. These statistics are removed only when the controller is rebooted or when you choose to clear the statistics.

Using the GUI to View Access Point Join Information

Using the controller GUI, follow these steps to view access point join information.

Step 1 Choose **Monitor** > **Statistics** > **AP Join** to open the AP Join Stats page (see Figure 14).

Figure 14 AP Join Stats Page



This page lists all of the access points that are joined to the controller or that have tried to join. It shows the radio MAC address, access point name, current join status, Ethernet MAC address, IP address, and last join time for each access point.

The total number of access points appears in the upper right-hand corner of the page. If the list of access points spans multiple pages, you can view these pages by clicking the page number links. Each page shows the join statistics for up to 25 access points.

Note If you ever want to remove an access point from the list, hover your cursor over the blue drop-down arrow for that access point and click **Remove**.

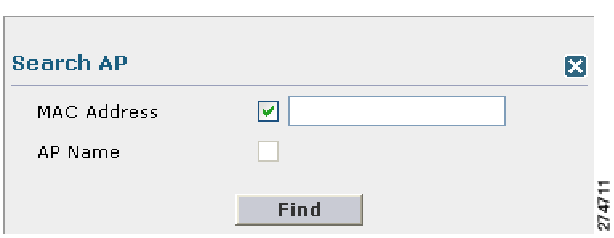
Note If you ever want to clear the statistics for all access points and start over, click **Clear Stats on All APs**.

Step 2 If you want to search for specific access points in the list of access points on the AP Join Stats page, follow these steps to create a filter to display only access points that meet certain criteria (such as MAC address or access point name).

Note This feature is especially useful if your list of access points spans multiple pages, preventing you from viewing them all at once.

a. Click **Change Filter** to open the Search AP window (see Figure 15).

Figure 15 Search AP Window



b. Check one of the following check boxes to specify the criteria used when displaying access points:
   - **MAC Address**—Enter the base radio MAC address of an access point.
   - **AP Name**—Enter the name of an access point.

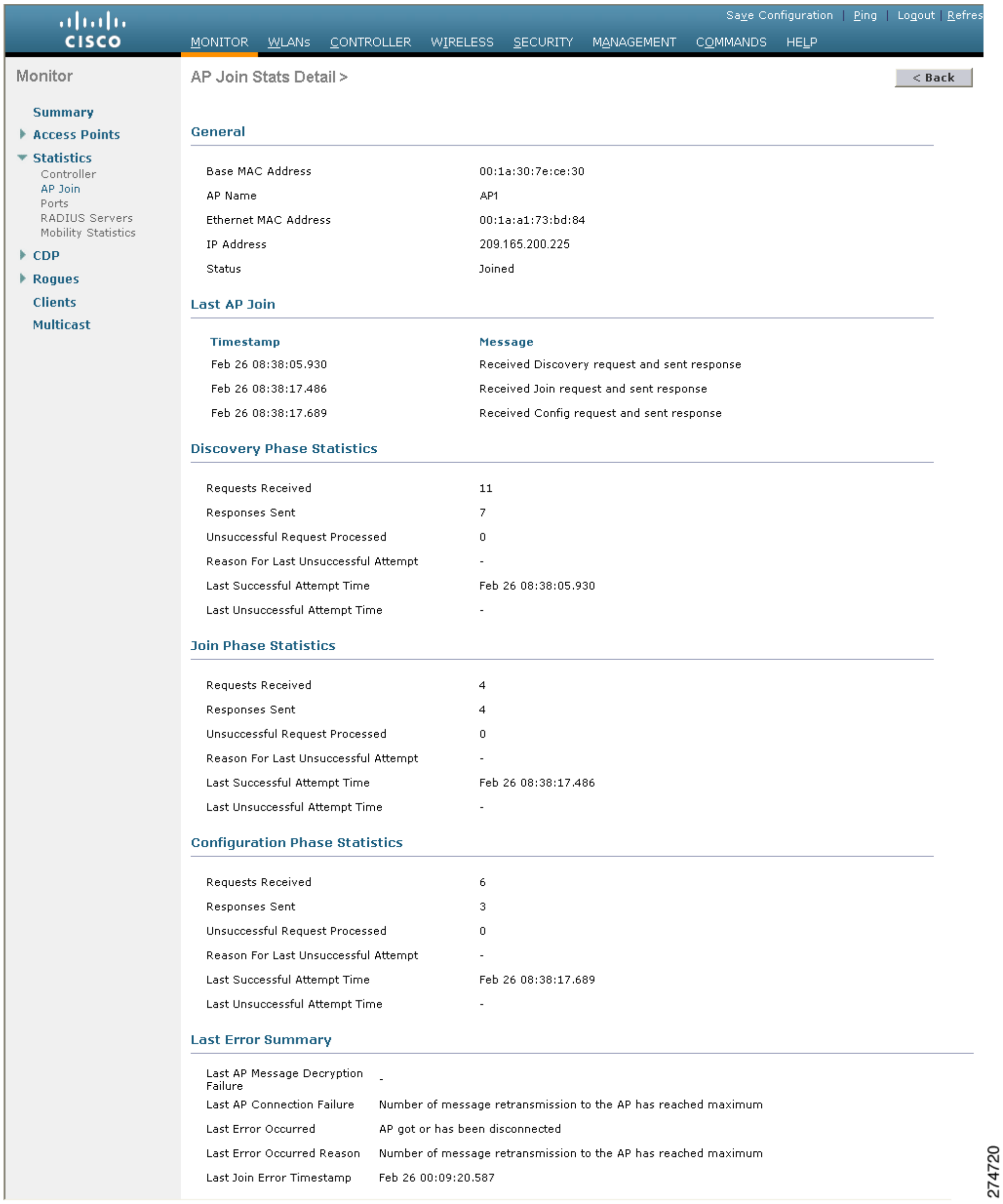
   Note When you enable one of these filters, the other filter is disabled automatically.

c. Click **Find** to commit your changes. Only the access points that match your search criteria appear on the AP Join Stats page, and the Current Filter parameter at the top of the page specifies the filter used to generate the list (for example, MAC Address:00:1e:f7:75:0a:a0 or AP Name:pmsk-ap).

   Note If you want to remove the filter and display the entire access point list, click **Clear Filter**.

Step 3 To see detailed join statistics for a specific access point, click the radio MAC address of the access point. The AP Join Stats Detail page appears (see Figure 16).

Figure 16 AP Join Stats Detail Page



This page provides information from the controller's perspective on each phase of the join process and shows any errors that have occurred.

Using the CLI to View Access Point Join Information

Use these CLI commands to view access point join information:

- To see the MAC addresses of all the access points that are joined to the controller or that have tried to join, enter this command:

  show ap join stats summary all

Information similar to the following appears:

```
Number of APs............................................. 4

Base Mac             AP EthernetMac     AP Name       IP Address       Status
00:0b:85:57:bc:c0    00:0b:85:57:bc:c0   AP1130       10.10.163.217   Joined
00:1c:0f:81:db:80    00:1c:63:23:ac:a0   AP1140       10.10.163.216   Not joined
00:1c:0f:81:fc:20    00:1b:d5:9f:7d:b2   AP1          10.10.163.215   Joined
00:21:1b:ea:36:60   00:0c:d4:8a:6b:c1    AP2          10.10.163.214   Not joined
```

- To see the last join error detail for a specific access point, enter this command:

  show ap join stats summary *ap_mac*

  where *ap_mac* is the MAC address of the 802.11 radio interface.

  Note To obtain the MAC address of the 802.11 radio interface, enter this command on the access point CLI: **show interfaces Dot11Radio 0**

  Information similar to the following appears:

```
Is the AP currently connected to controller................ Yes
Time at which the AP joined this controller last time...... Aug 21 12:50:36.061
Type of error that occurred last........................... AP got or has been
disconnected
Reason for error that occurred last........................ The AP has been reset by
the controller
Time at which the last join error occurred............. Aug 21 12:50:34.374
```

- To see all join-related statistics collected for a specific access point, enter this command:

  show ap join stats detailed *ap_mac*

  Information similar to the following appears:

```
Discovery phase statistics
- Discovery requests received............................. 2
- Successful discovery responses sent...................... 2
- Unsuccessful discovery request processing................ 0
- Reason for last unsuccessful discovery attempt........... Not applicable
- Time at last successful discovery attempt................ Aug 21 12:50:23.335
- Time at last unsuccessful discovery attempt.............. Not applicable

Join phase statistics
- Join requests received.................................. 1
- Successful join responses sent.......................... 1
- Unsuccessful join request processing.................... 1
- Reason for last unsuccessful join attempt................ RADIUS authorization
 is pending for the AP
- Time at last successful join attempt.................... Aug 21 12:50:34.481
- Time at last unsuccessful join attempt.................. Aug 21 12:50:34.374

Configuration phase statistics
- Configuration requests received......................... 1
- Successful configuration responses sent................. 1
- Unsuccessful configuration request processing............ 0
- Reason for last unsuccessful configuration attempt....... Not applicable
- Time at last successful configuration attempt............ Aug 21 12:50:34.374
- Time at last unsuccessful configuration attempt.......... Not applicable

Last AP message decryption failure details
- Reason for last message decryption failure.............. Not applicable
```

```
Last AP disconnect details
- Reason for last AP connection failure................... The AP has been reset by
the controller

Last join error summary
- Type of error that occurred last........................ AP got or has been
disconnected
- Reason for error that occurred last..................... The AP has been reset by
the controller
- Time at which the last join error occurred.............. Aug 21 12:50:34.374
```

- To clear the join statistics for all access points or for a specific access point, enter this command:

  clear ap join stats {**all** | *ap_mac*}

Using a Controller to Send Debug Commands to Access Points Converted to Lightweight Mode

Enter this command to enable the controller to send debug commands to an access point converted to lightweight mode:

debug ap {**enable** | **disable** | **command** *cmd*} *Cisco_AP*

When this feature is enabled, the controller sends debug commands to the converted access point as character strings. You can send any debug command supported by Cisco Aironet access points that run Cisco IOS software in lightweight mode.

Converted Access Points Send Crash Information to Controller

When a converted access point unexpectedly reboots, the access point stores a crash file on its local flash memory at the time of the crash. After the unit reboots, it sends the reason for the reboot to the controller. If the unit rebooted because of a crash, the controller pulls up the crash file using existing CAPWAP messages and stores it in the controller flash memory. The crash info copy is removed from the access point flash memory when the controller pulls it from the access point.

Converted Access Points Send Radio Core Dumps to Controller

When a radio module in a converted access point generates a core dump, the access point stores the core dump file of the radio on its local flash memory at the time of the radio crash. It sends a notification message to the controller indicating which radio generated a core dump file. The controller sends a trap alerting the network administrator, and the administrator can retrieve the radio core file from the access point.

The retrieved core file is stored in the controller flash and can subsequently be uploaded through TFTP or FTP to an external server for analysis. The core file is removed from the access point flash memory when the controller pulls it from the access point.

Using the CLI to Retrieve Radio Core Dumps

Using the controller CLI, follow these steps to retrieve the radio core dump file.

Step 1 To transfer the radio core dump file from the access point to the controller, enter this command:

config ap crash-file get-radio-core-dump *slot Cisco_AP*

For the *slot* parameter, enter the slot ID of the radio that crashed.

Step 2 To verify that the file was downloaded to the controller, enter this command:

show ap crash-file

Information similar to the following appears:

```
Local Core Files:
lrad_AP1130.rdump0   (156)
```

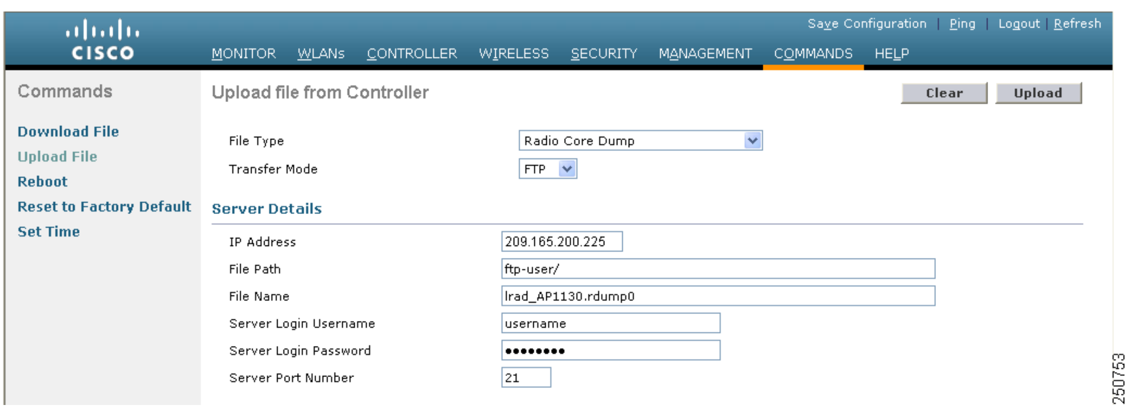
The number in parentheses indicates the size of the file. The size should be greater than zero if a core dump file is available.

Using the GUI to Upload Radio Core Dumps

Using the controller GUI, follow these steps to upload the radio core dump file to a TFTP or FTP server.

Step 1 Choose **Commands** > **Upload File** to open the Upload File from Controller page (see Figure 17).

Figure 17 Upload File from Controller Page



Step 2 From the File Type drop-down box, choose **Radio Core Dump**.

Step 3 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 4 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 5 In the File Path field, enter the directory path of the file.

Step 6 In the File Name field, enter the name of the radio core dump file.

> **Note** The *filename* that you enter should match the filename generated on the controller. You can determine the *filename* on the controller by entering the **show ap crash-file** command.

Step 7 If you chose FTP as the Transfer Mode, follow these steps:

a. In the Server Login Username field, enter the FTP server login name.

b. In the Server Login Password field, enter the FTP server login password.

c. In the Server Port Number field, enter the port number of the FTP server. The default value for the server port is 21.

Step 8 Click **Upload** to upload the radio core dump file from the controller. A message appears indicating the status of the upload.

Using the CLI to Upload Radio Core Dumps

Using the controller CLI, follow these steps to upload the radio core dump file to a TFTP or FTP server.

Step 1 To transfer the file from the controller to a TFTP or FTP server, enter these commands:

- **transfer upload mode** {**tftp** | **ftp**}
- **transfer upload datatype radio-core-dump**
- **transfer upload serverip** *server_ip_address*
- **transfer upload path** *server_path_to_file*
- **transfer upload filename** *filename*

> **Note** The *filename* that you enter should match the filename generated on the controller. You can determine the *filename* on the controller by entering the **show ap crash-file** command.

Step 2 If you are using an FTP server, also enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

> **Note** The default value for the *port* parameter is 21.

Step 3 To view the updated settings, enter this command:

transfer upload start

Step 4 When prompted to confirm the current settings and start the software upload, answer **y**.

Uploading Memory Core Dumps from Converted Access Points

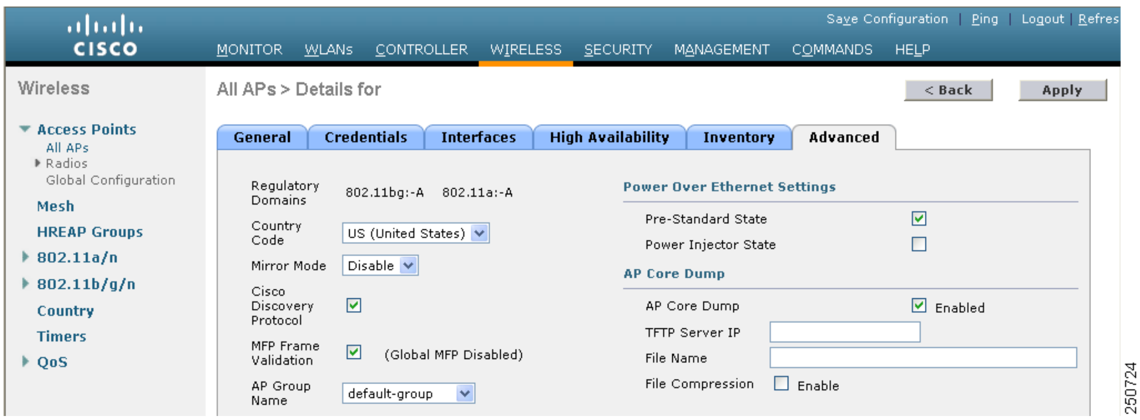
By default, access points converted to lightweight mode do not send memory core dumps to the controller. This section provides instructions to upload access point core dumps using the controller GUI or CLI.

Using the GUI to Upload Access Point Core Dumps

Using the controller GUI, follow these steps to upload a core dump file of the access point.

Step 1 Choose **Wireless** > **Access Points** > **All APs** > *access point name* > the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 18).

Figure 18 All APs > Details for (Advanced) Page



Step 2 To upload a core dump of the access point, check the **AP Core Dump** check box.

Step 3 In the TFTP Server IP field, enter the IP address of the TFTP server.

Step 4 In the File Name field, enter a name of the access point core dump file (such as *dump.log*).

Step 5 To compress the access point core dump file, check the **File Compression** check box. When you enable this option, the file is saved with a .gz extension (such as *dump.log.gz*). This file can be opened with WinZip.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Upload Access Point Core Dumps

Using the controller CLI, follow these steps to upload a core dump file of the access point.

Step 1 To upload a core dump of the access point, enter this command on the controller:

config ap core-dump enable *tftp_server_ip_address filename* {**compress** | **uncompress**} {*ap_name* | **all**}

where

- *tftp_server_ip_address* is the IP address of the TFTP server to which the access point sends core dump files,

  Note The access point must be able to reach the TFTP server.

- *filename* is the name that the access points uses to label the core file,
- **compress** configures the access point to send compressed core files whereas **uncompress** configures the access point to send uncompressed core files, and

  Note When you choose **compress**, the file is saved with a .gz extension (for example, dump.log.gz). This file can be opened with WinZip.

- *ap_name* is the name of a specific access point for which core dumps are uploaded whereas **all** is all access points converted to lightweight mode.

Step 2 To save your changes, enter this command:

save config

Display of MAC Addresses for Converted Access Points

There are some differences in the way that controllers display the MAC addresses of converted access points on information pages in the controller GUI:

- On the AP Summary page, the controller lists the Ethernet MAC addresses of converted access points.
- On the AP Detail page, the controller lists the BSS MAC addresses and Ethernet MAC addresses of converted access points.
- On the Radio Summary page, the controller lists converted access points by radio MAC address.

Disabling the Reset Button on Access Points Converted to Lightweight Mode

You can disable the reset button on access points converted to lightweight mode. The reset button is labeled MODE on the outside of the access point.

Use this command to disable or enable the reset button on one or all converted access points associated to a controller:

config ap reset-button {**enable** | **disable**} {*ap-name* | **all**}

The reset button on converted access points is enabled by default.

Configuring a Static IP Address on a Lightweight Access Point

If you want to specify an IP address for an access point rather than having one assigned automatically by a DHCP server, you can use the controller GUI or CLI to configure a static IP address for the access point. Static IP addresses are generally used only for deployments with a limited number of users.

Note Refer to the "Configuring DHCP" section on page 9 for information on assigning IP addresses using DHCP.

An access point cannot discover the controller using domain name system (DNS) resolution if a static IP address is configured for the access point, unless you specify a DNS server and the domain to which the access point belongs. Previously, these parameters could be configured only using the CLI, but controller software release 6.0 expands this functionality to the GUI.

Note If you configure an access point to use a static IP address that is not on the same subnet on which the access point's previous DHCP address was, the access point falls back to a DHCP address after the access point reboots. If the access point falls back to a DHCP address, the **show ap config general** *Cisco_AP* CLI command correctly shows that the access point is using a fallback IP address. However, the GUI shows both the static IP address and the DHCP address, but it does not identify the DHCP address as a fallback address.

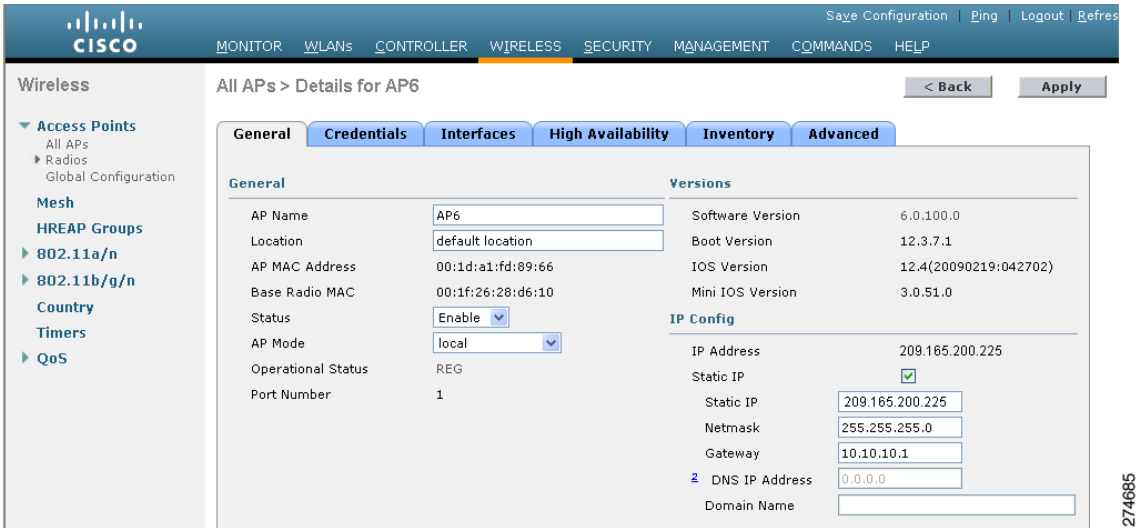
Using the GUI to Configure a Static IP Address

Using the controller GUI, follow these steps to configure a static IP address for a lightweight access point.

Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to configure a static IP address. The All APs > Details for (General) page appears (see Figure 19).

Figure 19 All APs > Details for (General) Page



Step 3 Under IP Config, check the **Static IP** check box if you want to assign a static IP address to this access point. The default value is unchecked.

Step 4 Enter the static IP address, netmask, and default gateway in the corresponding fields.

Step 5 Click **Apply** to commit your changes. The access point reboots and rejoins the controller, and the static IP address that you specified in Step 4 is sent to the access point.

Step 6 After the static IP address has been sent to the access point, you can configure the DNS server IP address and domain name. To do so, follow these steps:

a. In the DNS IP Address field, enter the IP address of the DNS server.

b. In the Domain Name field, enter the name of the domain to which the access point belongs.

c. Click **Apply** to commit your changes.

d. Click **Save Configuration** to save your changes.

Using the CLI to Configure a Static IP Address

Using the controller CLI, follow these steps to configure a static IP address for a lightweight access point.

Step 1 To configure a static IP address on the access point, enter this command:

config ap static-ip enable *Cisco_AP ip_address mask gateway*

Note To disable static IP for the access point, enter this command: **config ap static-ip disable** *Cisco_AP*.

Step 2 To save your changes, enter this command:

save config

The access point reboots and rejoins the controller, and the static IP address that you specified in Step 1 is pushed to the access point.

Step 3 After the static IP address has been sent to the access point, you can configure the DNS server IP address and domain name. To do so, follow these steps:

a. To specify a DNS server so that a specific access point or all access points can discover the controller using DNS resolution, enter this command:

config ap static-ip add nameserver {*Cisco_AP* | **all**} *ip_address*

> **Note** To delete a DNS server for a specific access point or all access points, enter this command: **config ap static-ip delete nameserver** {*Cisco_AP* | **all**}.

b. To specify the domain to which a specific access point or all access points belong, enter this command:

config ap static-ip add domain {*Cisco_AP* | **all**} *domain_name*

> **Note** To delete a domain for a specific access point or all access points, enter this command: **config ap static-ip delete domain** {*Cisco_AP* | **all**}.

c. To save your changes, enter this command:

save config

Step 4 To see the IP address configuration for the access point, enter this command:

show ap config general *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier............................. 4
Cisco AP Name................................. AP6
...
IP Address Configuration........................ Static IP assigned
IP Address...................................... 10.10.10.118
IP NetMask...................................... 255.255.255.0
Gateway IP Addr............................. 10.10.10.1
Domain.......................................... Domain1
Name Server................................. 10.10.10.205
...
```

Supporting Oversized Access Point Images

Controller software release 5.0 or later allows you to upgrade to an oversized access point image by automatically deleting the recovery image to create sufficient space. This feature affects only access points with 8 MB of flash (the 1100, 1200, and 1310 series access points). All newer access points have a larger flash size than 8 MB.

> **Note** As of August 2007, there are no oversized access point images, but as new features are added, the access point image size will continue to grow.

The recovery image provides a backup image that can be used if an access point power-cycles during an image upgrade. The best way to avoid the need for access point recovery is to prevent an access point from power-cycling during a system upgrade. If a power-cycle occurs during an upgrade to an oversized access point image, you can recover the access point using the TFTP recovery procedure.

Follow these steps to perform the TFTP recovery procedure.

Step 1 Download the required recovery image from Cisco.com (c1100-rcvk9w8-mx, c1200-rcvk9w8-mx, or c1310-rcvk9w8-mx) and install it in the root directory of your TFTP server.

Step 2 Connect the TFTP server to the same subnet as the target access point and power-cycle the access point. The access point boots from the TFTP image and then joins the controller to download the oversized access point image and complete the upgrade procedure.

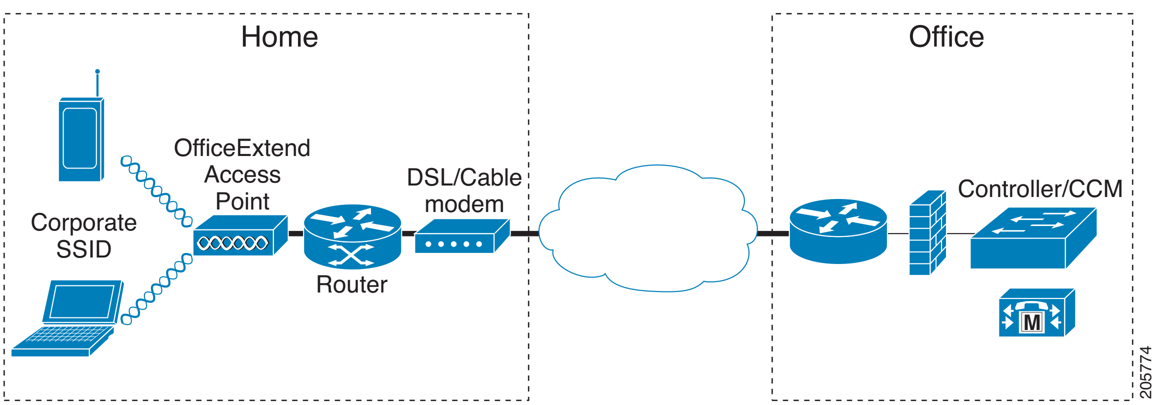
Step 3 After the access point has been recovered, you may remove the TFTP server.

OfficeExtend Access Points

An OfficeExtend access point provides secure communications from a controller to an access point at a remote location, seamlessly extending the corporate WLAN over the Internet to an employee's residence. The teleworker's experience at the home office is exactly the same as it would be at the corporate office. Datagram Transport Layer Security (DTLS) encryption between the access point and the controller ensures that all communications have the highest level of security.

Figure 20 illustrates a typical OfficeExtend access point setup.

Figure 20 Typical OfficeExtend Access Point Setup



Note OfficeExtend access points are designed to work behind a router or other gateway device that is using network address translation (NAT). NAT allows a device, such as a router, to act as an agent between the Internet (public) and a personal network (private), thereby enabling an entire group of computers to be represented by a single IP address. In controller software release 6.0, only one OfficeExtend access point can be deployed behind a single NAT device.

Currently, only Cisco Aironet 1130 series and 1140 series access points that are joined to a Cisco 5500 series controller with a wplus license can be configured to operate as OfficeExtend access points.

Note Your firewall must be configured to allow traffic from access points using CAPWAP. Make sure that UDP ports 5246 and 5247 are enabled and are not blocked by an intermediate device that could prevent an access point from joining the controller.

Implementing Security

Follow these steps to ensure that only valid OfficeExtend access points join the company network.

Step 1 To use local significant certificates (LSCs) to authorize your OfficeExtend access points, follow the instructions in the "Authorizing Access Points Using LSCs" section on page 29.

Note Configuring LSC is optional.

Step 2 To implement AAA server validation using the access point's MAC address, name, or both as the username in authorization requests, enter this command:

config auth-list ap-policy authorize-ap username {*ap_mac* | *Cisco_AP* | **both**}

Using the access point name for validation can ensure that only the OfficeExtend access points of valid employees can join the controller. To implement this security policy, make sure to name each OfficeExtend access point with an employee ID or employee number. When an employee is terminated, you can then run a script to remove this user from the AAA server database, thereby preventing that employee's OfficeExtend access point from joining the network.

Step 3 To save your changes, enter this command:

save config

Licensing for an OfficeExtend Access Point

In order to use OfficeExtend access points, a wplus license must be installed and in use on the 5500 series controller. After the license is installed, you can enable the OfficeExtend mode on an 1130 series or 1140 series access point.

If an OfficeExtend access point attempts to join a controller that is using only a base license (and not the wplus license), the following message appears in the controller trap log: "License Not Available for feature: OfficeExtendAP." To view the controller trap log, choose **Monitor** and click **View All** under "Most Recent Traps" on the controller GUI.

Note Refer to the *Configuring Controller Settings* chapter for information on obtaining and installing licenses.

Configuring OfficeExtend Access Points

After the 1130 series or 1140 series access point has joined the controller, you can configure it as an OfficeExtend access point using the controller GUI or CLI.

Using the GUI to Configure OfficeExtend Access Points

Using the controller GUI, follow these steps to configure an OfficeExtend access point.

Step 1 Follow these steps to enable hybrid REAP on the access point:

a. Choose **Wireless** to open the All APs page.

b. Click the name of the desired access point. The All APs > Details for (General) page appears.

c. Choose **H-REAP** from the AP Mode drop-down box to enable hybrid REAP for this access point.

Step 2 Follow these steps to configure one or more controllers for the access point:

a. Choose the **High Availability** tab to open the All APs > Details for (High Availability) page.

b. Enter the name and IP address of the primary controller for this access point in the Primary Controller Name and Management IP Address fields.

Note You must enter both the name and IP address of the controller. Otherwise, the access point cannot join this controller.

c. If desired, enter the name and IP address of a secondary or tertiary controller (or both) in the corresponding Controller Name and Management IP Address fields.

d. Click **Apply** to commit your changes. The access point reboots and then rejoins the controller.

Note OfficeExtend access points do not use the generic broadcast or over-the air (OTAP) discovery process to locate a controller. You must configure one or more controllers because OfficeExtend access points try to connect only to their configured controllers.

Note The names and IP addresses must be unique for the primary, secondary, and tertiary controllers.

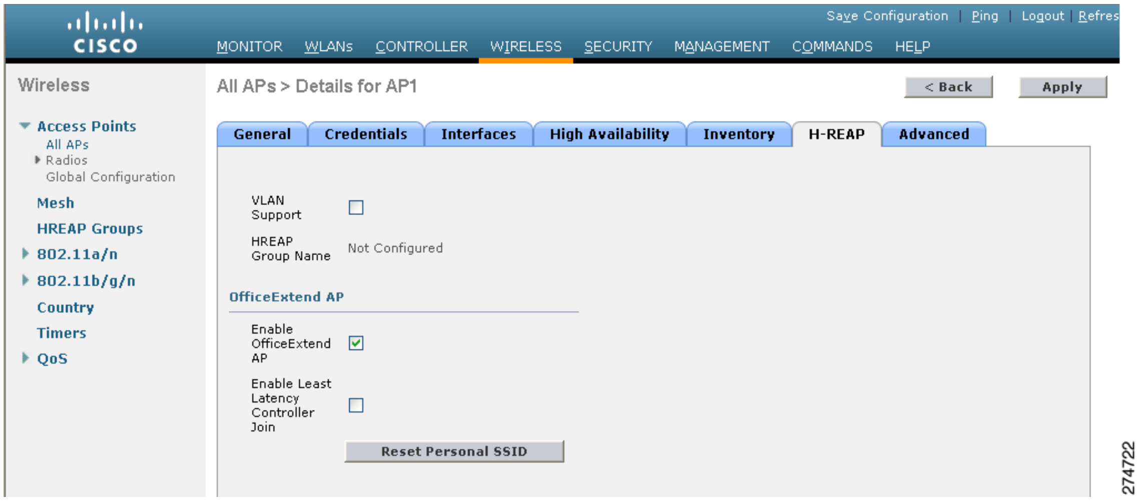
Note Make sure that you configure only 5500 series controllers with a wplus license. If you configure a non-5500 series controller or a 5500 series controller without a wplus license, the OfficeExtend access point cannot join the controller.

Step 3 Follow these steps to enable OfficeExtend access point settings:

a. Re-click the access point name on the All APs page.

b. Choose the **H-REAP** tab to open the All APs > Details for (H-REAP) page (see Figure 21).

Figure 21 All APs > Details for (H-REAP) Page



c. Check the **Enable OfficeExtend AP** check box to enable the OfficeExtend mode for this access point. The default value is checked.

Unchecking this check box simply disables OfficeExtend mode for this access point. It does not undo all of the configuration settings on the access point. If you want to clear the access point's configuration and return it to factory default settings, enter **clear ap config** *Cisco_AP* on the controller CLI. If you want to clear only the access point's personal SSID, click **Reset Personal SSID**.

Note Rogue detection is disabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable rogue detection for a specific access point by checking the **Rogue Detection** check box on the All APs > Details for (Advanced) page. Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect a large number of rogue devices. Refer to the "Managing Rogue Devices" section on page 84 for more information on rogue detection.

Note DTLS data encryption is enabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable DTLS data encryption for a specific access point by checking the **Data Encryption** check box on the All APs > Details for (Advanced) page. Refer to the "Configuring Data Encryption" section on page 4 for more information on DTLS data encryption.

Note Telnet and SSH access are disabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable Telnet or SSH access for a specific access point by checking the Telnet or SSH check box on the All APs > Details for (Advanced) page. Refer to the "Troubleshooting Access Points Using Telnet or SSH" section on page 50 for more information on Telnet and SSH.

> **Note** Link latency is enabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable link latency for a specific access point by checking the **Enable Link Latency** check box on the All APs > Details for (Advanced) page. Refer to the "Configuring Link Latency" section on page 94 for more information on this feature.

d. Check the **Enable Least Latency Controller Join** check box if you want the access point to choose the controller with the least latency when joining. Otherwise, leave this check box unchecked, which is the default value. When you enable this feature, the access point calculates the time between discovery request and discovery response and joins the 5500 series controller that responds first.

e. Click **Apply** to commit your changes.

The OfficeExtend AP field on the All APs page shows which access points are configured as OfficeExtend access points.

Step 4 Follow these steps if you want to configure a specific username and password for the OfficeExtend access point. The teleworker can use these credentials to log into the GUI of the OfficeExtend access point.

a. Re-click the access point name on the All APs page.

b. Choose the **Credentials** tab to open the All APs > Details for (Credentials) page.

c. Check the **Over-ride Global Credentials** check box to prevent this access point from inheriting the global username, password, and enable password from the controller. The default value is unchecked.

d. In the Username, Password, and Enable Password fields, enter the unique username, password, and enable password that you want to assign to this access point.

> **Note** The information that you enter is retained across controller and access point reboots and if the access point joins a new controller.

e. Click **Apply** to commit your changes.

f. Click **Save Configuration** to save your changes.

> **Note** If you ever want to force this access point to use the controller's global credentials, simply uncheck the **Over-ride Global Credentials** check box.

Step 5 If your controller supports only OfficeExtend access points, refer to the "Configuring RRM" section on page 10 for instructions on setting the recommended values for DCA interval, channel scan duration, and neighbor packet frequency.

Using the CLI to Configure OfficeExtend Access Points

Using the controller CLI, follow these steps to configure an OfficeExtend access point.

Step 1 To enable hybrid-REAP on the access point, enter this command:

config ap mode h-reap *Cisco_AP*

Step 2 To configure one or more controllers for the access point, enter one or all of these commands:

config ap primary-base *controller_name Cisco_AP controller_ip_address*

config ap secondary-base *controller_name Cisco_AP controller_ip_address*

config ap tertiary-base *controller_name Cisco_AP controller_ip_address*

Note You must enter both the name and IP address of the controller. Otherwise, the access point cannot join this controller.

Note OfficeExtend access points do not use the generic broadcast or over-the air (OTAP) discovery process to find a controller. You must configure one or more controllers because OfficeExtend access points try to connect only to their configured controllers.

Note The names and IP addresses must be unique for the primary, secondary, and tertiary controllers.

Note Make sure that you configure only 5500 series controllers with a wplus license. If you configure a non-5500 series controller or a 5500 series controller without a wplus license, the OfficeExtend access point cannot join the controller.

Step 3 To enable the OfficeExtend mode for this access point, enter this command:

config hreap office-extend {**enable** | **disable**} *Cisco_AP*

The default value is enabled. The **disable** parameter simply disables OfficeExtend mode for this access point. It does not undo all of the configuration settings on the access point. If you want to clear the access point's configuration and return it to factory default settings, enter this command:

clear ap config *Cisco_AP*

If you want to clear only the access point's personal SSID, enter this command:

config hreap office-extend clear-personalssid-config *Cisco_AP*.

Note Rogue detection is disabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable rogue detection for a specific access point or for all access points using this command: **config rogue detection** {**enable** | **disable**} {*Cisco_AP* | **all**}. Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect a large number of rogue devices. Refer to the "Managing Rogue Devices" section on page 84 for more information on rogue detection.

Note DTLS data encryption is enabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable DTLS data encryption for a specific access point or for all access points using this command: **config ap link-encryption** {**enable** | **disable**} {*Cisco_AP* | **all**}. Refer to the "Configuring Data Encryption" section on page 4 for more information on DTLS data encryption.

Note Telnet and SSH access are disabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable Telnet or SSH access for a specific access point using this command: **config ap** {**telnet** | **ssh**} {**enable** | **disable**} *Cisco_AP*. Refer to the "Troubleshooting Access Points Using Telnet or SSH" section on page 50 for more information on Telnet and SSH.

Note Link latency is enabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable link latency for a specific access point or for all access points currently associated to the controller using this command: **config ap link-latency** {**enable** | **disable**} {*Cisco_AP* | **all**}. Refer to the "Configuring Link Latency" section on page 94 for more information on this feature.

Step 4 To enable the access point to choose the controller with the least latency when joining, enter this command:

config hreap join min-latency {**enable** | **disable**} *Cisco_AP*

The default value is disabled. When you enable this feature, the access point calculates the time between discovery request and discovery response and joins the 5500 series controller that responds first.

Step 5 To configure a specific username and password that teleworkers can enter to log into the GUI of the OfficeExtend access point, enter this command:

config ap mgmtuser add username *user* **password** *password* **enablesecret** *enable_password Cisco_AP*

The credentials that you enter in this command are retained across controller and access point reboots and if the access point joins a new controller.

Note If you ever want to force this access point to use the controller's global credentials, enter this command: **config ap mgmtuser delete** *Cisco_AP*. The following message appears after you execute this command: "AP reverted to global username configuration."

Step 6 To save your changes, enter this command:

save config

Step 7 If your controller supports only OfficeExtend access points, refer to the "Configuring RRM" section on page 10 for instructions on setting the recommended value for the DCA interval.

Configuring a Personal SSID on an OfficeExtend Access Point

Instruct teleworkers to follow these steps to log into the GUI of their OfficeExtend access point and configure a personal SSID.

Step 1 Find the IP address of your OfficeExtend access point by doing one of the following:

- Log into your home router and look for the IP address of your OfficeExtend access point.
- Ask your company's IT professional for the IP address of your OfficeExtend access point.
- Use an application such as Network Magic (a Linksys product) to detect devices on your network and their IP addresses.

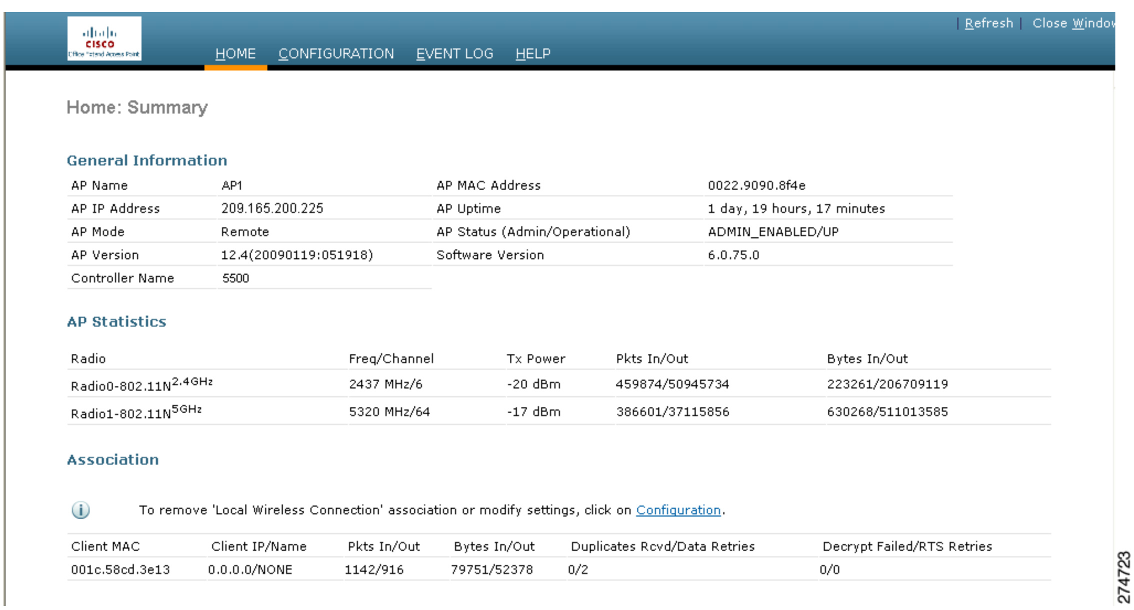
Step 2 With the OfficeExtend access point connected to your home router, enter the IP address of the OfficeExtend access point in the Address field of your Internet browser and click **Go**.

Note Make sure you are not connected to your company's network using a virtual private network (VPN) connection.

Step 3 When prompted, enter the username and password to log into the access point.

Step 4 On the OfficeExtend Access Point Welcome page, click **Enter**. The OfficeExtend Access Point Home page appears (see Figure 22).

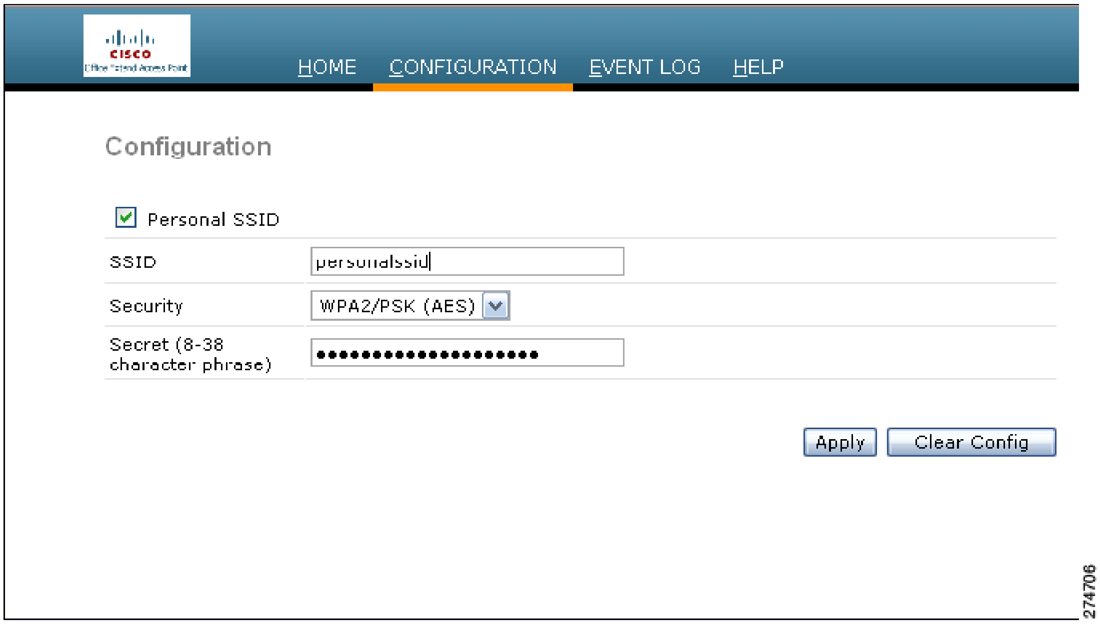
Figure 22 ***OfficeExtend Access Point Home Page***



This page shows the access point name, IP address, MAC address, software version, status, channel, transmit power, and client traffic.

Step 5 Choose **Configuration** to open the Configuration page (see Figure 23).

Figure 23 OfficeExtend Access Point Configuration Page



Step 6 Check the **Personal SSID** check box to enable this wireless connection. The default value is disabled.

Step 7 In the SSID field, enter the personal SSID that you want to assign to this access point. This SSID will be locally switched.

Note A controller with an OfficeExtend access point publishes only up to 15 WLANs to each connected access point because it reserves one WLAN for the personal SSID.

Step 8 From the Security drop-down box, choose **Open**, **WPA2/PSK (AES)**, or **104 bit WEP** to set the security type to be used by this access point.

Note If you choose WPA2/PSK (AES), make sure that the client is configured for WPA2/PSK and AES encryption.

Step 9 If you chose WPA2/PSK (AES) in Step 8, enter an 8- to 38-character WPA2 passphrase in the Secret field. If you chose 104 bit WEP, enter a 13-character ASCII key in the Key field.

Step 10 Click **Apply** to commit your changes.

Note If you ever want to use the OfficeExtend access point for another application, you can clear this configuration and return the access point to factory default settings by clicking **Clear Config**. You can also clear the access point's configuration from the controller CLI by entering this command: **clear ap config** *Cisco_AP*.

Viewing OfficeExtend Access Point Statistics

Use these controller CLI commands to view information about the OfficeExtend access points on your network.

- To see a list of all OfficeExtend access points, enter this command:

  show hreap office-extend summary

  Information similar to the following appears:

```
Summary of OfficeExtend AP
AP Name      Ethernet MAC       Encryption  Join-Mode   Join-Time
----------- ------------------ ----------- ----------- ----------------------------
AP1130      00:22:90:e3:37:70   Enabled    Latency    Sun Jan  4 21:46:07 2009
AP1140      01:40:91:b5:31:70   Enabled    Latency    Sat Jan  3 19:30:25 2009
```

- To see the link delay for OfficeExtend access points, enter this command:

  show hreap office-extend latency

  Information similar to the following appears:

```
Summary of OfficeExtend AP link latency
AP Name   Status       Current   Maximum   Minimum
--------- ----------- ---------- --------- ---------
AP1130     Enabled     15 ms      45 ms     12 ms
AP1140     Enabled    14 ms    179 ms     12 ms
```

- To see the encryption state of all access points or a specific access point, enter this command:

  show ap link-encryption {**all** | *Cisco_AP*}

  Information similar to the following appears:

```
               Encryption  Dnstream  Upstream Last
AP Name        State       Count     Count    Update
--------------  ---------- --------  --------  --------
AP1130         En          112       1303      23:49
AP1140         En          232      2146       23:49
            auth err: 198 replay err: 0
AP1250         En          0        0          Never
AP1240         En          6191    15011       22:13
```

  This command also shows authentication errors, which track the number of integrity check failures, and replay errors, which track the number of times that the access point receives the same packet.

- To see the data plane status for all access points or a specific access point, enter this command:

  show ap data-plane {**all** | *Cisco_AP*}

  Information similar to the following appears:

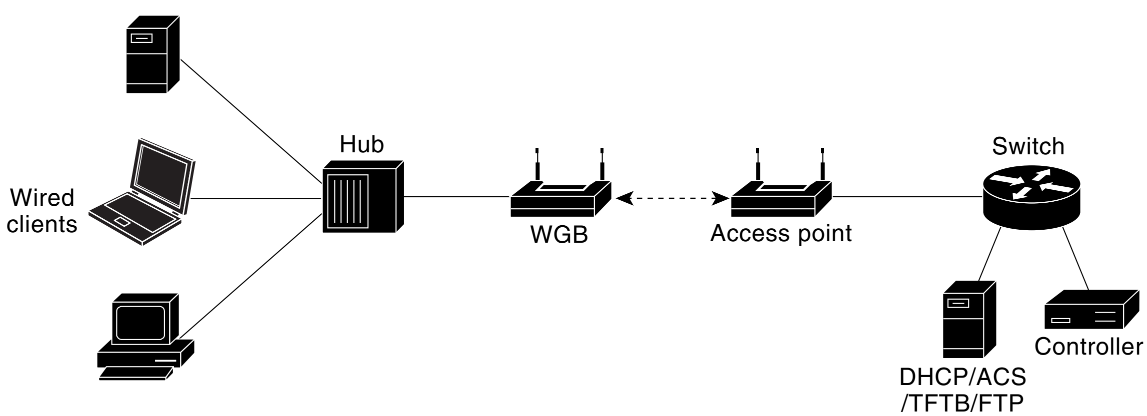
```
                   Min Data         Data            Max Data    Last
AP Name            Round Trip       Round Trip      Round Trip     Update
----------------  --------------  --------------  -------------- ---------
AP1130              0.012s        0.014s          0.020s      13:46:23
AP1140              0.012s        0.017s          0.111s      13:46:46
```

- To see the join statistics for the OfficeExtend access points, refer to the "Using the CLI to View Access Point Join Information" section on page 41.

Cisco Workgroup Bridges

A workgroup bridge (WGB) is a mode that can be configured on an autonomous IOS access point to provide wireless connectivity to a lightweight access point on behalf of clients that are connected by Ethernet to the WGB access point. A WGB connects a wired network over a single wireless segment by learning the MAC addresses of its wired clients on the Ethernet interface and reporting them to the lightweight access point using Internet Access Point Protocol (IAPP) messaging. The WGB provides wireless access connectivity to wired clients by establishing a single wireless connection to the lightweight access point. The lightweight access point treats the WGB as a wireless client. See the example in Figure 24.

Figure 24 WGB Example



Note If the lightweight access point fails, the WGB attempts to associate to another access point.

Guidelines for Using WGBs

Follow these guidelines for using WGBs on your network:

- The WGB can be any autonomous access point that supports the workgroup bridge mode and is running Cisco IOS Release 12.4(3g)JA or later (on 32-MB access points) or Cisco IOS Release 12.3(8)JEB or later (on 16-MB access points). These access points include the AP1120, AP1121, AP1130, AP1140, AP1231, AP1240, AP1250, and AP1310. Cisco IOS Releases prior to 12.4(3g)JA and 12.3(8)JEB are not supported.

  Note If your access point has two radios, you can configure only one for workgroup bridge mode. This radio is used to connect to the lightweight access point. Cisco recommends that you disable the second radio.

  Note The controller supports only Cisco WGB products. Linksys and OEM WGB devices are not supported. Although the Cisco Wireless Unified Solution does not support the Linksys WET54G and WET11B Ethernet Bridges, you can use these devices in a Wireless Unified Solution configuration if you follow these guidelines:
  1. Connect only one device to the WET54G or WET11B.
  2. Enable the MAC cloning feature on the WET54G or WET11B to clone the connected device.
  3. Install the latest drivers and firmware on devices connected to the WET54G or WET11B. This guideline is especially important for JetDirect printers because early firmware versions might cause problems with DHCP.
  Note: Because these devices are not supported in the Cisco Wireless Unified Solution, Cisco Technical Support cannot help you troubleshoot any problems associated with them.

  Perform one of the following to enable the workgroup bridge mode on the WGB:
  - On the WGB access point GUI, choose **Workgroup Bridge** for the role in radio network on the Settings > Network Interfaces page.
  - On the WGB access point CLI, enter this command: **station-role workgroup-bridge**

  Note See the sample WGB access point configuration in the "Sample WGB Configuration" section on page 64.

- The WGB can associate only to lightweight access points.
- Only WGBs in client mode (which is the default value) are supported. Those in infrastructure mode are not supported. Perform one of the following to enable client mode on the WGB:
  - On the WGB access point GUI, choose **Disabled** for the Reliable Multicast to WGB parameter.
  - On the WGB access point CLI, enter this command: **no infrastructure client**.

  Note VLANs are not supported for use with WGBs.

  Note See the sample WGB access point configuration in the "Sample WGB Configuration" section on page 64.

- These features are supported for use with a WGB:
  - Guest N+1 redundancy

  - Local EAP
  - Open, WEP 40, WEP 128, CKIP, WPA+TKIP, WPA2+AES, LEAP, EAP-FAST, and EAP-TLS authentication modes
- These features are not supported for use with a WGB:
  - Cisco Centralized Key Management (CCKM)
  - Hybrid REAP
  - Idle timeout
  - Web authentication

Note If a WGB associates to a web-authentication WLAN, the WGB is added to the exclusion list, and all of the WGB wired clients are deleted.

- The WGB supports a maximum of 20 wired clients. If you have more than 20 wired clients, use a bridge or another device.
- Wired clients connected to the WGB are not authenticated for security. Instead, the WGB is authenticated against the access point to which it associates. Therefore, Cisco recommends that you physically secure the wired side of the WGB.
- With Layer 3 roaming, if you plug a wired client into the WGB network after the WGB has roamed to another controller (for example, to a foreign controller), the wired client's IP address displays only on the anchor controller, not on the foreign controller.
- If a wired client does not send traffic for an extended period of time, the WGB removes the client from its bridge table, even if traffic is continuously being sent to the wired client. As a result, the traffic flow to the wired client fails. To avoid the traffic loss, prevent the wired client from being removed from the bridge table by configuring the aging-out timer on the WGB to a large value using the following IOS commands on the WGB:

```
configure terminal
bridge bridge-group-number aging-time seconds
exit
end
```

  where *bridge-group-number* is a value between 1 and 255, and *seconds* is a value between 10 and 1,000,000 seconds. Cisco recommends configuring the *seconds* parameter to a value greater than the wired client's idle period.
- When you delete a WGB record from the controller, all of the WGB wired clients' records are also deleted.
- Wired clients connected to a WGB inherit the WGB's QoS and AAA override attributes.

- These features are not supported for wired clients connected to a WGB:
  - MAC filtering
  - Link tests
  - Idle timeout
- To enable the WGB to communicate with the lightweight access point, create a WLAN and make sure that Aironet IE is enabled.

Sample WGB Configuration

Here is a sample configuration of a WGB access point using static WEP with a 40-bit WEP key:

```
ap#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
ap(config)#dot11 ssid WGB_with_static_WEP
ap(config-ssid)#authentication open
ap(config-ssid)#guest-mode
ap(config-ssid)#exit
ap(config)#interface  dot11Radio 0
ap(config)#station-role workgroup-bridge
ap(config-if)#encry mode wep 40
ap(config-if)#encry key 1 size 40 0 1234567890
ap(config-if)#ssid WGB_with_static_WEP
ap(config-if)#end
```

To verify that the WGB is associated to an access point, enter this command on the WGB:

show dot11 association

Information similar to the following appears:

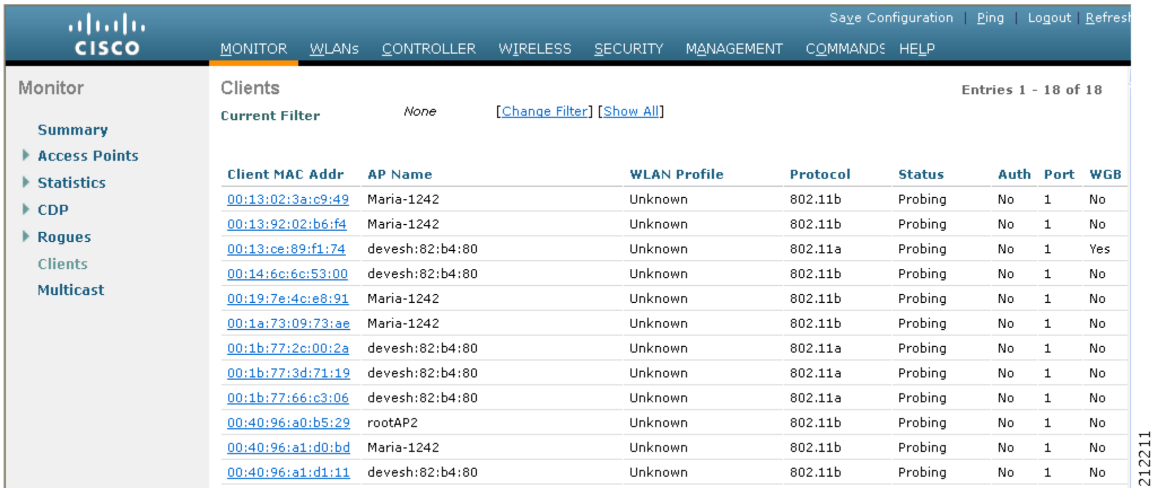
```
ap#show dot11 associations
802.11 Client Stations on Dot11Radio0:
SSID [FCVTESTING] :
MAC Address    IP address      Device        Name            Parent         State
000b.8581.6aee 10.11.12.1      WGB-client    map1            -              Assoc
ap#
```

Using the GUI to View the Status of Workgroup Bridges

Follow these steps to view the status of WGBs on your network using the controller GUI.

Step 1 Choose **Monitor** > **Clients** to open the Clients page (see Figure 25).

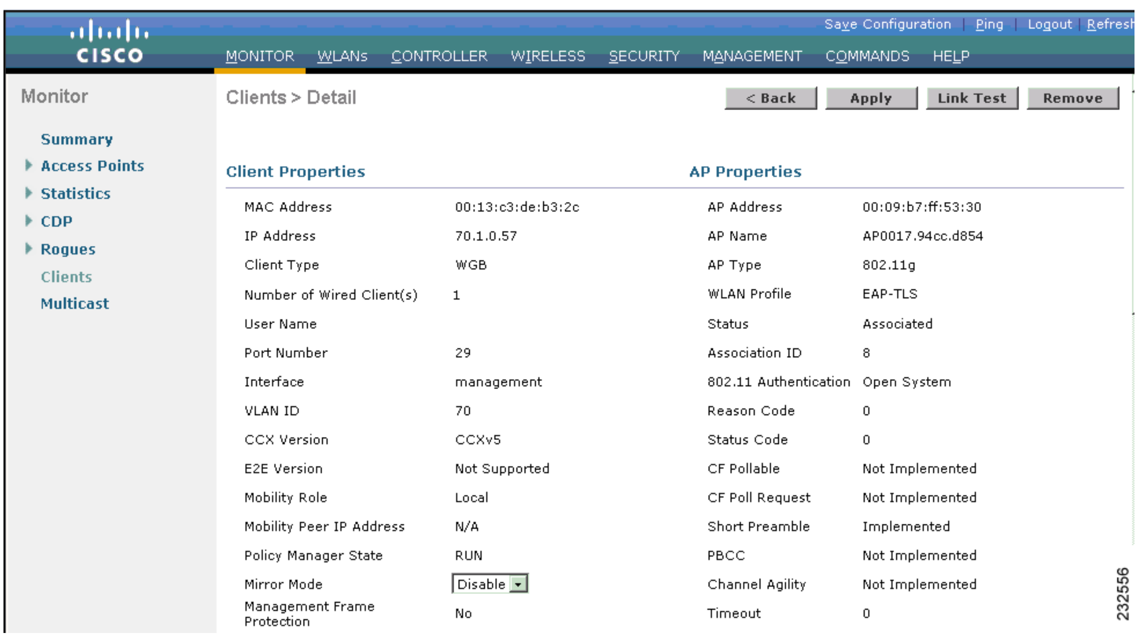
Figure 25 Clients Page



The WGB field on the right side of the page indicates whether any of the clients on your network are workgroup bridges.

Step 2 Click the MAC address of the desired client. The Clients > Detail page appears (see Figure 26).

Figure 26 Clients > Detail Page



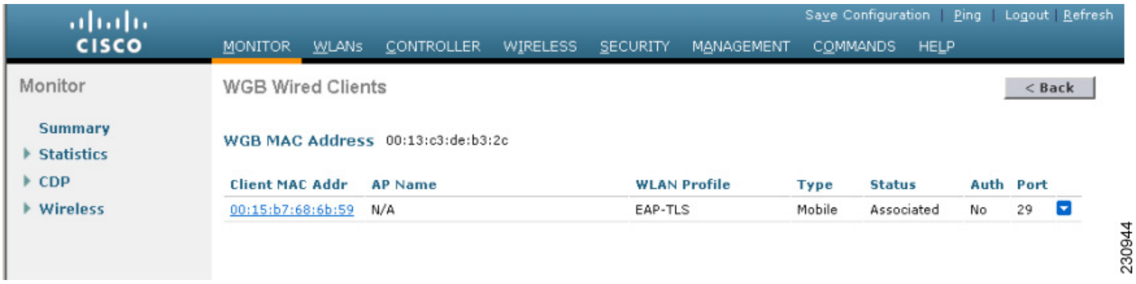
The Client Type field under Client Properties shows "WGB" if this client is a workgroup bridge, and the Number of Wired Client(s) field shows the number of wired clients that are connected to this WGB.

Step 3 To see the details of any wired clients that are connected to a particular WGB, follow these steps:

a. Click **Back** on the Clients > Detail page to return to the Clients page.

b. Hover your cursor over the blue drop-down arrow for the desired WGB and choose **Show Wired Clients**. The WGB Wired Clients page appears (see Figure 27).

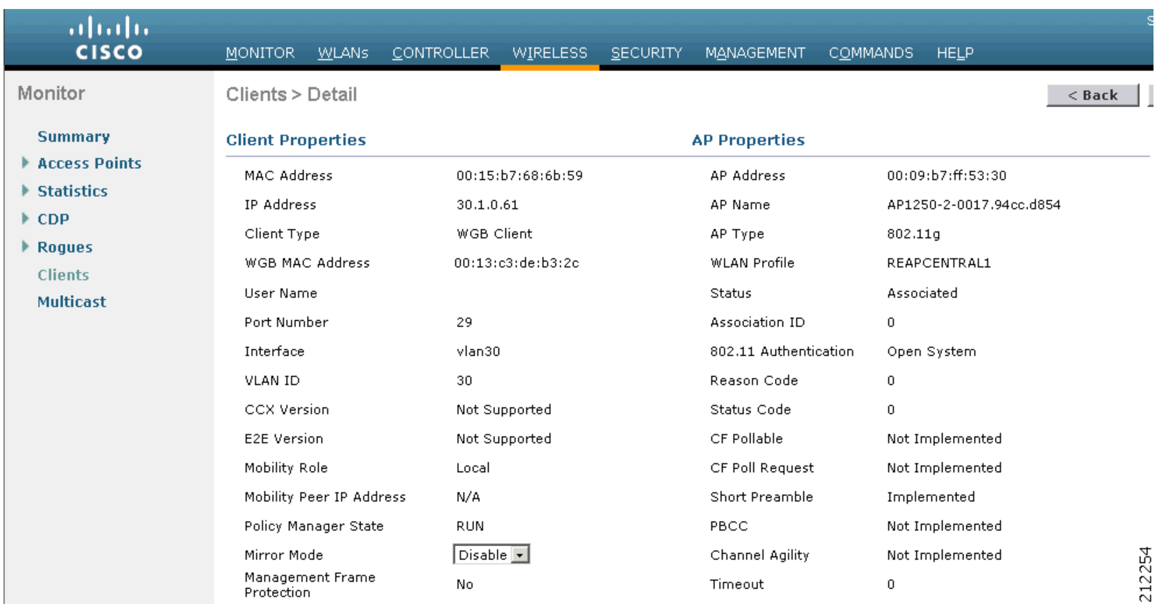
Figure 27 WGB Wired Clients Page



Note If you ever want to disable or remove a particular client, hover your cursor over the blue drop-down arrow for the desired client and choose **Remove** or **Disable**, respectively.

c. Click the MAC address of the desired client to see more details for this particular client. The Clients > Detail page appears (see Figure 28).

Figure 28 Clients > Detail Page



The Client Type field under Client Properties shows “WGB Client,” and the rest of the fields on this page provide additional information for this client.

Using the CLI to View the Status of Workgroup Bridges

Follow these steps to view the status of WGBs on your network using the controller CLI.

Step 1 To see any WGBs on your network, enter this command:

show wgb summary

Information similar to the following appears:

```
Number of WGBs.................................. 1

MAC Address        IP Address AP Name  Status  WLAN  Auth  Protocol  Clients
----------------- ----------  -------- ------  ----  ----- --------- --------
00:0d:ed:dd:25:82  10.24.8.73      a1   Assoc   3     Yes   802.11b   1
```

Step 2 To see the details of any wired clients that are connected to a particular WGB, enter this command:

show wgb detail *wgb_mac_address*

Information similar to the following appears:

```
Number of wired client(s): 1

MAC Address         IP Address AP Name  Mobility   WLAN   Auth
------------------- ---------- -------- ---------  ----- -----
00:0d:60:fc:d5:0b   10.24.8.75   a1      Local      3     Yes
```

Using the CLI to Debug WGB Issues

Use the commands in this section if you experience any problems with the WGB.

1. To enable debugging for IAPP messages, errors, and packets, enter these commands:
   - **debug iapp all enable**—Enables debugging for IAPP messages.
   - **debug iapp error enable**—Enables debugging for IAPP error events.
   - **debug iapp packet enable**—Enables debugging for IAPP packets.
2. If you experience a roaming issue, enter this command:

   debug mobility handoff enable
3. If you experience an IP assignment issue and DHCP is used, enter these commands:
   - **debug dhcp message enable**
   - **debug dhcp packet enable**
4. If you experience an IP assignment issue and static IP is used, enter these commands:
   - **debug dot11 mobile enable**
   - **debug dot11 state enable**

Configuring Backup Controllers

A single controller at a centralized location can act as a backup for access points when they lose connectivity with the primary controller in the local region. Centralized and regional controllers need not be in the same mobility group. In controller software release 4.2 or later, you can specify a primary, secondary, and tertiary controller for specific access points in your network. Using the controller GUI or CLI, you can specify the IP addresses of the backup controllers, which allows the access points to fail over to controllers outside of the mobility group.

In controller software release 5.0 or later, you can also configure primary and secondary backup controllers (which are used if primary, secondary, or tertiary controllers are not specified or are not responsive) for all access points connected to the controller as well as various timers, including heartbeat timers and discovery request timers. To reduce the controller failure detection time, you can configure the fast heartbeat interval (between the controller and the access point) with a smaller timeout value. When the fast heartbeat timer expires (at every heartbeat interval), the access point determines if any data packets have been received from the controller within the last interval. If no packets have been received, the access point sends a fast echo request to the controller.

Note You can configure the fast heartbeat timer only for access points in local and hybrid-REAP modes.

The access point maintains a list of backup controllers and periodically sends primary discovery requests to each entry on the list. When the access point receives a new discovery response from a controller, the backup controller list is updated. Any controller that fails to respond to two consecutive primary discovery requests is removed from the list. If the access point's local controller fails, it chooses an available controller from the backup controller list in this order: primary, secondary, tertiary, primary backup, secondary backup. The access point waits for a discovery response from the first available controller in the backup list and joins the controller if it receives a response within the time configured for the primary discovery request timer. If the time limit is reached, the access point assumes that the controller cannot be joined and waits for a discovery response from the next available controller in the list.

Note When an access point's primary controller comes back online, the access point disassociates from the backup controller and reconnects to its primary controller. The access point falls back to its primary controller and not to any secondary controller for which it is configured. For example, if an access point is configured with primary, secondary, and tertiary controllers, it fails over to the tertiary controller when the primary and secondary controllers become unresponsive and waits for the primary controller to come back online so that it can fall back to the primary controller. The access point does not fall back from the tertiary controller to the secondary controller if the secondary controller comes back online; it stays connected to the tertiary controller until the primary controller comes back up.

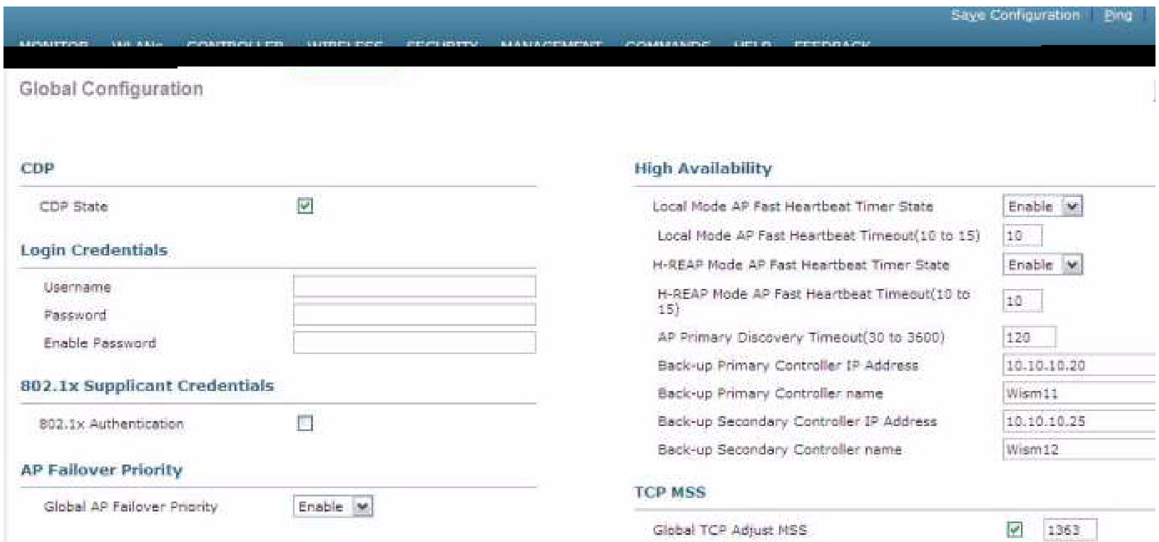
Note If you inadvertently configure a controller that is running software release 5.2 or later with a failover controller that is running a different software release (such as 4.2, 5.0, or 5.1), the access point might take a long time to join the failover controller because the access point starts the discovery process in CAPWAP and then changes to LWAPP discovery.

Using the GUI to Configure Backup Controllers

Using the controller GUI, follow these steps to configure primary, secondary, and tertiary controllers for a specific access point and to configure primary and secondary backup controllers for all access points.

Step 1 Choose **Wireless** > **Access Points** > **Global Configuration** to open the Global Configuration page (see Figure 29).

Figure 29 Global Configuration Page



Step 2 From the Local Mode AP Fast Heartbeat Timer State drop-down box, choose **Enable** to enable the fast heartbeat timer for access points in local mode or **Disable** to disable this timer. The default value is Disable.

Step 3 If you chose Enable in Step 2, enter a number between 10 and 15 seconds (inclusive) in the Local Mode AP Fast Heartbeat Timeout field to configure the fast heartbeat timer for access points in local mode. Specifying a small heartbeat interval reduces the amount of time it takes to detect a controller failure. The default value is 0 seconds, which disables the timer.

Step 4 From the H-REAP Mode AP Fast Heartbeat Timer State drop-down box, choose **Enable** to enable the fast heartbeat timer for hybrid-REAP access points or **Disable** to disable this timer. The default value is Disable.

Step 5 If you chose Enable in Step 4, enter a value between 10 and 15 seconds (inclusive) in the H-REAP Mode AP Fast Heartbeat Timeout field to configure the fast heartbeat timer for hybrid-REAP access points. Specifying a small heartbeat interval reduces the amount of time it takes to detect a controller failure. The default value is 0 seconds, which disables the timer.

Step 6 In the AP Primary Discovery Timeout field, a value between 30 and 3600 seconds (inclusive) to configure the access point primary discovery request timer. The default value is 120 seconds.

Step 7 If you want to specify a primary backup controller for all access points, enter the IP address of the primary backup controller in the Back-up Primary Controller IP Address field and the name of the controller in the Back-up Primary Controller Name field.

Note The default value for the IP address is 0.0.0.0, which disables the primary backup controller.

Step 8 If you want to specify a secondary backup controller for all access points, enter the IP address of the secondary backup controller in the Back-up Secondary Controller IP Address field and the name of the controller in the Back-up Secondary Controller Name field.

Note The default value for the IP address is 0.0.0.0, which disables the secondary backup controller.

Step 9 Click **Apply** to commit your changes.

Step 10 If you want to configure primary, secondary, and tertiary backup controllers for a specific access point, follow these steps:

a. Choose **Access Points** > **All APs** to open the All APs page.

b. Click the name of the access point for which you want to configure primary, secondary, and tertiary backup controllers.

c. Choose the **High Availability** tab to open the All APs > Details for (High Availability) page (see Figure 30).

Figure 30 All APs > Details for (High Availability) Page

d. If desired, enter the name and IP address of the primary backup controller for this access point in the Primary Controller fields.

Note Entering an IP address for the backup controller is optional in this step and the next two steps. If the backup controller is outside the mobility group to which the access point is connected (the primary controller), then you need to provide the IP address of the primary, secondary, or tertiary controller, respectively. The controller name and IP address must belong to the same primary, secondary, or tertiary controller. Otherwise, the access point cannot join the backup controller.

e. If desired, enter the name and IP address of the secondary backup controller for this access point in the Secondary Controller fields.

f. If desired, enter the name and IP address of the tertiary backup controller for this access point in the Tertiary Controller fields.

g. Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Configure Backup Controllers

Using the controller CLI, follow these steps to configure primary, secondary, and tertiary controllers for a specific access point and to configure primary and secondary backup controllers for all access points.

Step 1 To configure a primary controller for a specific access point, enter this command:

config ap primary-base *controller_name Cisco_AP* [*controller_ip_address*]

Note The *controller_ip_address* parameter in this command and the next two commands is optional. If the backup controller is outside the mobility group to which the access point is connected (the primary controller), then you need to provide the IP address of the primary, secondary, or tertiary controller, respectively. In each command, the *controller_name* and *controller_ip_address* must belong to the same primary, secondary, or tertiary controller. Otherwise, the access point cannot join the backup controller.

Step 2 To configure a secondary controller for a specific access point, enter this command:

config ap secondary-base *controller_name Cisco_AP* [*controller_ip_address*]

Step 3 To configure a tertiary controller for a specific access point, enter this command:

config ap tertiary-base *controller_name Cisco_AP* [*controller_ip_address*]

Step 4 To configure a primary backup controller for all access points, enter this command:

config advanced backup-controller primary *backup_controller_name backup_controller_ip_address*

Step 5 To configure a secondary backup controller for all access points, enter this command:

config advanced backup-controller secondary *backup_controller_name backup_controller_ip_address*

Note To delete a primary or secondary backup controller entry, enter 0.0.0.0 for the controller IP address.

Step 6 To enable or disable the fast heartbeat timer for local or hybrid-REAP access points, enter this command:

config advanced timers ap-fast-heartbeat {**local** | **hreap** | **all**} {**enable** | **disable**} *interval*

where **all** is both local and hybrid-REAP access points, and *interval* is a value between 1 and 10 seconds (inclusive). Specifying a small heartbeat interval reduces the amount of time it takes to detect a controller failure. The default value is disabled.

Step 7 To configure the access point heartbeat timer, enter this command:

config advanced timers ap-heartbeat-timeout *interval*

where *interval* is a value between 1 and 30 seconds (inclusive). This value should be at least three times larger than the fast heartbeat timer. The default value is 30 seconds.

Step 8 To configure the access point primary discovery request timer, enter this command:

config advanced timers ap-primary-discovery-timeout *interval*

where *interval* is a value between 30 and 3600 seconds. The default value is 120 seconds.

Step 9 To configure the access point discovery timer, enter this command:

config advanced timers ap-discovery-timeout *interval*

where *interval* is a value between 1 and 10 seconds (inclusive). The default value is 10 seconds.

Step 10 To configure the 802.11 authentication response timer, enter this command:

config advanced timers auth-timeout *interval*

where *interval* is a value between 10 and 600 seconds (inclusive). The default value is 10 seconds.

Step 11 To save your changes, enter this command:

save config

Step 12 To view an access point's configuration, enter these commands:

- **show ap config general** *Cisco_AP*
- **show advanced backup-controller**
- **show advanced timers**

Information similar to the following appears for the **show ap config general** *Cisco_AP* command:

```
Cisco AP Identifier.............................. 1
Cisco AP Name.................................... AP5
Country code..................................... US  - United States
Regulatory Domain allowed by Country............ 802.11bg:-AB    802.11a:-AB
AP Country code.................................. US  - United States
AP Regulatory Domain............................ 802.11bg:-A    802.11a:-N
Switch Port Number .............................. 1
MAC Address...................................... 00:13:80:60:48:3e
IP Address Configuration........................ DHCP
IP Address....................................... 1.100.163.133
...
Primary Cisco Switch Name....................... 1-4404
Primary Cisco Switch IP Address.................. 2.2.2.2
Secondary Cisco Switch Name...................... 1-4404
Secondary Cisco Switch IP Address................ 2.2.2.2
Tertiary Cisco Switch Name....................... 2-4404
Tertiary Cisco Switch IP Address................. 1.1.1.4
...
```

Information similar to the following appears for the **show advanced backup-controller** command:

```
AP primary Backup Controller .................... controller1 10.10.10.10
AP secondary Backup Controller ............... 0.0.0.0
```

Information similar to the following appears for the **show advanced timers** command:

```
Authentication Response Timeout (seconds)........ 10
Rogue Entry Timeout (seconds).................... 1300
AP Heart Beat Timeout (seconds).................. 30
AP Discovery Timeout (seconds)................... 10
AP Local mode Fast Heartbeat (seconds)........... 10 (enable)
AP Hreap mode Fast Heartbeat (seconds)........... disable
AP Primary Discovery Timeout (seconds)........... 120
```

Configuring Failover Priority for Access Points

Each controller has a defined number of communication ports for access points. When multiple controllers with unused access point ports are deployed on the same network and one controller fails, the dropped access points automatically poll for unused controller ports and associate with them.

In controller software releases prior to 5.1, the backup controllers accept association requests in the order the requests are received until all the ports are in use. As a result, the probability of an access point finding an open port on a backup controller is determined by where in the association request queue it is after the controller failure.

In controller software release 5.1 or later, you can configure your wireless network so that the backup controller recognizes a join request from a higher-priority access point and if necessary disassociates a lower-priority access point as a means to provide an available port.

Note Failover priority is not in effect during the regular operation of your wireless network. It takes effect only if there are more association requests after a controller failure than there are available backup controller ports.

To configure this feature, you must enable failover priority on your network and assign priorities to the individual access points. You can do so using the controller GUI or CLI.

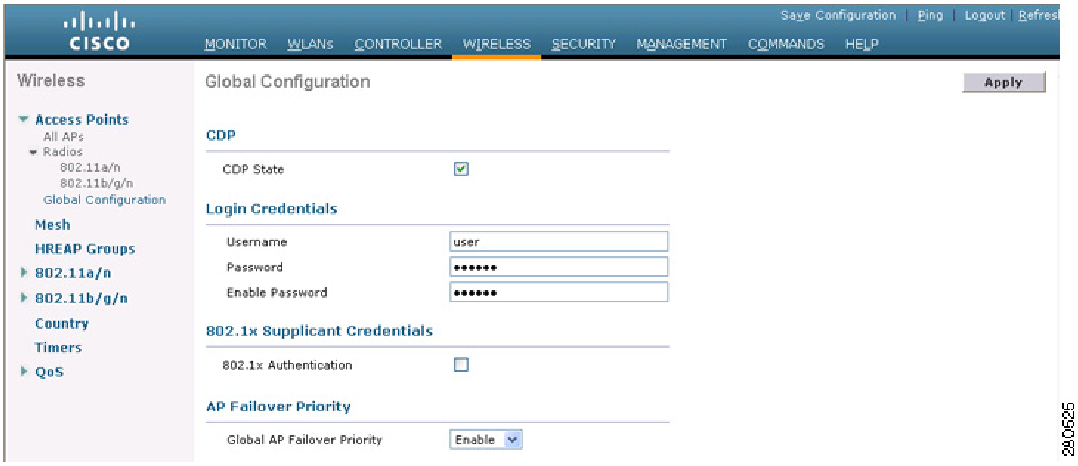
By default, all access points are set to priority level 1, which is the lowest priority level. Therefore, you need to assign a priority level only to those access points that warrant a higher priority.

Using the GUI to Configure Failover Priority for Access Points

Using the controller GUI, follow these steps to configure failover priority for access points that join the controller.

Step 1 Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page (see Figure 31).

Figure 31 Global Configuration Page



Step 2 From the Global AP Failover Priority drop-down box, choose **Enable** to enable access point failover priority or **Disable** to disable this feature and turn off any access point priority assignments. The default value is Disable.

Step 3 Click **Apply** to commit your changes.

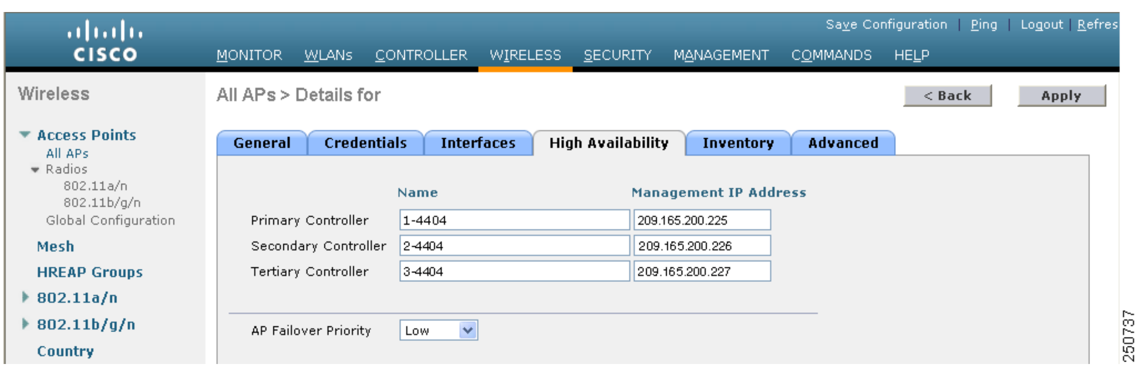
Step 4 Click **Save Configuration** to save your changes.

Step 5 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 6 Click the name of the access point for which you want to configure failover priority.

Step 7 Choose the **High Availability** tab. The All APs > Details for (High Availability) page appears (see Figure 32).

Figure 32 All APs > Details for (High Availability) Page



Step 8 From the AP Failover Priority drop-down box, choose one of the following options to specify the priority of the access point:

- **Low**—Assigns the access point to the level 1 priority, which is the lowest priority level. This is the default value.
- **Medium**—Assigns the access point to the level 2 priority.
- **High**—Assigns the access point to the level 3 priority.
- **Critical**—Assigns the access point to the level 4 priority, which is the highest priority level.

Step 9 Click **Apply** to commit your changes.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Configure Failover Priority for Access Points

Using the controller CLI, follow these steps to configure failover priority for access points that join the controller.

Step 1 To enable or disable access point failover priority, enter this command:

config network ap-priority {**enable** | **disable**}

Step 2 To specify the priority of an access point, enter this command:

config ap priority {**1** | **2** | **3** | **4**} *Cisco_AP*

where 1 is the lowest priority level and 4 is the highest priority level. The default value is 1.

Step 3 To save your changes, enter this command:

save config

Using the CLI to View Failover Priority Settings

Use these commands to view the failover priority configuration settings on your network:

- To confirm whether access point failover priority is enabled on your network, enter this command:

  show network summary

  Information similar to the following appears:

```
RF-Network Name............................. mrf
Web Mode.................................... Enable
Secure Web Mode............................. Enable
Secure Web Mode Cipher-Option High.......... Disable
Secure Shell (ssh).......................... Enable
Telnet...................................... Enable
Ethernet Multicast Mode..................... Disable
Ethernet Broadcast Mode..................... Disable
IGMP snooping............................... Disabled
IGMP timeout................................ 60 seconds
User Idle Timeout........................... 300 seconds
ARP Idle Timeout............................ 300 seconds
Cisco AP Default Master..................... Disable
AP Join Priority......................... Enabled
...
```

- To see the failover priority for each access point, enter this command:

  show ap summary

  Information similar to the following appears:

```
Number of APs.................................. 2
Global AP User Name............................ user
Global AP Dot1x User Name...................... Not Configured
```

```
AP Name   Slots  AP Model           Ethernet MAC       Location   Port Country Priority
-------   -----  ------------------ -----------------  ---------  ---- ------- -------
ap:1252   2      AIR-LAP1252AG-A-K9 00:1b:d5:13:39:74  hallway 6  1    US      1
ap:1121   1      AIR-LAP1121G-A-K9  00:1b:d5:a9:ad:08  reception  1    US      3
```

Configuring Country Codes

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

Generally, you configure one country code per controller, the one matching the physical location of the controller and its access points. However, controller software release 4.1 or later allows you to configure up to 20 country codes per controller. This multiple-country support enables you to manage access points in various countries from a single controller.

Note Although the controller supports different access points in different regulatory domains (countries), it requires all radios in a single access point to be configured for the same regulatory domain. For example, you should not configure a Cisco 1231 access point's 802.11b/g radio for the US (-A) regulatory domain and its 802.11a radio for the Great Britain (-E) regulatory domain. Otherwise, the controller allows only one of the access point's radios to turn on, depending on which regulatory domain you selected for the access point on the controller. Therefore, make sure that the same country code is configured for both of the access point's radios.

For a complete list of country codes supported per product, refer to http://www.ciscofax.com/ or http://www.cisco.com/c/en/us/products/collateral/wireless/access-points/product_data_sheet0900aecd80537b6a.html.

Guidelines for Configuring Multiple Country Codes

Follow these guidelines when configuring multiple country codes:

- When the multiple-country feature is being used, all controllers intended to join the same RF group must be configured with the same set of countries, configured in the same order.
- When multiple countries are configured and the radio resource management (RRM) auto-RF feature is enabled, the auto-RF feature is limited to only the channels that are legal in all configured countries and to the lowest power level common to all configured countries. The access points are always able to use all legal frequencies, but non-common channels can only be assigned manually.

  Note If an access point was already set to a higher legal power level or is configured manually, the power level is limited only by the particular country to which that access point is assigned.

You can configure country codes through the controller GUI or CLI.

Using the GUI to Configure Country Codes

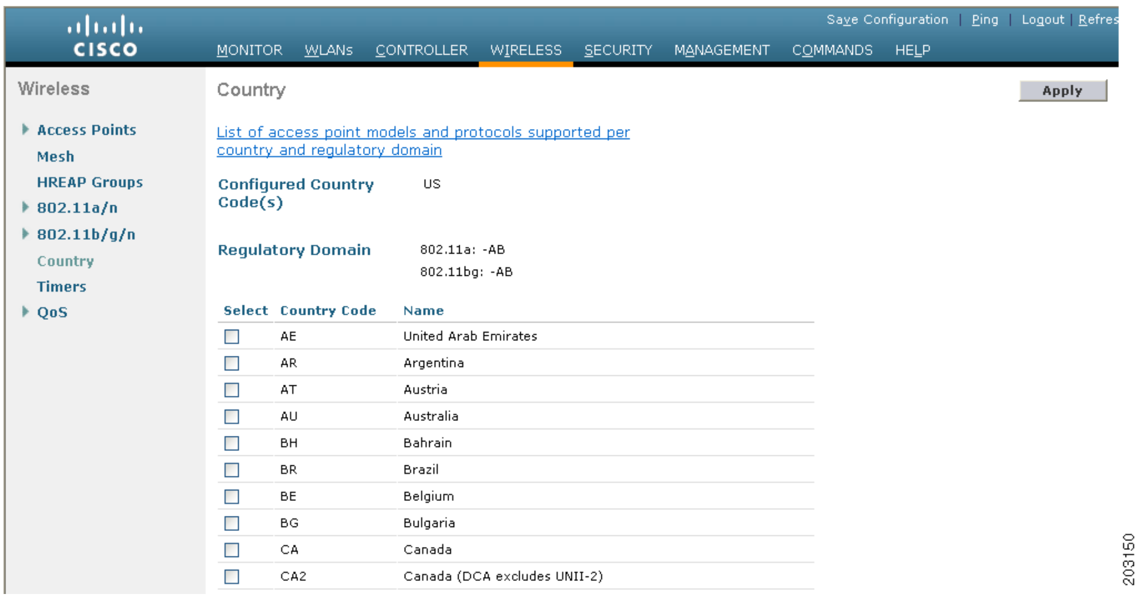
Follow these steps to configure country codes using the GUI.

Step 1 Follow these steps to disable the 802.11a and 802.11b/g networks:

- **a.** Choose **Wireless** > **802.11a/n** > **Network**.
- **b.** Uncheck the **802.11a Network Status** check box.
- **c.** Click **Apply** to commit your changes.
- **d.** Choose **Wireless** > **802.11b/g/n** > **Network**.
- **e.** Uncheck the **802.11b/g Network Status** check box.
- **f.** Click **Apply** to commit your changes.

Step 2 Choose **Wireless** > **Country** to open the Country page (see Figure 33).

Figure 33 Country Page



Step 3 Check the check box for each country where your access points are installed.

Step 4 If you checked more than one check box in Step 3, a message appears indicating that RRM channels and power levels are limited to common channels and power levels. Click **OK** to continue or **Cancel** to cancel the operation.

Step 5 Click **Apply** to commit your changes.

Step 6 If you selected multiple country codes in Step 3, each access point is assigned to a country. Follow these steps to see the default country chosen for each access point and to choose a different country if necessary.

> **Note** If you ever remove a country code from the configuration, any access points currently assigned to the deleted country reboot and when they rejoin the controller, they get re-assigned to one of the remaining countries if possible.

a. Perform one of the following:

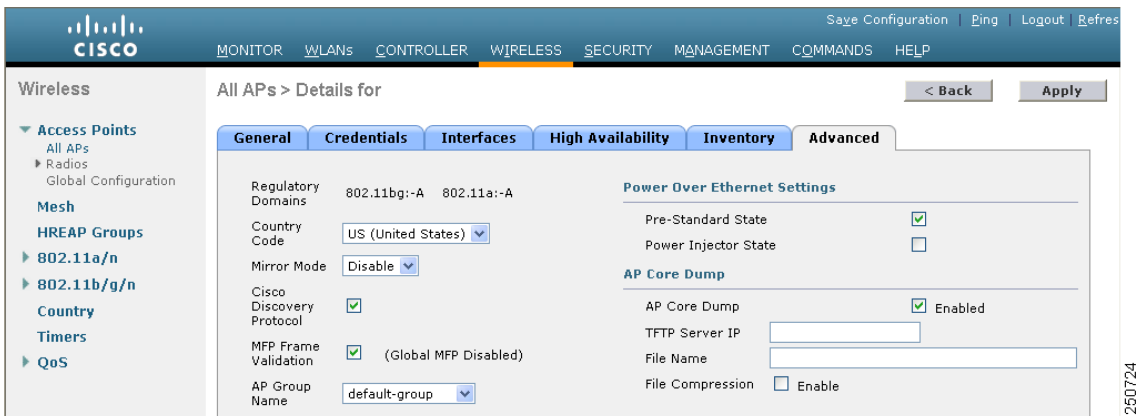
- Leave the 802.11a and 802.11b/g networks disabled.
- Re-enable the 802.11a and 802.11b/g networks and then disable only the access points for which you are configuring a country code. To disable an access point, choose **Wireless** > **Access Points** > **All APs**, click the link of the desired access point, choose **Disable** from the Status drop-down box, and click **Apply**.

b. Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

c. Click the link for the desired access point.

d. Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 34).

Figure 34 All APs > Details for (Advanced) Page



e. The default country for this access point appears in the Country Code drop-down box. If the access point is installed in a country other than the one shown, choose the correct country from the drop-down box. The box contains only those country codes that are compatible with the regulatory domain of at least one of the access point's radios.

f. Click **Apply** to commit your changes.

g. Repeat these steps to assign all access points joined to the controller to a specific country.

h. Re-enable any access points that you disabled in Step a.

Step 7 Re-enable the 802.11a and 802.11b/g networks, provided you did not re-enable them in Step 6.

Step 8 Click **Save Configuration** to save your settings.

Using the CLI to Configure Country Codes

Follow these steps to configure country codes using the CLI.

Step 1 To see a list of all available country codes, enter this command:

show country supported

Step 2 Enter these commands to disable the 802.11a and 802.11b/g networks:

config 802.11a disable network

config 802.11b disable network

Step 3 To configure the country codes for the countries where your access points are installed, enter this command:

config country *code1*[,*code2*,*code3*,...]

If you are entering more than one country code, separate each by a comma (for example, **config country US,CA,MX**). Information similar to the following appears:

```
Changing country code could reset channel configuration.
If running in RFM One-Time mode, reassign channels after this command.
Check customized APs for valid channel values after this command.
Are you sure you want to continue? (y/n) y
```

Step 4 Enter **Y** when prompted to confirm your decision. Information similar to the following appears:

```
Configured Country........................... Multiple Countries:US,CA,MX
Auto-RF for this country combination is limited to common channels and power.
      KEY: * = Channel is legal in this country and may be configured manually.
           A = Channel is the Auto-RF default in this country.
           . = Channel is not legal in this country.
           C = Channel has been configured for use by Auto-RF.
           x = Channel is available to be configured for use by Auto-RF.
         (-) = Regulatory Domains allowed by this country.
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-
802.11BG    :
Channels    :                   1 1 1 1 1
            : 1 2 3 4 5 6 7 8 9 0 1 2 3 4
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 US (-AB)   : A * * * * A * * * * A . . .
 CA (-AB)   : A * * * * A * * * * A . . .
 MX (-NA)   : A * * * * A * * * * A . . .
 Auto-RF    : C x x x x C x x x x C . . .
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 802.11A    :                         1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Channels    : 3 3 3 4 4 4 4 4 5 5 6 6 0 0 0 1 1 2 2 2 3 3 4 4 5 5 6 6
--More-- or (q)uit
            : 4 6 8 0 2 4 6 8 2 6 0 4 0 4 8 2 6 0 4 8 2 6 0 9 3 7 1 5
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 US (-AB)   : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
 CA (-ABN)  : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
 MX (-N)    : . A . A . A . A A A A A . . . . . . . . . . . A A A A *
    Auto-RF : . C . C . C . C C C C C . . . . . . . . . . . C C C C x
```

Step 5 To verify your country code configuration, enter this command:

show country

Step 6 To see the list of available channels for the country codes configured on your controller, enter this command:

show country channels

Information similar to the following appears:

```
Configured Country............................ Multiple Countries:US,CA,MX
Auto-RF for this country combination is limited to common channels and power.
      KEY: * = Channel is legal in this country and may be configured manually.
           A = Channel is the Auto-RF default in this country.
           . = Channel is not legal in this country.
           C = Channel has been configured for use by Auto-RF.
           x = Channel is available to be configured for use by Auto-RF.
         (-) = Regulatory Domains allowed by this country.
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-
802.11BG    :
Channels    :                   1 1 1 1 1
            : 1 2 3 4 5 6 7 8 9 0 1 2 3 4
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 US (-AB)   : A * * * * A * * * * A . . .
 CA (-AB)   : A * * * * A * * * * A . . .
 MX (-NA)   : A * * * * A * * * * A . . .
 Auto-RF    : C x x x x C x x x x C . . .
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 802.11A    :                         1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Channels    : 3 3 3 4 4 4 4 4 5 5 6 6 0 0 0 1 1 2 2 2 3 3 4 4 5 5 6 6

            : 4 6 8 0 2 4 6 8 2 6 0 4 0 4 8 2 6 0 4 8 2 6 0 9 3 7 1 5
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 US (-AB)   : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
 CA (-ABN)  : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
 MX (-N)    : . A . A . A . A A A A A . . . . . . . . . . . A A A A *
    Auto-RF : . C . C . C . C C C C C . . . . . . . . . . . C C C C x
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

Step 7 To save your settings, enter this command:

save config

Step 8 To see the countries to which your access points have been assigned, enter this command:

show ap summary

Information similar to the following appears:

```
Number of APs.................................... 2

AP Name  Slots  AP Model          Ethernet MAC       Location          Port    Country
-------- ------ ----------------- -----------------  ----------------  ------- --------
ap1        2   AP1030            00:0b:85:5b:8e:c0  default location     1     US
ap2        2   AIR-AP1242AG-A-K9  00:14:1c:ed:27:fe  default location     1     US
```

Step 9 If you entered multiple country codes in Step 3, follow these steps to assign each access point to a specific country:

a. Perform one of the following:

– Leave the 802.11a and 802.11b/g networks disabled.

– Re-enable the 802.11a and 802.11b/g networks and then disable only the access points for which you are configuring a country code. To re-enable the networks, enter these commands:

config 802.11a enable network

config 802.11b enable network

To disable an access point, enter this command:

config ap disable *ap_name*

b. To assign an access point to a specific country, enter this command:

config ap country *code* {*ap_name* | **all**}

Make sure that the country code you choose is compatible with the regulatory domain of at least one of the access point's radios.

Note If you enabled the networks and disabled some access points and then run the **config ap country** *code* **all** command, the specified country code is configured on only the disabled access points. All other access points are ignored.

For example, if you enter **config ap country mx all**, information similar to the following appears:

```
To change country code: first disable target AP(s) (or disable all networks).
  Changing the country may reset any customized channel assignments.
  Changing the country will reboot disabled target AP(s).

 Are you sure you want to continue? (y/n) y

AP Name     Country  Status
---------  -------- --------
ap2          US     enabled (Disable AP before configuring country)
ap1          MX     changed (New country configured, AP rebooting)
```

c. To re-enable any access points that you disabled in Step a, enter this command:

config ap enable *ap_name*

Step 10 If you did not re-enable the 802.11a and 802.11b/g networks in Step 9, enter these commands to re-enable them now:

config 802.11a enable network

config 802.11b enable network

Step 11 To save your settings, enter this command:

save config

Migrating Access Points from the -J Regulatory Domain to the -U Regulatory Domain

The Japanese government has changed its 5-GHz radio spectrum regulations. These regulations allow a field upgrade of 802.11a 5-GHz radios. Japan allows three frequency sets:

- J52 = 34 (5170 MHz), 38 (5190 MHz), 42 (5210 MHz), 46 (5230 MHz)
- W52 = 36 (5180 MHz), 40 (5200 MHz), 44 (5220 MHz), 48 (5240 MHz)
- W53 = 52 (5260 MHz), 56 (5280 MHz), 60 (5300 MHz), 64 (5320 MHz)

Cisco has organized these frequency sets into the following regulatory domains:

- -J regulatory domain = J52
- -P regulatory domain = W52 + W53
- -U regulatory domain = W52

Regulatory domains are used by Cisco to organize the legal frequencies of the world into logical groups. For example, most of the European countries are included in the -E regulatory domain. Cisco access points are configured for a specific regulatory domain at the factory and, with the exception of this migration process, never change. The regulatory domain is assigned per radio, so an access point's 802.11a and 802.11b/g radios may be assigned to different domains.

Note Controllers and access points may not operate properly if they are not designed for use in your country of operation. For example, an access point with part number AIR-AP1030-A-K9 (which is included in the Americas regulatory domain) cannot be used in Australia. Always be sure to purchase controllers and access points that match your country's regulatory domain.

The Japanese regulations allow the regulatory domain that is programmed into an access point's radio to be migrated from the -J domain to the -U domain. New access points for the Japanese market contain radios that are configured for the -P regulatory domain. -J radios are no longer being sold. In order to make sure that your existing -J radios work together with the new -P radios in one network, you need to migrate your -J radios to the -U domain.

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

- JP—Allows only -J radios to join the controller
- J2—Allows only -P radios to join the controller
- J3—Uses the -U frequencies but allows both -U and -P radios to join the controller

  Note After migration, you need to use the J3 country code. If your controller is running software release 4.1 or later, you can use the multiple-country feature, explained in the previous section, to choose both J2 and J3. Then you can manually configure your -P radios to use the channels not supported by J3.

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

Guidelines for Migration

Follow these guidelines before migrating your access points to the -U regulatory domain:

- You can migrate only Cisco Aironet 1130, 1200, and 1240 lightweight access points that support the -J regulatory domain and Airespace AS1200 access points. Other access points cannot be migrated.
- Your controller and all access points must be running software release 4.1 or greater or software release 3.2.193.0.

> **Note** Software release 4.0 is not supported. If you migrate your access points using software release 3.2.193.0, you cannot upgrade to software release 4.0. You can upgrade only to software release 4.1 or later or to a later release of the 3.2 software.

- You must have had one or more Japan country codes (JP, J2, or J3) configured on your controller at the time you last booted your controller.
- You must have at least one access point with a -J regulatory domain joined to your controller.
- You cannot migrate your access points from the -U regulatory domain back to the -J domain. The Japanese government has made reverse migration illegal.

> **Note** You cannot undo an access point migration. Once an access point has been migrated, you cannot return to software release 4.0. Migrated access points will have non-functioning 802.11a radios under software release 4.0.

Migrating Access Points to the -U Regulatory Domain

Follow these steps to migrate your access points from the -J regulatory domain to the -U regulatory domain using the controller CLI. This process cannot be performed using the controller GUI.

Step 1 To determine which access points in your network are eligible for migration, enter this command:

show ap migrate

Information similar to the following appears:

```
These 1 APs are eligible for migration:
00:14:1c:ed:27:fe AIR-AP1242AG-J-K9ap1240      "J"Reg. Domain

No APs have already been migrated.
```

Step 2 Enter these commands to disable the 802.11a and 802.11b/g networks:

config 802.11a disable network

config 802.11b disable network

Step 3 Enter this command to change the country code of the access points to be migrated to J3:

config country J3

Step 4 Wait for any access points that may have rebooted to rejoin the controller.

Step 5 Enter this command to migrate the access points from the -J regulatory domain to the -U regulatory domain:

config ap migrate j52w52 {**all** | *ap_name*}

Information similar to the following appears:

```
Migrate APs with 802.11A Radios in the "J" Regulatory Domain to the "U" Regulatory Domain.
The "J" domain allows J52 frequencies, the "U" domain allows W52 frequencies.
WARNING: This migration is permanent and is not reversible, as required by law.
WARNING: Once migrated the 802.11A radios will not operate with previous OS versions.
WARNING: All attached "J" radios will be migrated.
WARNING: All migrated APs will reboot.
WARNING: All migrated APs must be promptly reported to the manufacturer.
Send the AP list and your company name to: migrateapj52w52@cisco.com
```

```
This AP is eligible for migration:
00:14:1c:ed:27:fe AIR-AP1242AG-J-K9ap1240

Begin to migrate Access Points from “J”(J52) to “U”(W52). Are you sure? (y/n)
```

Step 6 Enter **Y** when prompted to confirm your decision to migrate.

Step 7 Wait for all access points to reboot and rejoin the controller. This process may take up to 15 minutes, depending on access point. The AP1130, AP1200, and AP1240 reboot twice; all other access points reboot once.

Step 8 Enter this command to verify migration for all access points:

show ap migrate

Information similar to the following appears:

```
No APs are eligible for migration.

These 1 APs have already been migrated:
00:14:1c:ed:27:fe AIR-AP1242AG-J-K9ap1240      “U”Reg. Domain
```

Step 9 Enter these commands to re-enable the 802.11a and 802.11b/g networks:

config 802.11a enable network

config 802.11b enable network

Step 10 Send an email with your company name and the list of access points that have been migrated to this email address: migrateapj52w52@cisco.com. Cisco recommends that you cut and paste the output from the **show ap migrate** command in Step 8 into the email.

Using the W56 Band in Japan

The Japanese government is formally permitting wireless LAN use of the frequencies in the W56 band for 802.11a radios. The W56 band includes the following channels, frequencies, and power levels (in dBm):

Channel	Frequency (MHz)	Maximum Power for AIR-LAP1132AG-Q-K9	Maximum Power for AIR-LAP1242AG-Q-K9
100	5500	17	15
104	5520	17	15
108	5540	17	15
112	5560	17	15
116	5580	17	15
120	5600	17	15
124	5620	17	15
128	5640	17	15
132	5660	17	15
136	5680	17	15
140	5700	17	15

All of the channels in the W56 band require dynamic frequency selection (DFS). In Japan, the W56 band is subject to Japan's DFS regulations. Currently, only the new 1130 and 1240 series access point SKUs (with the -Q product code) support this requirement: AIR-LAP1132AG-Q-K9 and AIR-LAP1242AG-Q-K9.

To set up a network consisting of only -P and -Q access points, configure the country code to J2. To set up a network consisting of -P, -Q, and -U access points, configure the country code to J3.

Dynamic Frequency Selection

The Cisco UWN Solution complies with regulations that require radio devices to use dynamic frequency selection (DFS) to detect radar signals and avoid interfering with them.

When a lightweight access point with a 5-GHz radio operates on one of the 15 channels listed in Table 2, the controller to which the access point is associated automatically uses DFS to set the operating frequency.

When you manually select a channel for DFS-enabled 5-GHz radios, the controller checks for radar activity on the channel for 60 seconds. If there is no radar activity, the access point operates on the channel you selected. If there is radar activity on the channel you selected, the controller automatically selects a different channel, and after 30 minutes, the access point retries the channel you selected.

Note After radar has been detected on a DFS-enabled channel, it cannot be used for 30 minutes.

Note Rogue Location Detection Protocol (RLDP) and rogue containment are not supported on the channels listed in Table 2.

Note The maximum legal transmit power is greater for some 5-GHz channels than for others. When the controller randomly selects a 5-GHz channel on which power is restricted, it automatically reduces transmit power to comply with power limits for that channel.

Table 2 DFS-Enabled 5-GHz Channels

52 (5260 MHz)	104 (5520 MHz)	124 (5620 MHz)
56 (5280 MHz)	108 (5540 MHz)	128 (5640 MHz)
60 (5300 MHz)	112 (5560 MHz)	132 (5660 MHz)
64 (5320 MHz)	116 (5580 MHz)	136 (5680 MHz)
100 (5500 MHz)	120 (5600 MHz)	140 (5700 MHz)

Using DFS, the controller monitors operating frequencies for radar signals. If it detects radar signals on a channel, the controller takes these steps:

- It changes the access point channel to a channel that has not shown radar activity within the last 30 minutes. (The radar event is cleared after 30 minutes.) The controller selects the channel at random.
- If the channel selected is one of the channels in Table 2, it scans the new channel for radar signals for 60 seconds. If there are no radar signals on the new channel, the controller accepts client associations.
- It records the channel that showed radar activity as a radar channel and prevents activity on that channel for 30 minutes.
- It generates a trap to alert the network manager.

Optimizing RFID Tracking on Access Points

To optimize the monitoring and location calculation of RFID tags, you can enable tracking optimization on up to four channels within the 2.4-GHz band of an 802.11b/g access point radio. This feature allows you to scan only the channels on which tags are usually programmed to operate (such as channels 1, 6, and 11).

You can use the controller GUI or CLI to configure the access point for monitor mode and to then enable tracking optimization on the access point radio.

Using the GUI to Optimize RFID Tracking on Access Points

Using the controller GUI, follow these steps to optimize RFID tracking.

Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to configure monitor mode. The All APs > Details for page appears.

Step 3 From the AP Mode drop-down box, choose **Monitor**.

Step 4 Click **Apply** to commit your changes.

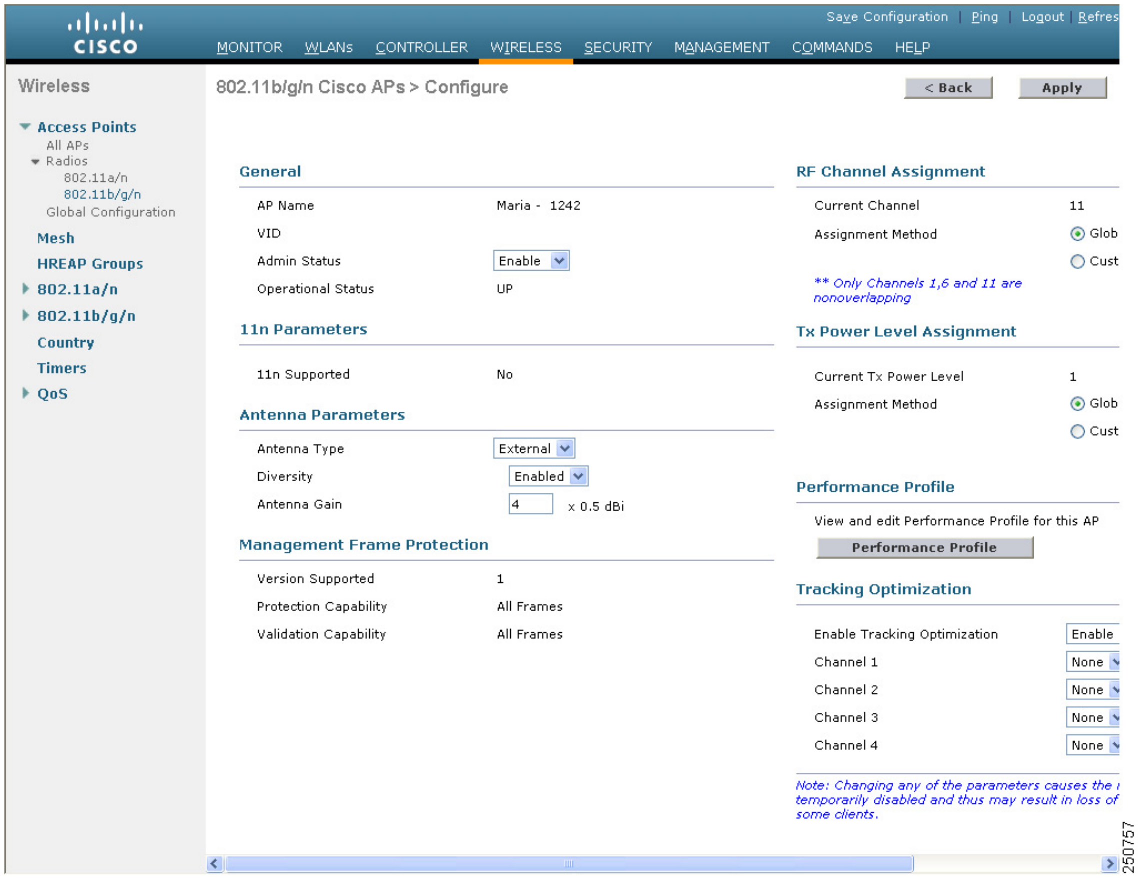
Step 5 Click **OK** when warned that the access point will be rebooted.

Step 6 Click **Save Configuration** to save your changes.

Step 7 Choose **Wireless** > **Access Points** > **Radios** > **802.11b/g/n** to open the 802.11b/g/n Radios page.

Step 8 Hover your cursor over the blue drop-down arrow for the desired access point and choose **Configure**. The 802.11b/g/n Cisco APs > Configure page appears (see Figure 35).

Figure 35 802.11b/g/n Cisco APs > Configure Page



Step 9 To disable the access point radio, choose **Disable** from the Admin Status drop-down box and click **Apply**.

Step 10 To enable tracking optimization on the radio, choose **Enable** from the Enable Tracking Optimization drop-down box.

Step 11 From the four Channel drop-down boxes, choose the channels on which you want to monitor RFID tags.

Note You must configure at least one channel on which the tags will be monitored.

Step 12 Click **Apply** to commit your changes.

Step 13 Click **Save Configuration** to save your changes.

Step 14 To re-enable the access point radio, choose **Enable** from the Admin Status drop-down box and click **Apply**.

Step 15 Click **Save Configuration** to save your changes.

Using the CLI to Optimize RFID Tracking on Access Points

Using the controller CLI, follow these steps to optimize RFID tracking.

Step 1 To configure an access point for monitor mode, enter this command:

config ap mode monitor *Cisco_AP*

Step 2 When warned that the access point will be rebooted and asked if you want to continue, enter **Y**.

Step 3 To save your changes, enter this command:

save config

Step 4 To disable the access point radio, enter this command:

config 802.11b disable *Cisco_AP*

Step 5 To configure the access point to scan only the DCA channels supported by its country of operation, enter this command:

config ap monitor-mode tracking-opt *Cisco_AP*

Note To specify the exact channels to be scanned, enter this command and the command in Step 6.

Note To disable tracking optimization for this access point, enter this command: **config ap monitor-mode no-optimization** *Cisco_AP*.

Step 6 After you have entered the command in Step 5, you can enter this command to choose up to four specific 802.11b channels to be scanned by the access point:

config ap monitor-mode 802.11b fast-channel *Cisco_AP channel1 channel2 channel3 channel4*

Note In the United States, you can assign any value between 1 and 11 (inclusive) to the *channel* variable. Other countries support additional channels. You must assign at least one channel.

Step 7 To re-enable the access point radio, enter this command:

config 802.11b enable *Cisco_AP*

Step 8 To save your changes, enter this command:

save config

Step 9 To see a summary of all access points in monitor mode, enter this command:

show ap monitor-mode summary

Information similar to the following appears:

```
AP Name             Ethernet MAC         Status      Scanning Channel List
------------------ -------------------- ----------  ------------------------
AP1131:46f2.98ac    00:16:46:f2:98:ac    Tracking        1, 6, NA, NA
```

Configuring Probe Request Forwarding

Probe requests are 802.11 management frames sent by clients to request information about the capabilities of SSIDs. By default, access points forward acknowledged probe requests to the controller for processing. Acknowledged probe requests are probe requests for SSIDs that are supported by the access point. If desired, you can configure access points to forward both acknowledged and unacknowledged probe requests to the controller. The controller can use the information from unacknowledged probe requests to improve location accuracy.

Using the controller CLI, follow these steps to configure probe request filtering and rate limiting.

Step 1 To enable or disable the filtering of probe requests forwarded from an access point to the controller, enter this command:

config advanced probe filter {**enable** | **disable**}

If you enable probe filtering, the default filter setting, the access point forwards only acknowledged probe requests to the controller. If you disable probe filtering, the access point forwards both acknowledged and unacknowledged probe requests to the controller.

Step 2 To limit the number of probe requests sent to the controller per client per access point radio in a given interval, enter this command:

config advanced probe limit *num_probes interval*

- *num_probes* is the number of probe requests (from 1 to 100) forwarded to the controller per client per access point radio in a given interval.
- *interval* is the probe limit interval (from 100 to 10000 milliseconds).

The default value for *num_probes* is 2 probe requests, and the default value for *interval* is 500 milliseconds.

Step 3 To save your changes, enter this command:

save config

Step 4 To view the probe request forwarding configuration, enter this command:

show advanced probe

Information similar to the following appears:

```
Probe request filtering.........................  Enabled
Probes fwd to controller per client per radio....  2
Probe request rate-limiting interval..........  500 msec
```

Retrieving the Unique Device Identifier on Controllers and Access Points

The unique device identifier (UDI) standard uniquely identifies products across all Cisco hardware product families, enabling customers to identify and track Cisco products throughout their business and network operations and to automate their asset management systems. The standard is consistent across all electronic, physical, and standard business communications. The UDI consists of five data elements:

- The orderable product identifier (PID)
- The version of the product identifier (VID)
- The serial number (SN)
- The entity name
- The product description

The UDI is burned into the EEPROM of controllers and lightweight access points at the factory. It can be retrieved through either the GUI or the CLI.

Using the GUI to Retrieve the Unique Device Identifier on Controllers and Access Points

Follow these steps to retrieve the UDI on controllers and access points using the GUI.

Step 1 Choose **Controller** > **Inventory** to open the Inventory page (see Figure 36).

Figure 36 Inventory Page

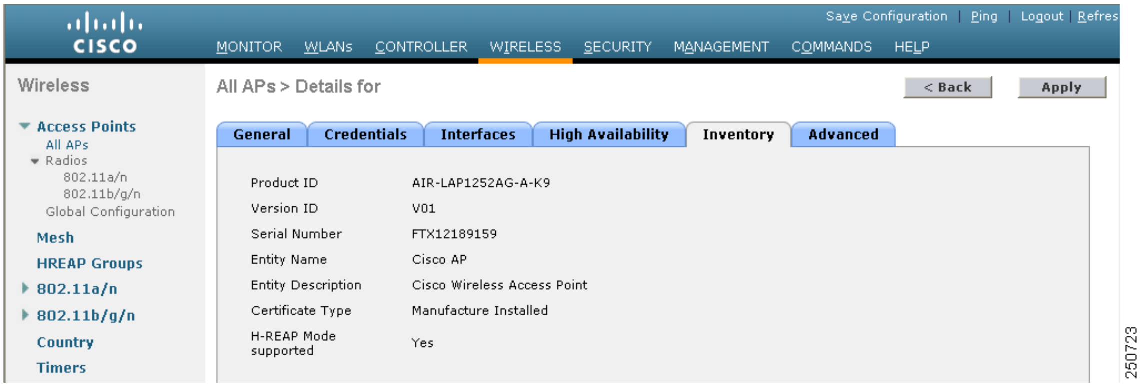
This page shows the five data elements of the controller UDI.

Step 2 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 3 Click the name of the desired access point.

Step 4 Choose the **Inventory** tab to open the All APs > Details for (Inventory) page (see Figure 37).

Figure 37 All APs > Details for (Inventory) Page



This page shows the inventory information for the access point.

Using the CLI to Retrieve the Unique Device Identifier on Controllers and Access Points

Enter these commands to retrieve the UDI on controllers and access points using the CLI:

- **show inventory**—Shows the UDI string of the controller. Information similar to the following appears:

```
NAME: "Chassis"    , DESCR: "Cisco Wireless Controller"
PID: WS-C3750G-24PS-W24,  VID: V01,  SN: FLS0952H00F
```

- **show inventory ap** *ap_id*—Shows the UDI string of the access point specified.

Performing a Link Test

A link test is used to determine the quality of the radio link between two devices. Two types of link-test packets are transmitted during a link test: request and response. Any radio receiving a link-test request packet fills in the appropriate fields and echoes the packet back to the sender with the response type set.

The radio link quality in the client-to-access point direction can differ from that in the access point-to-client direction due to the asymmetrical distribution of transmit power and receive sensitivity on both sides. Two types of link tests can be performed: a ping test and a CCX link test.

With the *ping link test*, the controller can test link quality only in the client-to-access point direction. The RF parameters of the ping reply packets received by the access point are polled by the controller to determine the client-to-access point link quality.

With the *CCX link test*, the controller can also test the link quality in the access point-to-client direction. The controller issues link-test requests to the client, and the client records the RF parameters [received signal strength indicator (RSSI), signal-to-noise ratio (SNR), etc.] of the received request packet in the response packet. Both the link-test requestor and responder roles are implemented on the access point and controller. Therefore, not only can the access point or controller initiate a link test to a CCX v4 or v5 client, but a CCX v4 or v5 client can initiate a link test to the access point or controller.

The controller shows these link-quality metrics for CCX link tests in both directions (out: access point to client; in: client to access point):

- Signal strength in the form of RSSI (minimum, maximum, and average)
- Signal quality in the form of SNR (minimum, maximum, and average)
- Total number of packets that are retried
- Maximum retry count for a single packet
- Number of lost packets
- Data rate of a successfully transmitted packet

The controller shows this metric regardless of direction:

- Link test request/reply round-trip time (minimum, maximum, and average)

The controller software supports CCX versions 1 through 5. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. The controller stores the CCX version of the client in its client database and uses it to limit the features for this client. If a client supports CCXv4 or v5, the controller performs a CCX link test on the client. See the "Configuring Cisco Client Extensions" section on page 49 for more information on CCX.

Note CCX is not supported on the AP1030.

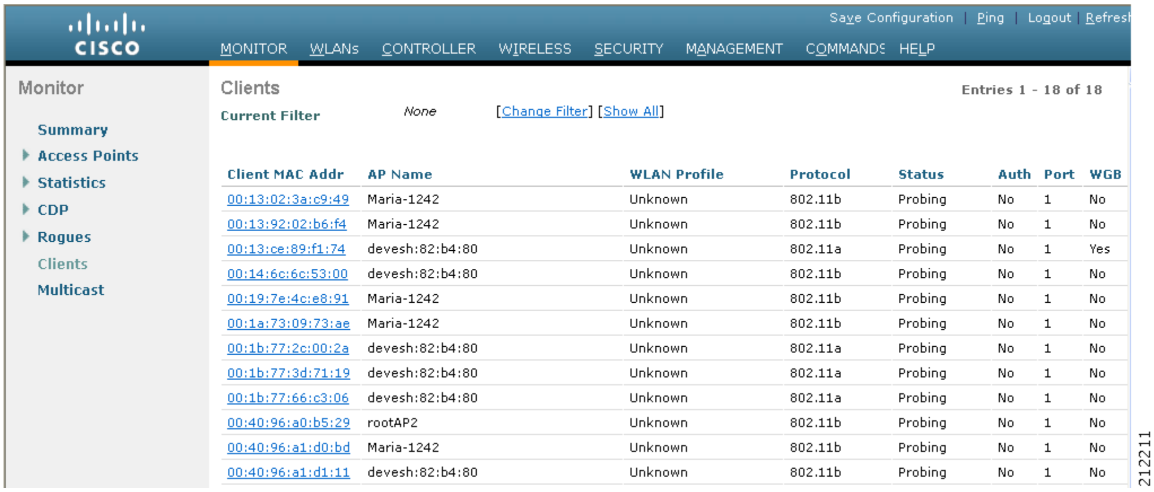
Follow the instructions in this section to perform a link test using either the GUI or the CLI.

Using the GUI to Perform a Link Test

Follow these steps to run a link test using the GUI.

Step 1 Choose **Monitor** > **Clients** to open the Clients page (see Figure 38).

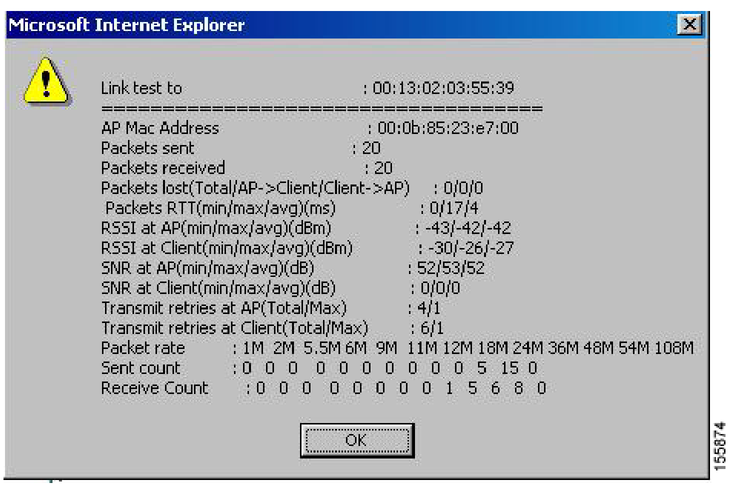
Figure 38 Clients Page



Step 2 Hover your cursor over the blue drop-down arrow for the desired client and choose **LinkTest**. A link test page appears (see Figure 39).

Note You can also access this page by clicking the MAC address of the desired client and then clicking the **Link Test** button on the top of the Clients > Detail page.

Figure 39 Link Test Page



This page shows the results of the CCX link test.

Note If the client and/or controller does not support CCX v4 or later, the controller performs a ping link test on the client instead, and a much more limited link test page appears.

Step 3 Click **OK** to exit the link test page.

Using the CLI to Perform a Link Test

Use these commands to run a link test using the CLI.

1. To run a link test, enter this command:

   linktest *client_mac*

   When CCX v4 or later is enabled on both the controller and the client being tested, information similar to the following appears:

```
CCX Link Test to 00:0d:88:c5:8a:d1.
     Link Test Packets Sent..................................... 20
     Link Test Packets Received................................ 10
     Link Test Packets Lost (Total/AP to Client/Client to AP).... 10/5/5
     Link Test Packets round trip time (min/max/average)......... 5ms/20ms/15ms
     RSSI at AP (min/max/average)................................ -60dBm/-50dBm/-55dBm
     RSSI at Client (min/max/average)............................ -50dBm/-40dBm/-45dBm
     SNR at AP (min/max/average)................................. 40dB/30dB/35dB
     SNR at Client (min/max/average)............................. 40dB/30dB/35dB
     Transmit Retries at AP (Total/Maximum)...................... 5/3
     Transmit Retries at Client (Total/Maximum).................. 4/2
     Transmit rate:  1M   2M   5.5M   6M   9M  11M 12M 18M   24M   36M  48M  54M  108M
     Packet Count:   0     0     0     0    0    0   0   0     0     2    0   18     0
     Transmit rate:  1M   2M   5.5M   6M   9M  11M 12M 18M   24M   36M  48M  54M  108M
     Packet Count:   0     0     0     0    0    0   0   0     0     2    0    8     0
```

   When CCX v4 or later is not enabled on either the controller or the client being tested, fewer details appear:

```
Ping Link Test to 00:0d:88:c5:8a:d1.
        Link Test Packets Sent.......................... 20
        Link Test Packets Received...................... 20
        Local Signal Strength........................... -49dBm
        Local Signal to Noise Ratio..................... 39dB
```

2. To adjust the link-test parameters that are applicable to both the CCX link test and the ping test, enter these commands from config mode:

   config > **linktest frame-size** *size_of_link-test_frames*

   config > **linktest number-of-frames** *number_of_link-test_request_frames_per_test*

Configuring Link Latency

You can configure link latency on the controller to measure the link between an access point and the controller. This feature can be used with all access points joined to the controller but is especially useful for hybrid-REAP and OfficeExtend access points, for which the link could be a slow or unreliable WAN connection.

Note Link latency is supported for use only with hybrid-REAP access points in connected mode. Hybrid-REAP access points in standalone mode are not supported.

Link latency monitors the round-trip time of the CAPWAP heartbeat packets (echo request and response) from the access point to the controller and back. This time can vary due to network link speed and controller processing loads. The access point timestamps the outgoing echo requests to the controller and the echo responses received from the controller. The access point sends this delta time to the controller as the system round-trip time. The access point sends heartbeat packets to the controller at a default interval of 30 seconds.

Note Link latency calculates the CAPWAP response time between the access point and the controller. It does not measure network latency or ping responses.

The controller displays the current round-trip time as well as a running minimum and maximum round-trip time. The minimum and maximum times continue to run as long as the controller is up or can be cleared and allowed to restart.

You can configure link latency for a specific access point using the controller GUI or CLI or for all access points joined to the controller using the CLI.

Using the GUI to Configure Link Latency

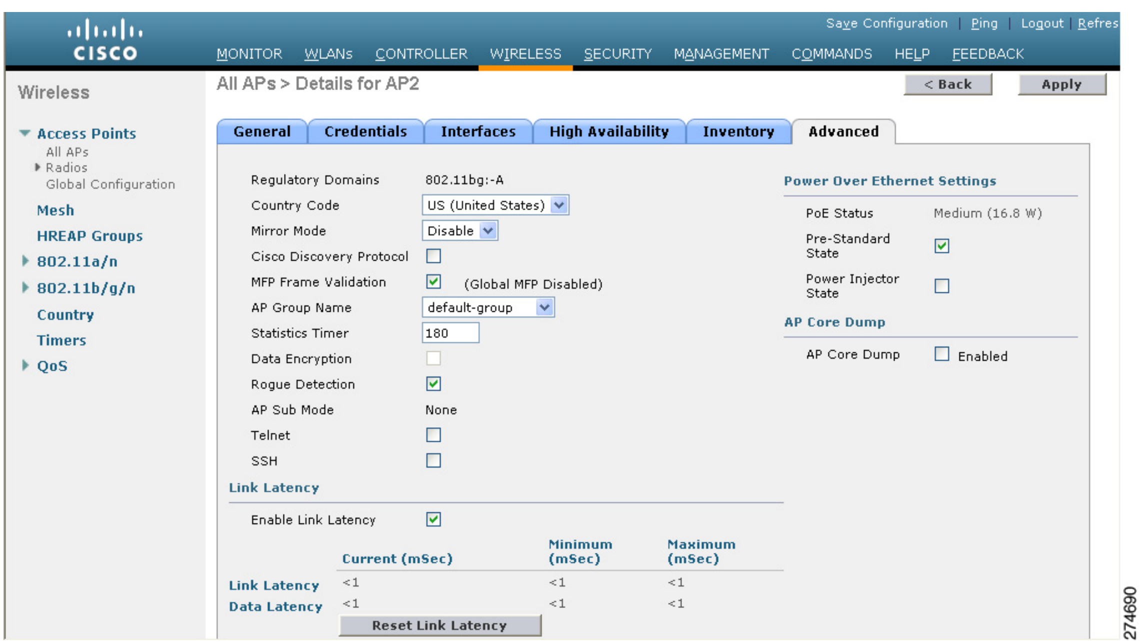
Using the controller GUI, follow these steps to configure link latency.

Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to configure link latency.

Step 3 Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 40).

Figure 40 All APs > Details for (Advanced) Page



Step 4 Check the **Enable Link Latency** check box to enable link latency for this access point or uncheck it to prevent the access point from sending the round-trip time to the controller after every echo response is received. The default value is unchecked.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Step 7 When the All APs page reappears, click the name of the access point again.

Step 8 When the All APs > Details for page reappears, choose the **Advanced** tab again. The link latency and data latency results appear below the Enable Link Latency check box:

- **Current**—The current round-trip time (in milliseconds) of CAPWAP heartbeat packets or data packets from the access point to the controller and back.
- **Minimum**—Since link latency has been enabled or reset, the minimum round-trip time (in milliseconds) of CAPWAP heartbeat packets or data packets from the access point to the controller and back.
- **Maximum**—Since link latency has been enabled or reset, the maximum round-trip time (in milliseconds) of CAPWAP heartbeat packets or data packets from the access point to the controller and back.

Step 9 To clear the current, minimum, and maximum link latency and data latency statistics on the controller for this access point, click **Reset Link Latency**.

Step 10 After the page refreshes and the All APs > Details for page reappears, choose the **Advanced** tab. The updated statistics appear in the Minimum and Maximum fields.

Using the CLI to Configure Link Latency

Using the controller CLI, follow these steps to configure link latency.

Step 1 To enable or disable link latency for a specific access point or for all access points currently associated to the controller, enter this command:

config ap link-latency {**enable** | **disable**} {*Cisco_AP* | **all**}

The default value is disabled.

Note The **config ap link-latency** {**enable** | **disable**} **all** command enables or disables link latency only for access points that are currently joined to the controller. It does not apply to access points that join in the future.

Step 2 To view the link latency results for a specific access point, enter this command:

show ap config general *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 1
Cisco AP Name.................................... AP1
...
AP Link Latency.................................. Enabled
 Current Delay................................... 1 ms
 Maximum Delay................................... 1 ms
 Minimum Delay................................... 1 ms
 Last updated (based on AP Up Time)........... 0 days, 05 h 03 m 25 s
```

The output of this command contains the following link latency results:

- **Current Delay—**The current round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back.
- **Maximum Delay**—Since link latency has been enabled or reset, the maximum round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back.
- **Minimum Delay**—Since link latency has been enabled or reset, the minimum round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back.

Step 3 To clear the current, minimum, and maximum link latency statistics on the controller for a specific access point, enter this command:

config ap link-latency reset *Cisco_AP*

Step 4 To view the results of the reset, enter this command:

show ap config general *Cisco_AP*

Configuring the TCP MSS

If the client's maximum segment size (MSS) in a Transmission Control Protocol (TCP) three-way handshake is greater than the maximum transmission unit can handle, the client might experience reduced throughput and the fragmentation of packets. To avoid this problem in controller software release 6.0, you can specify the MSS for all access points joined to the controller or for a specific access point.

When you enable this feature, the access point checks for TCP packets to and from wireless clients in its data path. If the MSS of these packets is greater than the value you configured or greater than the default value for the CAPWAP tunnel, the access point changes the MSS to the new configured value.

Using the controller CLI, follow these steps to configure the TCP MSS.

Step 1 To enable or disable the TCP MSS on a particular access point or on all access points, enter this command:

config ap tcp-adjust-mss {**enable** | **disable**} {*Cisco_AP* | **all**} *size*

where the *size* parameter is a value between 536 and 1363 bytes. The default value varies for different clients.

Step 2 To save your changes, enter this command:

save config

Step 3 To see the current TCP MSS setting for a particular access point or all access points, enter this command:

show ap tcp-mss-adjust {*Cisco_AP* | **all**}

Information similar to the following appears:

```
AP Name              TCP State  MSS Size
------------------   --------   -------
AP-1140             enabled    536
AP-1240              disabled   -
AP-1130             disabled    -
```

Configuring Power over Ethernet

When an access point that has been converted to lightweight mode (such as an AP1131 or AP1242) or a 1250 series access point is powered by a power injector that is connected to a Cisco pre-Intelligent Power Management (pre-IPM) switch, you need to configure Power over Ethernet (PoE), also known as *inline power*.

The dual-radio 1250 series access points can operate in four different modes when powered using PoE:

- **20.0 W (Full Power)**—This mode is equivalent to using a power injector or an AC/DC adapter.
- **16.8 W**—Both transmitters are used but at reduced power. Legacy data rates are not affected, but the M0 to M15 data rates are reduced in the 2.4-GHz band. Throughput should be minimally impacted because all data rates are still enabled. The range is affected because of the lower transmit power. All receivers remain enabled.
- **15.4 W**—Only a single transmitter is enabled. Legacy data rates and M0 to M7 rates are minimally affected. M8 to M15 rates are disabled because they require both transmitters. Throughput is better than that received with legacy access points but less than the 20 and 16.8 W power modes.
- **11.0 W (Low Power)**—The access point runs, but both radios are disabled.

Note When a dual-radio 1250 series access point is powered using 15.4-W PoE, it cannot operate at full functionality, which requires 20 W. The access point can operate with dual radios on 15.4-W PoE, but performance is reduced in terms of throughput and range. If full functionality is required on 15.4 W, you can remove one of the radios from the 1250 series access point chassis or disable it in controller software release 6.0 so that the other radio can operate in full 802.11n mode. After the access point radio is administratively disabled, the access point must be rebooted for the change to take effect. The access point must also be rebooted after you re-enable the radio to put it into reduced throughput mode.

These modes provide the flexibility of running the 1250 series access points with the available wired infrastructure to obtain the desired level of performance. With enhanced PoE switches (such as the Cisco Catalyst 3750-E Series Switches), the 1250 series access points can provide maximum features and functionality with minimum total cost of ownership. Alternatively, if you decide to power the access point with the existing PoE (802.3af) switches, the access point chooses the appropriate mode of operation based on whether it has one radio or two.

Note For more information on the Cisco PoE switches, see http://www.cisco.com/c/en/us/products/switches/epoe.html.

Table 3 shows the maximum transmit power settings for 1250 series access points using PoE.

Table 3 Maximum Transmit Power Settings for 1250 Series Access Points Using PoE

Radio Band	Data Rates	Number of Transmitters	Cyclic Shift Diversity (CSD)	Maximum Transmit Power (dBm)[1]		
				802.3af Mode (15.4 W)	ePoE Power Optimized Mode (16.8 W)	ePoE Mode (20 W)
2.4 GHz	802.11b	1	—	20	20	20
	802.11g	1	—	17	17	17
	802.11n MCS 0-7	1	Disabled	17	17	17
		2	Enabled (default)	Disabled	14 (11 per Tx)	20 (17 per Tx)
	802.11n MCS 8-15	2	—	Disabled	14 (11 per Tx)	20 (17 per Tx)
5 GHz	802.11a	1	—	17	17	17
	802.11n MCS 0-7	1	Disabled	17	17	17
		2	Enabled (default)	Disabled	20 (17 per Tx)	20 (17 per Tx)
	802.11n MCS 8-15	2	—	Disabled	20 (17 per Tx)	20 (17 per Tx)

1. Maximum transmit power varies by channel and according to individual country regulations. Refer to the product documentation for specific details.

Note When powered with a non-Cisco standard PoE switch, the 1250 series access point operates under 15.4 Watts. Even if the non-Cisco switch or midspan device is capable of providing higher power, the access point does not operate in enhanced PoE mode.

You can configure PoE through either the controller GUI or CLI.

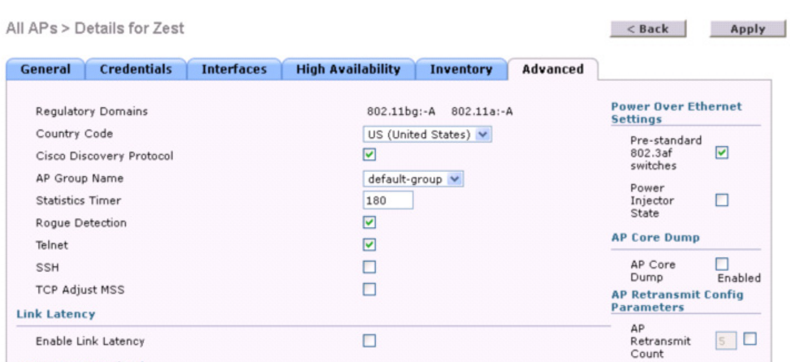
Using the GUI to Configure Power over Ethernet

Using the controller GUI, follow these steps to configure PoE.

Step 1 Choose **Wireless** > **Access Points** > **All APs** and then the name of the desired access point.

Step 2 Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 41).

Figure 41 All APs > Details for (Advanced) Page



The PoE Status field shows the power level at which the access point is operating: High (20 W), Medium (16.8 W), or Medium (15.4 W). This field is not configurable. The controller auto-detects the access point's power source and displays the power level here.

Note This field applies only to 1250 series access points that are powered using PoE. There are two other ways to determine if the access point is operating at a lower power level. First, the "Due to low PoE, radio is transmitting at degraded power" message appears under the Tx Power Level Assignment section on the 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page. Second, the "PoE Status: degraded operation" message appears in the controller's trap log on the Trap Logs page.

Step 3 Perform one of the following:

- Check the **Pre-Standard State** check box if the access point is being powered by a high-power Cisco switch. These switches provide more than the traditional 6 Watts of power but do not support the intelligent power management (IPM) feature. These switches include:
  - 2106 controller,
  - WS-C3550, WS-C3560, WS-C3750,
  - C1880,
  - 2600, 2610, 2611, 2621, 2650, 2651,
  - 2610XM, 2611XM, 2621XM, 2650XM, 2651XM, 2691,
  - 2811, 2821, 2851,
  - 3620, 3631-telco, 3640, 3660,
  - 3725, 3745,
  - 3825, and 3845.
- Uncheck the **Pre-Standard State** check box if power is being provided by a power injector or by a switch not on the above list. This is the default value.

Step 4 Check the **Power Injector State** check box if the attached switch does not support IPM and a power injector is being used. If the attached switch supports IPM, you do not need to check this check box.

Step 5 If you checked the Power Injector State check box in the previous step, the Power Injector Selection and Injector Switch MAC Address parameters appear. The Power Injector Selection parameter enables you to protect your switch port from an accidental overload if the power injector is inadvertently bypassed. Choose one of these options from the drop-down box to specify the desired level of protection:

- **Installed**—This option examines and remembers the MAC address of the currently connected switch port and assumes that a power injector is connected. Choose this option if your network contains older Cisco 6-Watt switches and you want to avoid possible overloads by forcing a double-check of any relocated access points.

  If you want to configure the switch MAC address, enter the MAC address in the Injector Switch MAC Address field. If you want the access point to find the switch MAC address, leave the Injector Switch MAC Address field blank.

  Note Each time an access point is relocated, the MAC address of the new switch port fails to match the remembered MAC address, and the access point remains in low-power mode. You must then physically verify the existence of a power injector and reselect this option to cause the new MAC address to be remembered.

- **Override**—This option allows the access point to operate in high-power mode without first verifying a matching MAC address. It is acceptable to use this option if your network does not contain any older Cisco 6-Watt switches that could be overloaded if connected directly to a 12-Watt access point. The advantage of this option is that if you relocate the access point, it continues to operate in high-power mode without any further configuration. The disadvantage of this option is that if the access point is connected directly to a 6-Watt switch, an overload occurs.

Step 6 Click **Apply** to commit your changes.

Step 7 If you have a dual-radio 1250 series access point and want to disable one of its radios in order to enable the other radio to receive full power, follow these steps:

a. Choose **Wireless** > **Access Points** > **Radios** > **802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

b. Hover your cursor over the blue drop-down arrow for the radio that you want to disable and choose **Configure**.

c. On the 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page, choose **Disable** from the Admin Status drop-down box.

d. Click **Apply** to commit your changes.

e. Manually reset the access point in order for the change to take effect.

Step 8 Click **Save Configuration** to save your settings.

Using the CLI to Configure Power over Ethernet

Using the controller CLI, enter these commands to configure and view PoE settings.

- If your network contains any older Cisco 6-Watt switches that could be accidentally overloaded if connected directly to a 12-Watt access point, enter this command:

  config ap power injector enable {*Cisco_AP* | **all**} **installed**

  The access point remembers that a power injector is connected to this particular switch port. If you relocate the access point, you must reissue this command after the presence of a new power injector is verified.

  Note Make sure CDP is enabled before issuing this command. Otherwise, this command will fail. See the "Configuring Cisco Discovery Protocol" section on page 91 for information on enabling CDP.

- To remove the safety checks and allow the access point to be connected to any switch port, enter this command:

  config ap power injector enable {*Cisco_AP* | **all**} **override**

  It is acceptable to use this command if your network does not contain any older Cisco 6-Watt switches that could be overloaded if connected directly to a 12-Watt access point. The access point assumes that a power injector is always connected. If you relocate the access point, it continues to assume that a power injector is present.

- If you know the MAC address of the connected switch port and do not wish to automatically detect it using the installed option, enter this command:

  config ap power injector enable {*Cisco_AP* | **all**} *switch_port_mac_address*

- If you have a dual-radio 1250 series access point and want to disable one of its radios in order to enable the other radio to receive full power, enter this command:

  config {**802.11a** | **802.11b**} **disable** *Cisco_AP*

  > **Note** You must manually reset the access point in order for the change to take effect.

- To view the PoE settings for a specific access point, enter this command:

  show ap config general *Cisco_AP*

  Information similar to the following appears:

```
Cisco AP Identifier............................. 1
Cisco AP Name................................... AP1
...
PoE Pre-Standard Switch......................... Enabled
PoE Power Injector MAC Addr..................... Disabled
Power Type/Mode................................. PoE/Low Power (degraded mode)
...
```

  The Power Type/Mode field shows "degraded mode" if the access point is not operating at full power.

- To view the controller's trap log, enter this command:

  show traplog

  If the access point is not operating at full power, the trap contains "PoE Status: degraded operation."

Configuring Flashing LEDs

Controller software release 4.0 or later enables you to flash the LEDs on an access point in order to locate it. All IOS lightweight access points support this feature.

Use these commands to configure LED flashing from the Privileged Exec mode of the controller.

> **Note** The output of these commands is sent only to the controller console, regardless of whether the commands were issued on the console or in a TELNET/SSH CLI session.

1. To enable the controller to send commands to the access point from its CLI, enter this command:

   debug ap enable *Cisco_AP*

2. To cause a specific access point to flash its LEDs for a specified number of seconds, enter this command:

   debug ap command "led flash *seconds***"** *Cisco_AP*

   You can enter a value between 1 and 3600 seconds for the *seconds* parameter.

3. To disable LED flashing for a specific access point, enter this command:

   debug ap command "led flash disable" *Cisco_AP*

   This command disables LED flashing immediately. For example, if you run the previous command (with the *seconds* parameter set to 60 seconds) and then disable LED flashing after only 20 seconds, the access point's LEDs stop flashing immediately.

Viewing Clients

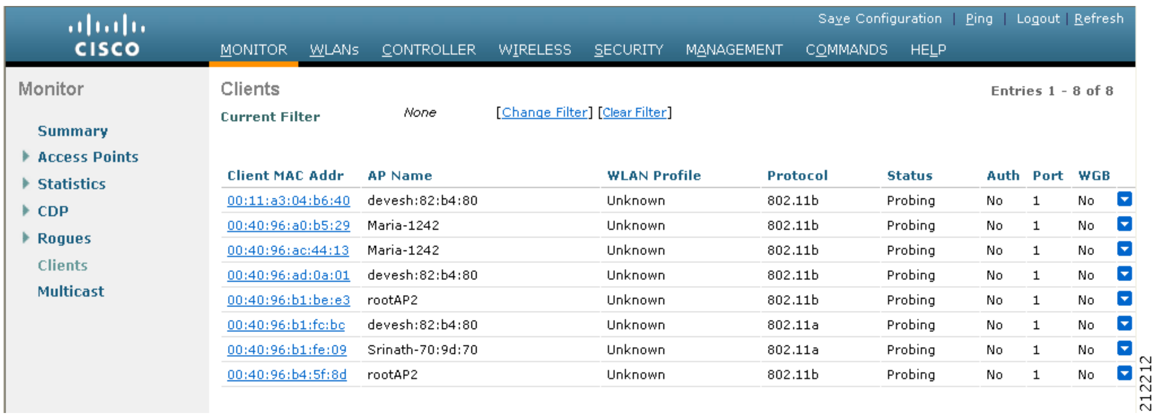
You can use the controller GUI or CLI to view information about the clients that are associated to the controller's access points.

Using the GUI to View Clients

Using the GUI, follow these steps to view client information.

Step 1 Choose **Monitor** > **Clients** to open the Clients page (see Figure 42).

Figure 42 Clients Page



This page lists all of the clients that are associated to the controller's access points. It provides the following information for each client:

- The MAC address of the client
- The name of the access point to which the client is associated
- The name of the WLAN used by the client
- The type of client (802.11a, 802.11b, 802.11g, or 802.11n)

Note If the 802.11n client associates to an 802.11a radio that has 802.11n enabled, then the client type shows as 802.11n(5). If the 802.11n client associates to an 802.11b/g radio with 802.11n enabled, then the client type shows as 802.11n (2.4).

- The status of the client connection
- The authorization status of the client
- The port number of the access point to which the client is associated
- An indication of whether the client is a WGB

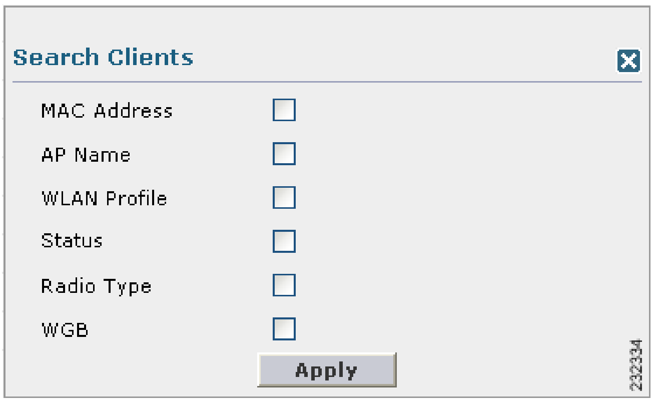
Note Refer to the "Cisco Workgroup Bridges" section on page 61 for more information on the WGB status.

Note If you want to remove or disable a client, hover your cursor over the blue drop-down arrow for that client and choose **Remove** or **Disable**, respectively. If you want to test the connection between the client and the access point, hover your cursor over the blue drop-down arrow for that client and choose **Link Test**.

Step 2 To create a filter to display only clients that meet certain criteria (such as MAC address, status, or radio type), follow these steps:

a. Click **Change Filter** to open the Search Clients page (see Figure 43).

Figure 43 Search Clients Page



b. Check one or more of the following check boxes to specify the criteria used when displaying clients:

- **MAC Address**—Enter a client MAC address.

  Note When you enable the MAC Address filter, the other filters are disabled automatically. When you enable any of the other filters, the MAC Address filter is disabled automatically.

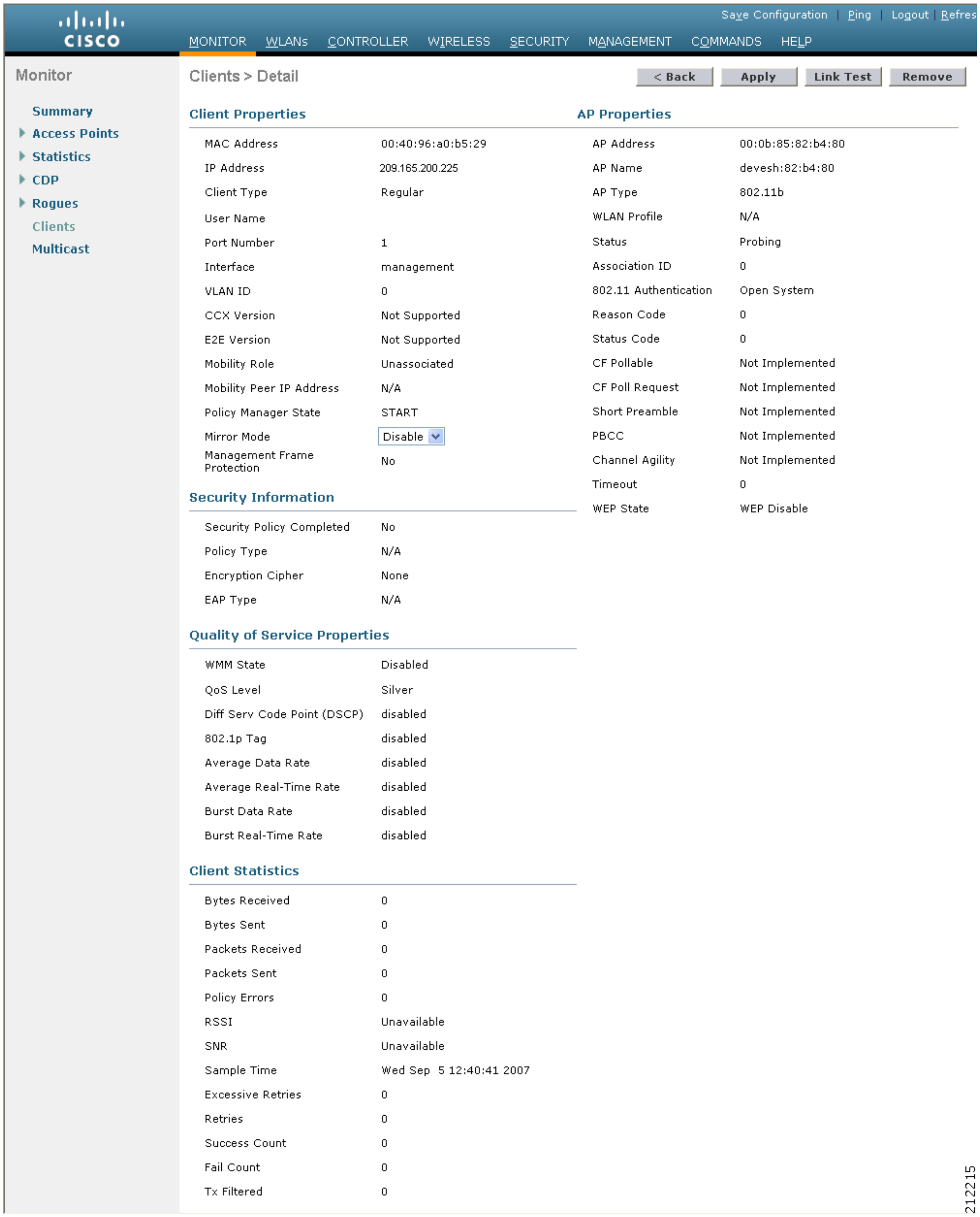
- **AP Name**—Enter the name of an access point.
- **WLAN Profile**—Enter the name of a WLAN.
- **Status**—Check the **Associated**, **Authenticated**, **Excluded**, **Idle**, and/or **Probing** check boxes.
- **Radio Type**—Choose **802.11a**, **802.11b**, **802.11g**, **802.11n**, or **Mobile**.
- **WGB**—Shows WGB clients associated to the controller's access points.

c. Click **Apply** to commit your changes. The Current Filter parameter at the top of the Clients page shows the filters that are currently applied.

Note If you want to remove the filters and display the entire client list, click **Clear Filter**.

Step 3 To view detailed information for a specific client, click the MAC address of the client. The Clients > Detail page appears (see Figure 44).

Figure 44 Clients > Detail Page



This page shows the following information:

- The general properties of the client
- The security settings of the client
- The QoS properties of the client
- Client statistics
- The properties of the access point to which the client is associated

Using the CLI to View Clients

Use these CLI commands to view client information.

- To see the clients associated to a specific access point, enter this command:

  show client ap {**802.11a** | **802.11b**} *Cisco_AP*

  Information similar to the following appears:

```
MAC Address        AP Id   Status         WLAN Id Authenticated
-----------------  ------  -------------  ---------  -------------
00:13:ce:cc:8e:b8   1     Associated      1          No
```

- To see a summary of the clients associated to the controller's access points, enter this command:

  show client summary

  Information similar to the following appears:

```
Number of Clients................................ 1

MAC Address       AP Name      Status    WLAN/Guest-Lan Auth Protocol Port Wired
----------------- ------------- ---------- --------------- ---- -------- ---- -----
00:13:02:2d:96:24 AP_1130      Associated      1        Yes  802.11a  1    No
```

- To see detailed information for a specific client, enter this command:

  show client detail *client_mac*

  Information similar to the following appears:

```
Client MAC Address............................... 00:40:96:b2:a3:44
Client Username ................................. N/A
AP MAC Address................................... 00:18:74:c7:c0:90
Client State..................................... Associated
Wireless LAN Id.................................. 1
BSSID............................................ 00:18:74:c7:c0:9f
Channel.......................................... 56
IP Address....................................... 192.168.10.28
Association Id................................... 1
Authentication Algorithm......................... Open System
Reason Code...................................... 0
Status Code...................................... 0
Session Timeout.................................. 0
Client CCX version............................... 5
Client E2E version............................... No E2E support
Diagnostics Capability........................... Supported
S69 Capability................................... Supported
Mirroring........................................ Disabled
QoS Level........................................ Silver
...
```

Controlling Mesh Access Points

This chapter describes Cisco indoor and outdoor mesh access points and explains how to connect them to the controller and manage access point settings. It contains these sections:

Cisco Aironet Mesh Access Points

Controller software release 6.0 supports these Cisco Aironet mesh access points:

- Cisco Aironet 1520 series outdoor mesh access points consist of the 1522 dual-radio mesh access point and the 1524PS/1524SB multi-radio mesh access point.

  Note Refer to the *Cisco Aironet 1520 Series Outdoor Mesh Access Point Hardware Installation Guide* for details on the physical installation and initial configuration of the mesh access points at the following link:

  http://www.cisco.com/c/en/us/support/wireless/aironet-1520-series/tsd-products-support-series-home.html

- Cisco Aironet 1130AG and 1240AG series indoor mesh access points.

  Note AP1130 and AP1240 must be converted to operate as indoor mesh access points. Refer to the "Converting Indoor Access Points to Mesh Access Points (1130AG, 1240AG)" section on page 8-54.

Note All features discussed in this chapter apply to indoor (1130, 1240) and outdoor mesh access points (1522, 1524PS/1524SB) unless noted otherwise. *Mesh access point* or *MAP* is hereafter used to address both indoor and outdoor mesh access points.

Note Cisco Aironet 1505 and 1510 access points are not supported in this release.

Note Refer to the *Release Notes for Cisco Wireless LAN Controllers and Mesh Access Points for Release 6.0* for mesh feature summary, operating notes and software upgrade steps for migrating from 4.1.19x.xx mesh releases to controller release 6.0 at:

http://www.cisco.com/c/en/us/support/wireless/4400-series-wireless-lan-controllers/products-release-notes-list.html

Licensing for Indoor Mesh Access Points on a 5500 Series Controller

In order to use indoor mesh access points with a 5500 series controller, a wplus license must be used on the controller. If an indoor mesh access point attempts to join a controller that is using only a base license (and not the wplus license), the following message appears in the controller trap log: "License Not Available for feature: IndoorMeshAP." To view the controller trap log, choose **Monitor** and click **View All** under "Most Recent Traps" on the controller GUI.

Refer to the *Configuring Controller Settings* chapter for information on obtaining and installing licenses.

Note Outdoor mesh access points do not require a wplus license.

Note Other controller platforms (such as the 2100 and 4400 series controllers) also require a license for use with indoor mesh access points.

Note The wplus license is not applicable for controller release 6.0.196.0 and above.

Access Point Roles

Access points within a mesh network operate as either a root access point (RAP) or a mesh access point (MAP).

RAPs have wired connections to their controller, and MAPs have wireless connections to their controller.

MAPs communicate among themselves and back to the RAP using wireless connections over the 802.11a radio backhaul. MAPs use the Cisco Adaptive Wireless Path Protocol (AWPP) to determine the best path through the other mesh access points to the controller.

All the possible paths between the MAPs and RAPs form the wireless mesh network.

Network Access

Wireless mesh networks can simultaneously carry two different traffic types: wireless LAN client traffic and MAP Ethernet port traffic.

Wireless LAN client traffic terminates on the controller, and the Ethernet traffic terminates on the Ethernet ports of the mesh access points.

Access to the wireless LAN mesh for mesh access points is managed by:

- MAC authentication–Mesh access points are added to a reference-able database to ensure they are allowed access to a given controller and the mesh network. Refer to "Adding Mesh Access Points to the Mesh Network" section on page 8-11.
- External RADIUS authentication–Mesh access points can be externally authorized and using a RADIUS server such as Cisco ACS (4.1 and later) that supports the client authentication type of EAP-FAST with certificates. Refer to the "Configuring RADIUS Servers" section on page 8-14.

Network Segmentation

Membership to the wireless LAN mesh network for mesh access points is controlled by:

- Bridge group name–Mesh access points can be placed in like bridge groups to manage membership or provide network segmentation. Refer to "Using the GUI to Configure Antenna Gain" section on page 8-28.

Deployment Modes

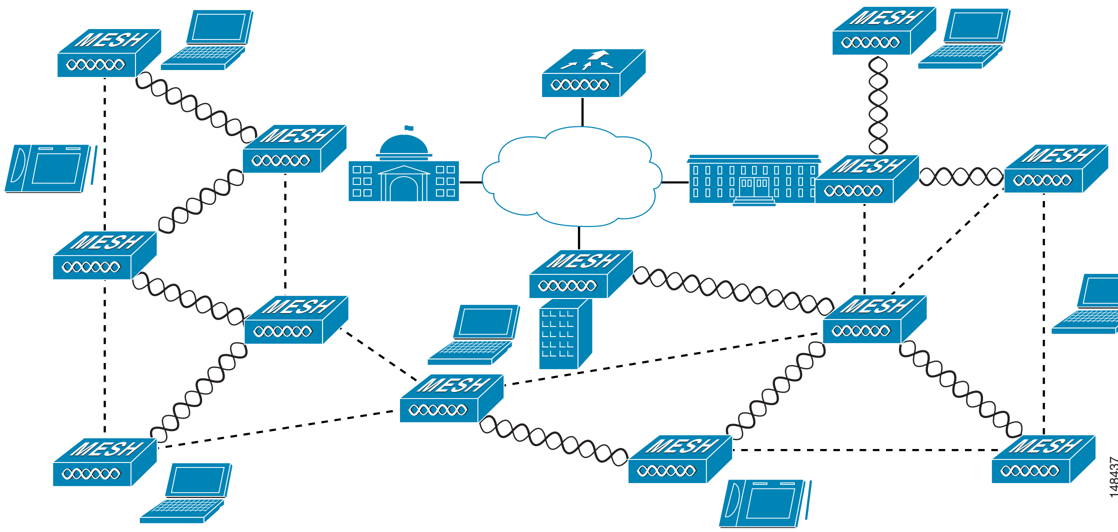
Mesh access points support multiple deployment modes, including the following:

- Wireless mesh
- WLAN backhaul
- Point-to-multipoint wireless bridging
- Point-to-point wireless bridging

Cisco Wireless Mesh Network

In a Cisco wireless outdoor mesh network, multiple mesh access points comprise a network that provides secure, scalable outdoor wireless LANs. Figure 8-1 shows an example mesh deployment.

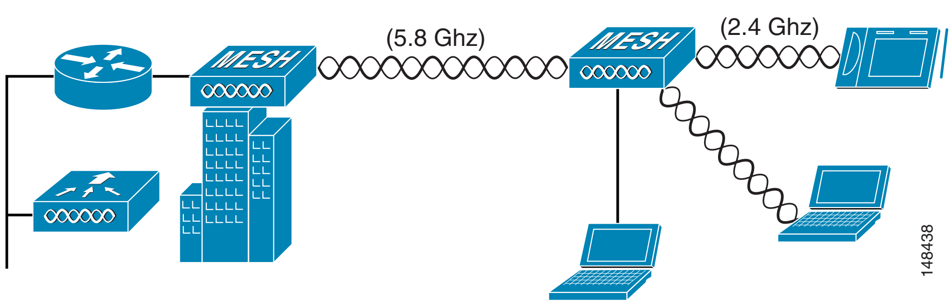
Figure 8-1 *Wireless Mesh Deployment*



Wireless Backhaul

Mesh access points can provide a simple wireless backhaul solution, which provides 802.11b/g services to wireless LAN and wired clients. This configuration is basically a wireless mesh with one MAP. Figure 8-2 shows an example of this deployment type.

Figure 8-2 *Wireless Backhaul Deployment*



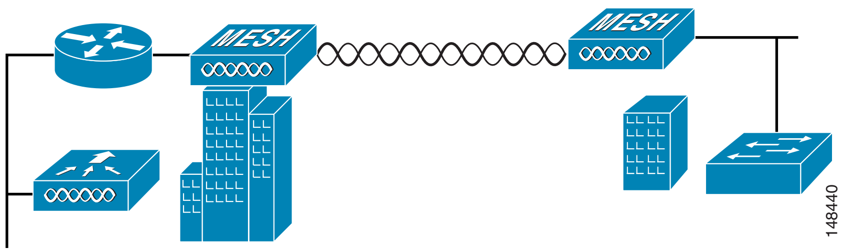
Point-to-Point Wireless Bridging

Mesh access points can support a point-to-point bridging application. In this deployment, mesh access points extend a Layer 2 network by using the backhaul radio to bridge two segments of a switched network (see Figure 8-3). This is fundamentally a wireless mesh network with one MAP and no wireless LAN clients.

Client access can be provided with Ethernet bridging enabled, although if bridging between buildings, MAP coverage from a high rooftop might not be suitable for client access.

If you intend to use an Ethernet bridged application, you must enable the bridging feature on the RAP and on all MAPs in that segment. Also verify that any attached switches to the Ethernet ports of your MAPs are not using VLAN Trunking Protocol (VTP). VTP can reconfigure the trunked VLANs across your mesh and possibly cause a loss in connection for your RAP to its primary WLC. If improperly configured, it can take down your mesh deployment.

Figure 8-3 Wireless Point-to-Point Bridge Deployment

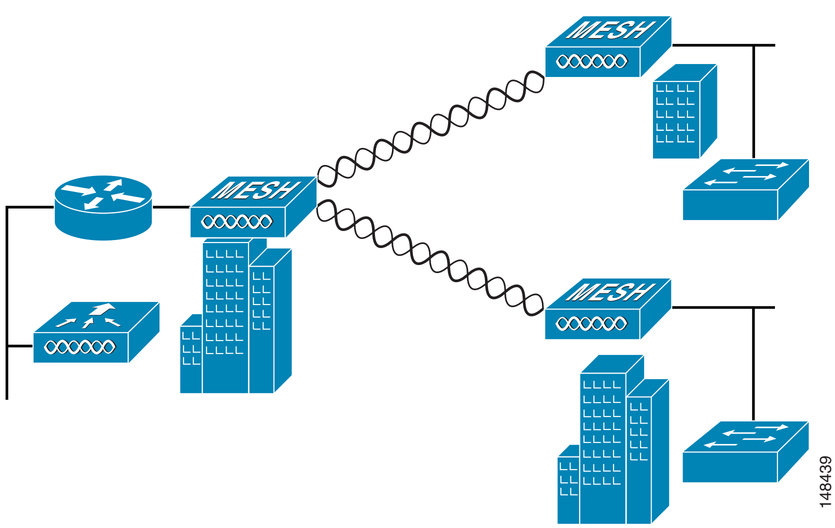


Point-to-Multipoint Wireless Bridging

Mesh access points support point-to-multipoint bridging applications. Specifically, a RAP acting as a root bridge connects to multiple MAPs as non-root bridges with their associated wired LANs. By default, bridging is disabled for all MAPs. If Ethernet bridging is used, you must enable it on the controller for the respective MAP and for the RAP. Refer to the "Configuring Ethernet Bridging and Ethernet VLAN Tagging" section on page 8-31 for configuration details.

Figure 8-4 shows a simple point-to-multipoint deployment with one RAP and two MAPs. This configuration is fundamentally a wireless mesh network with no wireless LAN clients. Client access can be provided with Ethernet bridging enabled; however, if bridging between buildings, MAP coverage from a high rooftop might not be suitable for client access.

Figure 8-4 Wireless Point-to-Multipoint Bridge Deployment



Architecture Overview

CAPWAP

CAPWAP is the provisioning and control protocol used by the controller to manage access points (mesh and non-mesh) in the network. This protocol replaces LWAPP in controller software release 5.2 or later.

Cisco Adaptive Wireless Path Protocol Wireless Mesh Routing

The Cisco Adaptive Wireless Path Protocol (AWPP) is designed specifically for wireless mesh networking. The path decisions of AWPP are based on link quality and the number of hops.

Ease of deployment, fast convergence, and minimal resource consumption are also key components of AWPP.

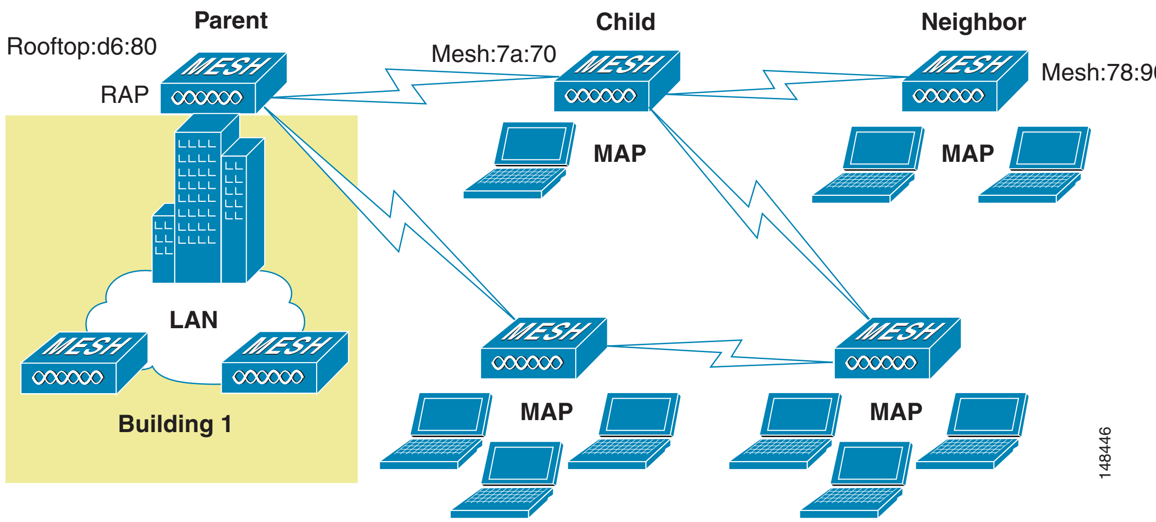
The goal of AWPP is to find the best path back to a RAP for each MAP that is part of the RAP's bridge group. To do this, the MAP actively solicits for neighbor MAPs. During the solicitation, the MAP learns all of the available neighbors back to a RAP, determines which neighbor offers the best path, and then synchronizes with that neighbor.

Mesh Neighbors, Parents, and Children

Relationships among access points with the mesh network are labelled as parent, child, or neighbor (see Figure 8-5).

- A parent access point offers the best route back to the RAP based on its ease values. A parent can be either the RAP itself or another MAP.
  - Ease is calculated using the SNR and link hop value of each neighbor. Given multiple choices, generally an access point with a higher ease value is selected.
- A child access point selects the parent access point as its best route back to the RAP.
- A neighbor access point is within the radio frequency (RF) range of another access point but is not selected as its parent or a child because its *ease* values are lower than that of the parent.

Figure 8-5 Parent, Child and Neighbor Access Points



Wireless Mesh Constraints

Here are a few system characteristics to consider when designing and building a wireless mesh network. Some of these apply to the backhaul network design and others to the CAPWAP controller design:

- Cisco recommends setting the backhaul rate to **auto**.

  When the bridge data rate is set to **auto**, the mesh backhaul chooses the highest rate where the next higher rate cannot be used due to unsuitable conditions for that specific rate (and not because of conditions that affect all rates).

  - Typically, 24 Mbps is chosen as the optimal backhaul rate because it corresponds with the maximum coverage of the WLAN portion of the client WLAN of the MAP; that is, the distance between MAPs using 24 Mbps backhaul should allow for seamless WLAN client coverage between the MAPs.
  - A lower bit rate might allow a greater distance between mesh access points, but there are likely to be gaps in the WLAN client coverage, and the capacity of the backhaul network is reduced.
  - An increased bit rate for the backhaul network either requires more mesh access points or results in a reduced SNR between mesh access points, limiting mesh reliability and interconnection.
  - The wireless mesh backhaul bit rate is set on the access point.

Note To set backhaul bit rate for each access point, choose **WIRELESS** > **Access Points** > **All APs**, then click an AP name and click the **Mesh** tab.

  - The required minimum LinkSNR for backhaul links per data rate is shown in Table 8-1.

Table 8-1 Backhaul Data Rates and Minimum LinkSNR Requirements

Data Rate	Minimum Required LinkSNR (dB)
54 Mbps	31
48 Mbps	29
36 Mbps	26
24 Mbps	22
18 Mbps	18
12 Mbps	16
9 Mbps	15
6 Mbps	14

- The required minimum LinkSNR is driven by the data rate and the following formula: Minimum SNR + fade margin. Table 8-2 summarizes the calculation by data rate.
  - Minimum SNR refers to an ideal state of non-interference, non-noise and a system packet error rate (PER) of no more than 10%
  - Typical fade margin is approximately 9 to 10 dB
  - We do not recommend using data rates greater than 24 Mbps in municipal mesh deployments as the SNR requirements do not make the distances practical

Table 8-2 Minimum Required LinkSNR Calculations by Data Rate

Date Rate	Minimum SNR (dB) +	Fade Margin =	Minimum Required LinkSNR (dB)
6	5	9	14
9	6	9	15
12	7	9	16
18	9	9	18
24	13	9	22
36	17	9	26

- Number of backhaul hops is limited to eight, but three to four is recommended

  The number of hops is recommended to be limited to three–four primarily to maintain sufficient backhaul throughput, because each mesh AP uses the same radio for transmission and reception of backhaul traffic. This means that throughput is approximately halved over every hop. For example, the maximum throughput for 24 Mbps is approximately 14 Mbps for the first hop, 9 Mbps for the second hop, and 4 Mbps for the third hop.
- Number of MAPs per RAP

  There is no current software limitation of how many MAPs per RAP you can configure. However, it is suggested that you limit this to 20 MAPs per RAP.
- Number of controllers

  The number of controllers per mobility group is limited to 72.
- Number of mesh access points supported per controller (see Table 8-3).

Table 8-3 Mesh Access Point Support by Controller Model

Controller Model	Local AP Support (non-mesh)[1]	Maximum Possible Mesh AP Support	RAPs	MAPs	Total Mesh AP Support (RAP + MAP)
5508[2]	250	250	1	249	250
			100	150	250
			150	100	250
			250	0	250
4404[3]	100	150	1	149	150
			50	100	150
			75	50	125
			100	0	100
2106[3]	6	11	1	10	11
			2	8	10
			3	6	9
			4	4	8
			5	2	7
			6	0	6
2112[2]	12	12	1	11	12
			3	9	12
			6	6	12
			9	3	12
			12	0	12
2125[2]	25	25	1	24	25
			5	20	25
			10	15	25
			15	10	25
			20	5	25
			25	0	25
WiSM[3]	300	375	1	374	375
			100	275	375
			250	100	350
			300	0	300

1. Local AP support is the total number of non-mesh APs supported on the controller model.
2. For 5508, 2112, and 2125 controllers, the number of MAPs is equal to (local AP support - number of RAPs).
3. For 4404, 2106, and WiSM controllers, the number of MAPs is equal to ((local AP support - number of RAPs) x 2), not to exceed the maximum possible mesh AP support.

Adding Mesh Access Points to the Mesh Network

This section assumes that the controller is already active in the network and is operating in Layer 3 mode. Layer 3 mode is recommended for large deployments.

Before adding a mesh access point to a network, do the following:

1. Add the MAC address of the MAP to the controller's MAC filter. See the "Adding MAC Addresses of Mesh Access Points to the Controller Filter List" section on page 8-12.
   - To configure external authentication of MAC addresses using an external RADIUS server, see the "Configuring External Authentication and Authorization Using a RADIUS Server" section on page 8-14.
2. Configure the DCA channels for the mesh access points. See the "Using the GUI to Configure Dynamic Channel Assignment" section on page 11-13 for details.
3. Configure the AP mode for the mesh access point. See the "Configuring the AP Mode" section on page 8-17.

Note This procedure is not required for 1520 series access points. The default mode for 1520 series access points is Bridge.

4. Define the role (RAP or MAP) for the mesh access point. See the "Defining the Mesh Access Point Role" section on page 8-18.
5. Configure the channel assignment on the RAP for serial backhaul (if desired). See the "Antennas and Channel Assignment on the AP1524SB" section on page 8-19.
6. Configure a primary, secondary, and tertiary controller for each MAP. See the "Verifying that Access Points Join the Controller" and "Configuring Backup Controllers" sections in Chapter 7.
7. Configure global mesh parameters. See the "Configuring Global Mesh Parameters" section on page 8-22.
8. Configure bridging parameters. See the "Configuring Ethernet Bridging and Ethernet VLAN Tagging" section on page 8-31.
   a. Configure Bridge Group Names.
   b. Assign IP addresses to MAPs unless using DHCP.

      If using DHCP, configure Option 43 and Option 60. Refer to the *Cisco Aironet 1520 Series Outdoor Mesh Access Point Hardware Installation Guide.*
9. Configure mobility groups (if desired) and assign controllers. See the Chapter 12, "Configuring Mobility Groups."
10. Configure advanced features such as using voice and video in the network. See the "Configuring Advanced Features" section on page 8-38.

Adding MAC Addresses of Mesh Access Points to the Controller Filter List

You must enter the MAC address for all mesh access points that you want to use in the mesh network into the appropriate controller. A controller only responds to discovery requests from outdoor radios that appear in its authorization list. MAC filtering is enabled by default on the controller, so only the MAC addressed need be configured.

You can add the access point using either the GUI or the CLI.

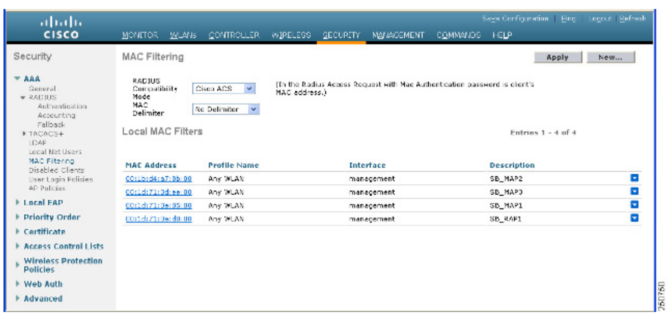
> **Note** You can also download the list of access point MAC addresses and push them to the controller using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide, Release 6.0* for instructions.

Using the GUI to Add MAC Addresses of Mesh Access Points to the Controller Filter List

Using the controller GUI, follow these steps to add a MAC filter entry for the access point on the controller.

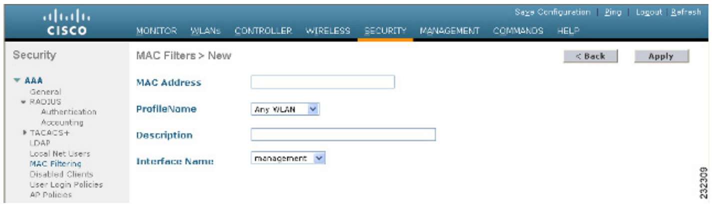
Step 1 Click **Security** > **AAA** > **MAC Filtering** to open the MAC Filtering page (see Figure 8-6).

Figure 8-6 MAC Filtering Page



Step 2 Click **New** to open the MAC Filters > New page (see Figure 8-7).

Figure 8-7 MAC Filters > New Page



Step 3 In the MAC Address field, enter the MAC address of the mesh access point.

Note For 1522 and 1524PS/1524SB outdoor mesh access points, enter the BVI MAC address of the mesh access point into the controller as a MAC filter. For 1130 and 1240 indoor mesh access points, enter the Ethernet MAC address. If the required MAC address does not appear on the exterior of the mesh access point, enter the following command from the access point console to determine the BVI and Ethernet MAC addresses: **sh int | i Hardware**.

Step 4 From the Profile Name drop-down box, choose **Any WLAN**.

Step 5 In the Description field, enter a description of the access point. The text that you enter identifies the mesh access point on the controller.

Note You might want to include an abbreviation of its name and the last few digits of the MAC address, such as *ap1522:62:39:10*. You can also note details on its location, such as *roof top* or *pole top* or its cross streets.

Step 6 From the Interface Name drop-down box, choose the controller interface to which the access point is to connect.

Step 7 Click **Apply** to commit your changes. The access point now appears in the list of MAC filters on the MAC Filtering page.

Step 8 Click **Save Configuration** to save your changes.

Step 9 Repeat this procedure to add the MAC addresses of additional access points to the list.

Using the CLI to Add MAC Addresses of Mesh Access Points to the Controller Filter List

Using the controller CLI, follow these steps to add a MAC filter entry for the access point on the controller.

Step 1 To add the MAC address of an access point to the controller filter list, enter this command:

config macfilter add *ap_mac wlan_id interface* [*description*]

A value of zero (0) for the *wlan_id* parameter specifies any WLAN, and a value of zero (0) for the *interface* parameter specifies none. You can enter up to 32 characters for the optional *description* parameter.

Step 2 To save your changes, enter this command:

save config

Configuring External Authentication and Authorization Using a RADIUS Server

Controller software release 5.2 or later supports external authorization and authentication of mesh access points using a RADIUS server such as Cisco ACS (4.1 and later). The RADIUS server must support the client authentication type of EAP-FAST with certificates.

Before you employ external authentication within the mesh network, you must make these changes:

- Configure the RADIUS server to be used as an AAA server on the controller.
- Configure the controller on the RADIUS server.
- Add the mesh access point configured for external authorization and authentication to the user list of the RADIUS server. For additional details, refer to the "Adding a Username to a RADIUS Server" section on page 8-15.
- Configure EAP-FAST on the RADIUS server and install the certificates. EAP-FAST authentication is required if mesh access points are connected to the controller using an 802.11a interface; the external RADIUS servers need to trust Cisco Root CA 2048. For information on installing and trusting the CA certificates, see the "Configuring RADIUS Servers" section on page 8-14.

Note If mesh access points connect to a the controller using a Fast Ethernet or Gigabit Ethernet interface, only MAC authorization is required.

Note This feature also supports local EAP and PSK authentication on the controller.

Configuring RADIUS Servers

Follow these steps to install and trust the CA certificates on the RADIUS server:

Step 1 Using Internet Explorer, download the CA certificates for Cisco Root CA 2048:

- http://www.cisco.com/security/pki/certs/crca2048.cer
- http://www.cisco.com/security/pki/certs/cmca.cer

Step 2 Install the certificates:

a. From the CiscoSecure ACS main menu, click, click **System Configuration** > **ACS Certificate Setup** > **ACS Certification Authority Setup**.

b. In the **CA certificate file** box, type the CA certificate location (path and name). For example: c:\Certs\crca2048.cer.

c. Click **Submit**.

Step 3 Configure the external RADIUS servers to trust the CA certificate.

a. From the CiscoSecure ACS main menu, choose **System Configuration** > **ACS Certificate Setup** > **Edit Certificate Trust List**. The Edit Certificate Trust List appears.

b. Check the check box next to the **Cisco Root CA 2048 (Cisco Systems)** certificate name.

c. Click **Submit**.

d. To restart ACS, choose **System Configuration** > **Service Control**, and then click **Restart**.

Note For additional configuration details on Cisco ACS servers, refer to the following links: http://www.cisco.com/c/en/us/support/security/secure-access-control-server-windows/products-installation-and-configuration-guides-list.html (Windows)

http://www.cisco.com/c/en/us/support/security/secure-access-control-server-unix/tsd-products-support-configure.html (UNIX)

Adding a Username to a RADIUS Server

Add MAC addresses of mesh access point that are authorized and authenticated by external RADIUS servers to the user list of that server *prior* to enabling RADIUS authentication for a mesh access point.

For remote authorization and authentication, EAP-FAST uses the manufacturer's certificate (CERT) to authenticate the child mesh access point. Additionally, this manufacturer certificate-based identity serves as the username for the mesh access point in user validation.

For IOS-based mesh access points (1130, 1240, 1522, 1524), in addition to adding the MAC address to the user list, you need to enter the *platform_name_string–Ethernet_MAC_address* string to the user list (for example, c1240-001122334455). The controller first sends the MAC address as the username; if this first attempt fails, then the controller sends the *platform_name_string–Ethernet_MAC_address* string as the username.

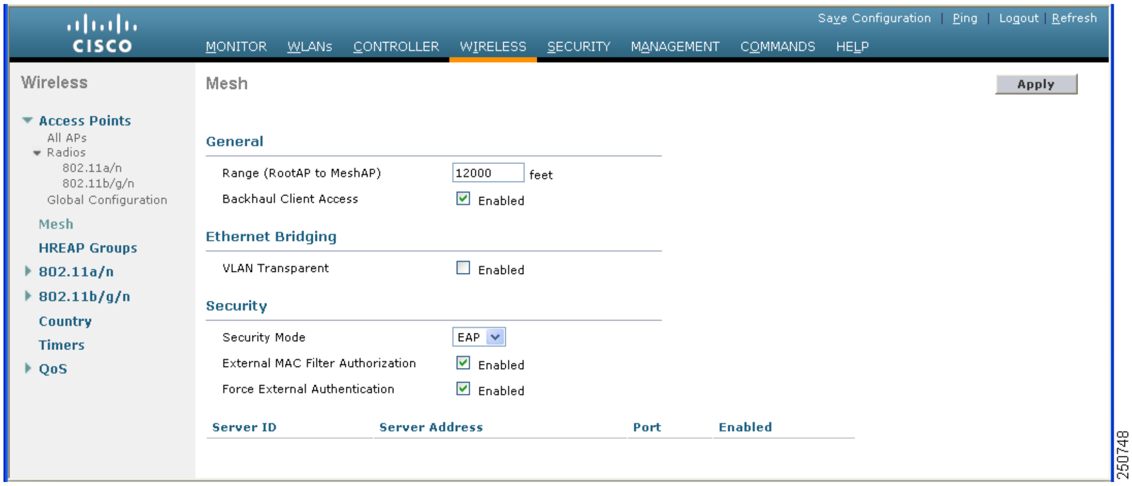
Note If you enter only the *platform_name_string–Ethernet_MAC_address* string to the user list, you will see a first-try failure log on the AAA server; however, the IOS-based mesh access point will still be authenticated on the second attempt using the *platform_name_string–Ethernet_MAC_address* string as the username.

Using the GUI to Enable External Authentication of Mesh Access Points

Using the controller GUI, follow these steps to enable external authentication for a mesh access point.

Step 1 Click **Wireless** > **Mesh** to open the Mesh page (see Figure 8-8).

Figure 8-8 Mesh Page



Step 2 Choose **EAP** from the Security Mode drop-down box.

Step 3 Check the **Enabled** check boxes for the External MAC Filter Authorization and Force External Authentication options.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Using the CLI to Enable External Authentication of Mesh Access Points

To enable external authentication for mesh access points using the CLI, enter the following commands:

config mesh security eap

config macfilter mac-delimiter colon

config mesh security rad-mac-filter enable

config mesh radius-server ***index*** **enable**

config mesh security force-ext-auth enable (Optional)

Using the CLI to View Security Statistics

To view security statistics for mesh access points using the CLI, enter the following command:

show mesh security-stats *Cisco_AP*

Command shows packet error statistics and a count of failures, timeouts, and association and authentication successes as well as reassociations and reauthentications for the specified access point and its child.

Configuring the AP Mode

Note This procedure is not required for 1520 series access points. The default mode for 1520 series access points is Bridge.

By default, access points are configured as Local. To configure the mesh access points, you first must change the access point mode to Bridge using the GUI or CLI.

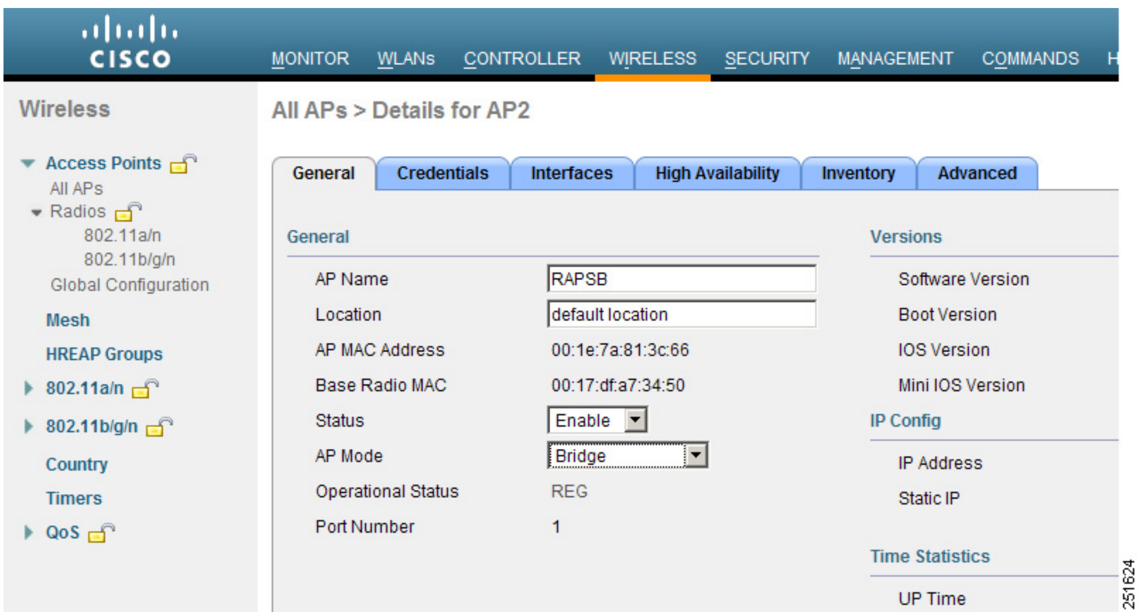
Using the GUI to Configure the AP Mode

To configure the AP mode using the GUI, follow these steps:

Step 1 Click **Wireless** to open the All APs page.

Step 2 Click the name of an access point. The All APs > Details (General) page appears (Figure 8-9).

Figure 8-9 All APs > Details for (General) Page



Step 3 Choose **Bridge** from the AP Mode drop-down box.

Step 4 Click **Apply** to commit your changes and to cause the access point to reboot.

Using the CLI to Configure the AP Mode

To configure the AP mode using the CLI, enter the following command:

config ap mode bridge *Cisco_AP*

Defining the Mesh Access Point Role

By default, the 152x mesh access points are shipped with a radio role set to MAP. You must reconfigure a mesh access point to act as a RAP.

Note In order to use the AP1130 and AP1240 indoor mesh access points with a 5500 series controller, a wplus license must be used on the controller.

Using the GUI to Configure the AP Role

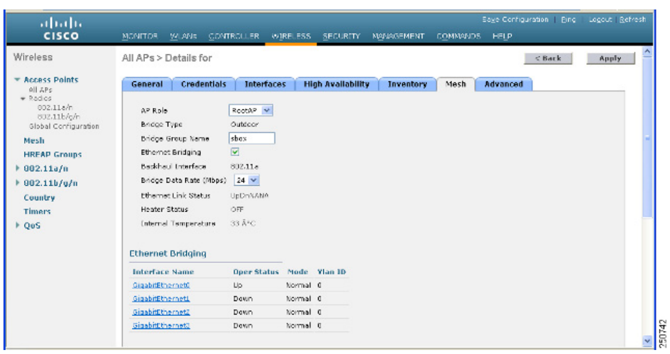
To configure the role of a mesh access point using the GUI, follow these steps:

Step 1 Click **Wireless** to open the All APs page.

Step 2 Click the name of an access point. The All APs > Details (General) page appears.

Step 3 Click the **Mesh** tab (Figure 8-10).

Figure 8-10 All APs > Details for (Mesh) Page



Step 4 Choose **RootAP or MeshAP** from the AP Role drop-down box.

Step 5 Click **Apply** to commit your changes and to cause the access point to reboot.

Using the CLI to Configure the AP Role

To configure the role of a mesh access point using the CLI, enter the following command:

config ap role {**rootAP** | **meshAP**} *Cisco_AP*

Antennas and Channel Assignment on the AP1524SB

The AP1524SB (serial backhaul) access point is introduced in controller software release 6.0. The AP1524SB has two backhaul radios: one uplink and one downlink. The AP1524SB is suitable for linear deployments.

The AP1524SB mesh access point operates as a RAP or a MAP. The antenna ports are labeled on the AP1524SB and are connected internally to the radios in each slot. The AP1524SB has six ports with three radio slots (0, 1, 2) as described in Table 8-4:

Table 8-4 AP1524SB Antenna Ports

Antenna Port	Radio Slot	Description
1	1	5 GHz Used for backhaul and universal client access
2	0	2.4 GHz Used for client access
3	0	2.4 GHz Used for client access
4	0	2.4 GHz Used for client access
5	–	Not connected
6	2	5 GHz Used for backhaul **Note** We recommend that you use the directional antenna on the MAPs for uplink on the slot 2 radio.

Note Depending on product model, the AP1524SB could have either 5.0-GHz radios or 5.8-GHz sub-band radios installed in slot 1 and slot 2. Regardless of the radios installed, the AP1524SB running controller software release 6.0 is restricted to the UNII-3 channels (149, 153, 157, 161, and 165) in slot 1 and slot 2.

The two 5.8-GHz radios are used for the serial backhaul, which provides uplink and downlink access. Each 5.8-GHz radio backhaul is configured with a different backhaul channel, so there is no need to use the same shared wireless medium between the north-bound and south-bound traffic in a mesh tree-based network.

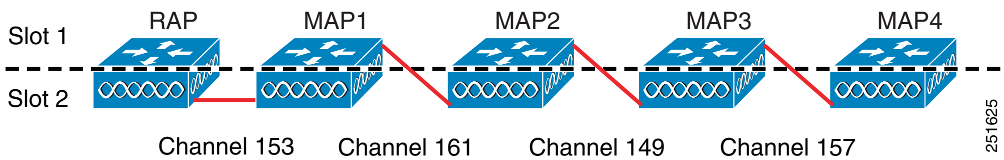
On the RAP, the radio in slot 2 is used to extend the backhaul in the downlink direction; the radio in slot 1 is used for client access.

On the MAP, the radio in slot 2 is used for the backhaul in the uplink direction; the radio in slot 1 is used for the backhaul in the downlink direction as well as client access.

You only need to configure the RAP downlink (slot 2) channel. The MAPs automatically select their channels from the channel subset. The available channels for the 5.8 GHz band are 149, 153, 157, 161, and 165.

Figure 8-11 shows a channel selection example when the RAP downlink channel is 153.

Figure 8-11 Channel Selections Examples

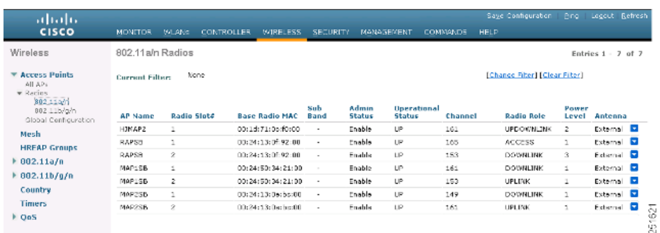


Using the GUI to Configure the Channels on the Serial Backhaul

Follow these steps to configure channels on the serial backhaul on the RAP using the controller GUI:

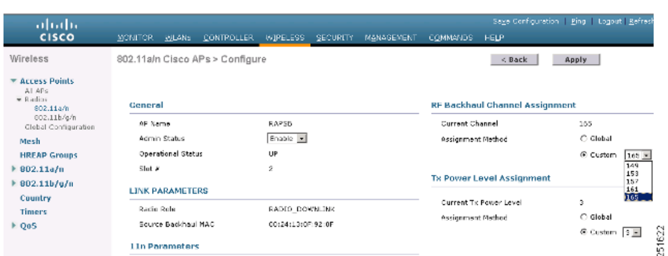
Step 1 Click **Wireless** > **Access Points** > **Radios** > **802.11a/n** to open the 802.11a/n Radios page (see Figure 8-12).

Figure 8-12 802.11a/n Radios Page



Step 2 Hover your cursor over the blue drop-down arrow for the RAP antenna in slot 2 (the backhaul downlink) and choose **Configure**. The 802.11a/n Cisco APs > Configure page appears (see Figure 8-13).

Figure 8-13 802.11a/n Cisco APs > Configure Page



Step 3 For the RF Backhaul Channel Assignment, choose the **Custom** assignment method, and select a channel from the drop-down list. The available channels for the 5.8-GHz band are 149, 153, 157, 161, and 165.

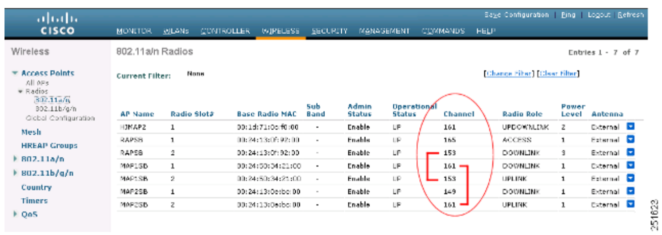
Step 4 For the Tx Power Level Assignment, choose the **Custom** assignment method, and select a power level. Valid values are 1 through 5; the default value is 1.

> **Note** Radio Resource Management (RRM) is disabled by default; RRM cannot be enabled for the backhaul.

Step 5 Click **Apply** to commit your changes.

Step 6 From the 802.11a/n Radios page, verify that uplink and downlink channels have been assigned (see Figure 8-14).

Figure 8-14 Channel Assignment



Using the CLI to Configure the Channels on the Serial Backhaul

Follow these steps to configure channels on the serial backhaul on the RAP using the controller CLI:

Step 1 To configure the backhaul channel on the radio in slot 2 of the RAP, enter this command:

config slot 2 channel ap *Cisco_RAPSB channel*

The available channels for the 5.8-GHz band are 149, 153, 157, 161, and 165.

Step 2 To configure the transmit power level on the radio in slot 2 of the RAP, enter this command:

config slot 2 txPower ap *Cisco_RAPSB power*

Valid values are 1 through 5; the default value is 1.

Step 3 To display the configurations on the mesh access points, enter these commands:

- **show mesh path** *MAP*

  Information similar to the following appears:

```
AP Name/Radio      Channel Rate Link-Snr Flags    State
-----------------  ------- ---- -------- -------  -----

MAP1SB             161     auto 60       0x10ea9d54 UPDATED NEIGH PARENT BEACON
RAPSB              153     auto 51       0x10ea9d54 UPDATED NEIGH PARENT BEACON
RAPSB             is a Root AP.
```

- **show mesh backhaul** *RAPSB*

  Information similar to the following appears:

```
Current Backhaul Slot(s)........................ 1, 2,

Basic Attributes for Slot  1
    Radio Type.................................. RADIO_TYPE_80211a
    Radio Role.................................. ACCESS
    Administrative State ....................... ADMIN_ENABLED
    Operation State ............................ UP
    Current Tx Power Level ..................... 1
    Current Channel ............................ 165
    Antenna Type................................ EXTERNAL_ANTENNA
    External Antenna Gain (in .5 dBm units)...... 0

Basic Attributes for Slot  2
    Radio Type.................................. RADIO_TYPE_80211a
    Radio Role.................................. RADIO_DOWNLINK
    Administrative State ....................... ADMIN_ENABLED
    Operation State ............................ UP
    Current Tx Power Level ..................... 3
    Current Channel ............................ 153
    Antenna Type................................ EXTERNAL_ANTENNA
    External Antenna Gain (in .5 dBm units)...... 0
```

- **show ap channel** *MAP1SB*

  Information similar to the following appears:

```
802.11b/g Current Channel ................ 11
Slot Id .................................. 0
Allowed Channel List...................... 1,2,3,4,5,6,7,8,9,10,11
802.11a(5.8Ghz) Current Channel ........... 161
Slot Id .................................. 1
Allowed Channel List...................... 149,153,157,161,165
802.11a(5.8Ghz) Current Channel ........... 153
Slot Id .................................. 2
Allowed Channel List...................... 149,153,157,161,165
```

Configuring Global Mesh Parameters

This section provides instructions for configuring the access point to establish a connection with the controller including:

- Setting the maximum range between RAP and MAP (not applicable to 1130 and 1240 indoor mesh access points)
- Enabling a backhaul to carry client traffic
- Defining whether VLAN tags are forwarded or not
- Defining the authentication mode (EAP or PSK) and method (local or external) for mesh access points including security settings (local and external authentication).

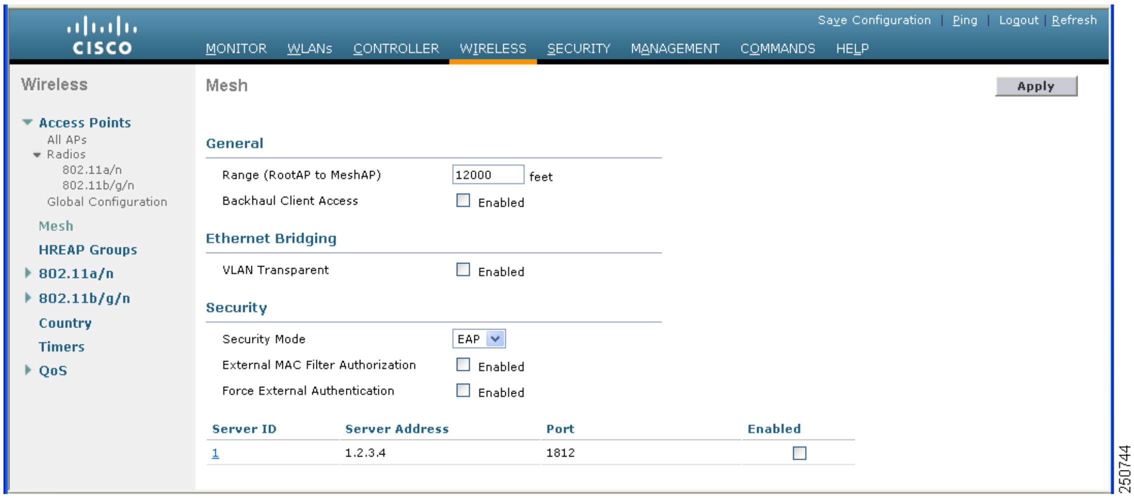
You can configure the necessary mesh parameters using the controller GUI or CLI. All parameters are applied globally.

Using the GUI to Configure Global Mesh Parameters

Using the controller GUI, follow these steps to configure global mesh parameters.

Step 1 Click **Wireless** > **Mesh** to open the Mesh page (see Figure 8-15).

Figure 8-15 Mesh Page



Step 2 Modify the mesh parameters as appropriate. Table 8-5 describes each parameter.

Table 8-5 Global Mesh Parameters

Parameter	Description
Range (RootAP to MeshAP)	**Note** This parameter applies to outdoor mesh access point. The optimum distance (in feet) that should exist between the root access point (RAP) and the mesh access point (MAP). This global parameter applies to all access points when they join the controller and all existing access points in the network. **Range:** 150 to 132,000 feet **Default:** 12,000 feet **Note** After this feature is enabled, all outdoor mesh access points reboot.
IDS (Rogue and Signature Detection	**Note** This parameter applies to outdoor mesh access points. When you enable this feature, IDS reports are generated for all traffic on the backhaul. These reports can be useful for university or enterprise outdoor campus areas, or for public safety users who want to find out who is operating in 4.9 GHz. When you disable this feature, no IDS reports are generated, which preserves bandwidth on the backhaul. **Note** IDS reporting is enabled for all indoor mesh access points and cannot be disabled. **Default:** Disabled

Table 8-5 Global Mesh Parameters (continued)

Parameter	Description
Backhaul Client Access	**Note** This parameter applies to mesh access points with two or more radios (1524SB, 1522, 1240 and 1130) *excluding* the 1524PS. When this feature is enabled, mesh access points allow wireless client association over the 802.11a radio. Therefore, a mesh access point can carry both backhaul traffic and 802.11a client traffic over the same 802.11a radio. When this feature is disabled, the mesh access point carries backhaul traffic over the 802.11a radio and allows client association only over the 802.11b/g radio. **Default:** Disabled **Note** After this feature is enabled, all mesh access points reboot.
VLAN Transparent	This feature determines how a mesh access point handles VLAN tags for Ethernet bridged traffic. **Note** See the "Configuring Ethernet Bridging and Ethernet VLAN Tagging" section on page 8-31 for overview and additional configuration details. When this feature is enabled, VLAN tags are not handled and packets are bridged as if they are untagged. When this feature is disabled, all packets are tagged as non-VLAN transparent or VLAN-opaque and all tagged packets are dropped. Unselect the check box to enable the VLAN Tagging feature. **Note** VLAN Transparent is enabled as a default to ensure a smooth software upgrade from 4.1.192.xxM releases to release 5.2 or later releases. Release 4.1.192.xxM does not support VLAN tagging. **Note** See the "Configuring Ethernet Bridging and Ethernet VLAN Tagging" section on page 8-31 for more details. The default is Enabled.
Security Mode	Defines the security mode for mesh access points: Pre-Shared Key (PSK) or Extensible Authentication Protocol (EAP). **Note** EAP must be selected if external MAC filter authorization using a RADIUS server is configured. **Note** Local EAP or PSK authentication is performed within the controller if the External MAC Filter Authorization parameter is disabled (check box unchecked). **Options:** PSK or EAP **Default:** EAP

Table 8-5 Global Mesh Parameters (continued)

Parameter	Description

External MAC Filter Authorization	MAC filtering uses the local MAC filter on the controller by default.
	
	When external MAC filter authorization is enabled, if the MAC address is not found in the local MAC filter, then the MAC address in the external RADIUS server is used.
	
	This protects your network against rogue mesh access points by preventing access points that are not defined on the external server from joining.
	
	Before you employ external authentication within the mesh network, the following configuration is required:
	• The RADIUS server to be used as an AAA server must be configured on the controller.
	• The controller must also be configured on the RADIUS server.
	• The mesh access point configured for external authorization and authentication must be added to the user list of the RADIUS server.
	  – For remote authorization and authentication, EAP-FAST uses the manufacturer's certificate (CERT) to authenticate the child mesh access point. Additionally, this manufacturer certificate-based identity serves as the username for the mesh access point in user validation.
	  – For IOS-based mesh access points (1130, 1240, 1522, 1524), in addition to adding the MAC address to the user list, you need to enter the *platform_name_string-Ethernet_MAC_address* string (for example, c1240-001122334455). The controller first sends the MAC address as the username; if this first attempt fails, the controller sends the *platform_name_string-Ethernet_MAC_address* string as the username.
	
	Note If you only enter the *platform_name_string-Ethernet_MAC_address* string to the user list, you will see a first-try failure log on the AAA server; however, the IOS-based mesh access point will still be authenticated on the second attempt using the *platform_name_string–Ethernet_MAC_address* string as the username.
	
	• The certificates must be installed and EAP-FAST must be configured on the RADIUS server. See the "Configuring RADIUS Servers" section on page 8-14 section for information on installing certificates.
	
	Note When this capability is not enabled, the controller authorizes and authenticates mesh access points using the MAC address filter.
	
	Default: Disabled.

Force External Authorization	When enabled along with *EAP* and *External MAC Filter Authorization* parameters, an external RADIUS server (such as Cisco 4.1 and later) handles external authorization and authentication for mesh access points by default. The RADIUS server overrides local authentication of the MAC address by the controller which is the default. **Default:** Disabled.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure Global Mesh Parameters

Using the controller CLI, follow these steps to configure global mesh parameters.

Note Refer to the "Using the GUI to Configure Global Mesh Parameters" section on page 8-23 for descriptions, valid ranges, and default values of the parameters used in the CLI commands.

Step 1 To specify the maximum range (in feet) of all access points in the network, enter this command:

config mesh range *feet*

To see the current range, enter **show mesh range**.

Step 2 To enable or disable IDS reports for all traffic on the backhaul, enter this command:

config mesh ids-state {**enable** | **disable**}

Step 3 To specify the rate (in Mb/s) at which data is shared between access points on the backhaul interface, enter this command:

config ap bhrate {*rate* | **auto**} *Cisco_AP*

Step 4 To enable or disable client association on the primary backhaul (802.11a) of an access point, enter these commands:

config mesh client-access {**enable** | **disable**}

config ap wlan {**enable** | **disable**} **802.11a** *Cisco_AP*

config ap wlan {add | delete} 802.11a *wlan_id Cisco_AP*

Step 5 To enable or disable VLAN transparent, enter this command:

config mesh ethernet-bridging vlan-transparent {enable | disable}

Step 6 To define a security mode for the mesh access point, enter one of the following commands:

a. To provide local authentication of the mesh access point by the controller, enter this command: **config mesh security {eap | psk}**

b. To store MAC address filter in an external RADIUS server for authentication instead of the controller (local), enter these commands:

config macfilter mac-delimiter colon

config mesh security rad-mac-filter enable

config mesh radius-server *index* enable

c. To provide external authentication on a RADIUS server and define a local MAC filter on the controller, enter these commands:

config mesh security eap

config macfilter mac-delimiter colon

config mesh security rad-mac-filter enable

config mesh radius-server *index* **enable**

config mesh security force-ext-auth enable

d. To provide external authentication on a RADIUS server using a MAC username (such as *c1520-123456*) on the RADIUS server, enter these commands:

config macfilter mac-delimiter colon

config mesh security rad-mac-filter enable

config mesh radius-server *index* enable

config mesh security force-ext-auth enable

Step 7 To save your changes, enter this command:

save config

Using the CLI to View Global Mesh Parameter Settings

Use these commands to obtain information on global mesh settings:

- **show mesh client-access**—Shows the status of the client-access backhaul as either enabled or disabled. When this option is enabled, mesh access points are able to associate with 802.11a wireless clients over the 802.11a backhaul. This client association is in addition to the existing communication on the 802.11a backhaul between the root and mesh access points.

```
controller >show mesh client-access
Backhaul with client access status: enabled
```

- **show mesh ids-state—**Shows the status of the IDS reports on the backhaul as either enabled or disabled.

```
controller >show mesh ids-state
Outdoor Mesh IDS(Rogue/Signature Detect): .... Disabled
```

- **show mesh env** {**summary** | *Cisco_AP*}—Shows the temperature, heater status, and Ethernet status for either all access points (summary) or a specific access point (*Cisco_AP*). The access point name, role (RootAP or MeshAP), and model are also shown.
  - The temperature is shown in both Fahrenheit and Celsius.
  - The heater status is ON or OFF.
  - The Ethernet status is UP or DOWN.

Note Battery status appears as N/A (not applicable) in the **show mesh env** *Cisco_AP* status display because it is not provided for access points.

```
controller >show mesh env summary

AP Name             Temperature(C/F)  Heater  Ethernet  Battery
------------------  ----------------  ------  --------  -------
SB_RAP1              39/102           OFF     UpDnNANA  N/A
SB_MAP1              37/98            OFF     DnDnNANA  N/A
SB_MAP2              42/107           OFF     DnDnNANA  N/A
SB_MAP3              36/96            OFF     DnDnNANA  N/A

controller >show mesh env SB_RAP1

AP Name......................................... SB_RAP1
AP Model........................................ AIR-LAP1522AG-A-K9
AP Role......................................... RootAP
```

```
Temperature.................................... 39 C, 102 F
Heater......................................... OFF
Backhaul....................................... GigabitEthernet0

GigabitEthernet0 Status........................ UP
    Duplex..................................... FULL
    Speed...................................... 100
    Rx Unicast Packets......................... 988175
    Rx Non-Unicast Packets..................... 8563
    Tx Unicast Packets......................... 106420
    Tx Non-Unicast Packets..................... 17122
GigabitEthernet1 Status........................ DOWN
  POE Out...................................... OFF

Battery........................................ N/A
```

Configuring Local Mesh Parameters

After configuring global mesh parameters, you must configure the following local mesh parameters:

- Antenna Gain—Refer to the "Configuring Antenna Gain" section on page 8-28.
- Workgroup Bridge Groups—Refer to the "Workgroup Bridge Groups on Mesh Access Points" section on page 8-30.

Configuring Antenna Gain

Using the controller GUI or controller CLI, configure the antenna gain for the access point to match that of the installed antenna.

Note Refer to the "External Antennas" section of the *Cisco Aironet 1520 Series Outdoor Mesh Access Points Getting Started Guide* for a summary of supported antennas and their antenna gains at http://www.cisco.com/en/US/docs/wireless/access_point/1520/quick/guide/ap1520qsg.html

Using the GUI to Configure Antenna Gain

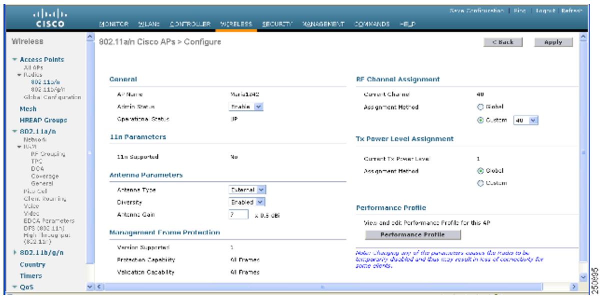
Using the controller GUI, follow these steps to configure the antenna gain.

Step 1 Click **Wireless** > **Access Points** > **Radios** > **802.11a/n** to open the 802.11a/n Radios page (see Figure 8-16).

Figure 8-16 802.11a/n Radios Page

Step 2 Hover your cursor over the blue drop-down arrow for the mesh access point antenna that you want to configure and choose **Configure**. The 802.11a/n Cisco APs > Configure page appears (see Figure 8-17).

Figure 8-17 802.11a/n Cisco APs > Configure Page



Step 3 Under the Antenna Parameters section, enter the antenna gain in 0.5-dBm units in the Antenna Gain field. For example, 2.5 dBm = 5.

Note You can configure gain settings only on external antennas. The value that you enter must match the value specified by the vendor for that antenna.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Using the CLI to Configure Antenna Gain

Using the controller CLI, follow these steps to configure the antenna gain.

Step 1 To configure the antenna gain for the 802.11a backhaul radio, enter this command:

config 802.11a antenna extAntGain *antenna_gain Cisco_AP*

where *antenna_gain* is in 0.5-dBm units (for example, 2.5 dBm = 5).

Step 2 To save your changes, enter this command:

save config

Workgroup Bridge Groups on Mesh Access Points

A workgroup bridge (WGB) connects a wired network over a single wireless segment by learning the MAC addresses of its wired clients on the Ethernet interface and reporting them to the mesh access point using Internet Access Point Protocol (IAPP) messaging. The mesh access point treats the WGB as a wireless client.

When configured as a WGB, the 1130, 1240, and 1310 autonomous access points as well as the series 3200 mobile access router (MAR) can associate with mesh access points. The mesh access points can be configured as RAPs or MAPs. WGB association is supported on both the 2.4-GHz (802.11b) and 5-GHz (802.11a) radio on the 1522, and the 2.4-GHz (802.11b) and 4.9-GHz (public safety radio) on the 1524PS.

Note Refer to the "Cisco Workgroup Bridges" section on page 7-61 for configuration details.

Supported Workgroup Modes and Capacities

- The 1130, 1240, 1310 autonomous access point must be running Cisco IOS release 12.4(3g)JA or later (on 32-MB access points) or Cisco IOS release 12.3(8)JEB or later (on 16-MB access points). Cisco IOS releases prior to 12.4(3g)JA and 12.3(8)JEB are not supported.

  Note If your mesh access point has two radios, you can only configure workgroup bridge mode on one of the radios. Cisco recommends that you disable the second radio. Workgroup bridge mode is not supported on access points with three radios such as 1524.

- Client mode WGB (BSS) is supported; however, infrastructure WGB is not supported.
- Mesh access points can support up to 200 clients including wireless clients, WGBs, and wired clients behind the associated WGBs.
- WGBs operating with Cisco IOS release 12.4(3g)JA cannot associate with mesh access points if the WLAN is configured with WPA1 (TKIP) +WPA2 (AES), and the corresponding WGB interface is configured with only one of these encryptions (either WPA1 or WPA2).

Client Roaming

High-speed roaming of Cisco Compatible Extension (CX), version 4 (v4) clients is supported at speeds up to 70 mph in outdoor mesh deployments of 1522 and 1524 mesh access points. An application example might be maintaining communication with a terminal in an emergency vehicle as it moves within a mesh public network.

Three Cisco CX v4 Layer 2 client roaming enhancements are supported:

- **Access point assisted roaming**—This feature helps clients save scanning time. When a Cisco CX v4 client associates to an access point, it sends an information packet to the new access point listing the characteristics of its previous access point. Roaming time decreases when the client recognizes and uses an access point list built by compiling all previous access points to which each client was associated and sent (unicast) to the client immediately after association. The access point list contains the channels, BSSIDs of neighbor access points that support the client's current SSID(s), and time elapsed since disassociation.
- **Enhanced neighbor list**—This feature focuses on improving a Cisco CX v4 client's roam experience and network edge performance, especially when servicing voice applications. The access point provides its associated client information about its neighbors using a neighbor-list update unicast message.

- **Roam reason report**—This feature enables Cisco CX v4 clients to report the reason why they roamed to a new access point. It also allows network administrators to build and monitor a roam history.

Note Client roaming is enabled by default.

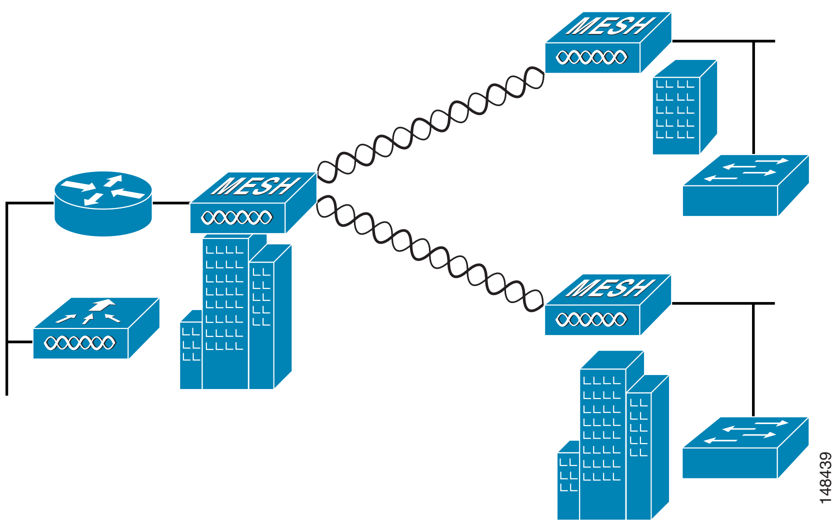
Configuring Ethernet Bridging and Ethernet VLAN Tagging

Ethernet bridging is used in two mesh network scenarios:

- Point-to-point and point-to-multipoint bridging between MAPs (untagged packets). A typical trunking application might be bridging traffic between buildings within a campus (Figure 8-18).

  Note You do not need to configure VLAN tagging to use Ethernet bridging for point-to-point and point-to-multipoint bridging deployments.

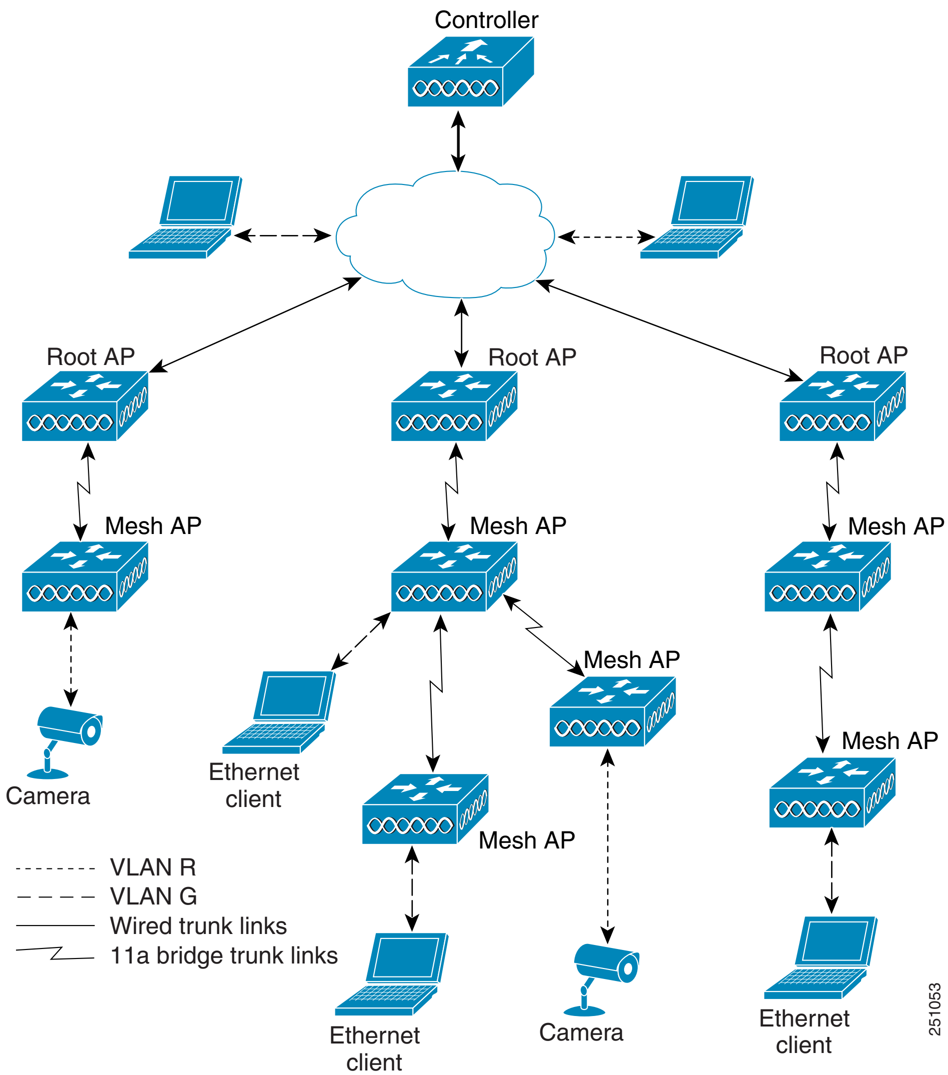
Figure 8-18 Point-to-Multipoint Bridging



- Ethernet VLAN tagging allows specific application traffic to be segmented within a wireless mesh network and then forwarded (bridged) to a wired LAN (access mode) or bridged to another wireless mesh network (trunk mode).

  A typical public safety access application using Ethernet VLAN tagging is placement of video surveillance cameras at various outdoor locations within a city. Each of these video cameras has a wired connection to a MAP. The video of all these cameras is then streamed across the wireless backhaul to a central command station on a wired network (see Figure 8-19).

Figure 8-19 Ethernet VLAN Tagging



Ethernet VLAN Tagging Guidelines

- For security reasons the Ethernet port on a mesh access point (RAP and MAP) is disabled by default. It is enabled by configuring Ethernet Bridging on the mesh access point port.
- Ethernet bridging must be enabled on all the access points in the mesh network to allow Ethernet VLAN tagging to operate.
- VLAN mode must be set as non-VLAN transparent (global mesh parameter). Refer to "Configuring Global Mesh Parameters" section on page 8-22.
  - VLAN transparent is enabled by default. To set as non-VLAN transparent you must uncheck the VLAN transparent option in the global mesh parameters window.
- VLAN configuration on a mesh access point is only applied if all the uplink mesh access points are able to support that VLAN.
  - If uplink access points are not able to support the VLAN, then the configuration is stored rather than applied.

- VLAN tagging can only be configured on Ethernet interfaces.
  - On 152x mesh access points, three of the four ports can be used as *secondary Ethernet interfaces*: *port 0-PoE in, port 1-PoE out, and port 3- fiber. Port 2 - cable* cannot be configured as a secondary Ethernet interface.
  - In Ethernet VLAN tagging, *port 0-PoE in* on the RAP is used to connect to the trunk port of the switch of the wired network. *Port 1-PoE out* on the MAP is used to connect to external devices such as video cameras.
- Backhaul interfaces (802.11a radios) act as *primary Ethernet interfaces*. Backhauls function as trunks in the network and carry all VLAN traffic between the wireless and wired network. No configuration of primary Ethernet interfaces is required.
- The switch port in the wired network that is attached to the RAP (*port 0–PoE in*) must be configured to accept tagged packets on its trunk port. The RAP forwards all tagged packets received from the mesh network to the wired network.
- No configuration is required to support VLAN tagging on any 802.11a backhaul Ethernet interface within the mesh network.
  - This includes the RAP uplink Ethernet port. The required configuration happens automatically using a registration mechanism.
  - Any configuration changes to an 802.11a Ethernet link acting as a backhaul are ignored and a warning results. When the Ethernet link no longer functions as a backhaul the modified configuration is applied.
- VLAN configuration is not allowed on port-02-cable modem port of an 152x access point. VLANs can be configured on ports 0 (PoE-in), 1 (PoE-out) and 3 (fiber).
- If bridging between two MAPs, enter the distance (mesh range) between the two access points that are bridging. (Not applicable to applications in which you are forwarding traffic connected to the MAP to the RAP, access mode)
- Up to 16 VLANs are supported on each sector. Therefore, the cumulative number of VLANs supported by a RAP's children (MAPs) cannot exceed 16.
- Ethernet ports on access points function as either *access* or *trunk* ports within an Ethernet tagging deployment.
- Access Mode– In this mode only untagged packets are accepted. All packets are tagged with a user-configured VLAN called access-VLAN. For this mode to take effect, the global VLAN mode should be non-VLAN transparent.
  - This option is used for applications in which information is collected from devices connected to the MAP such as cameras or PCs and then forwarded to the RAP. The RAP then applies tags and forwards traffic to a switch on the wired network.
- Trunk mode—This mode requires the user to configure a native VLAN and an allowed VLAN list (no defaults). In this mode, both tagged and untagged packets are accepted. Untagged packets are always accepted and are tagged with the user specified native VLAN. Tagged packets are accepted if they are tagged with a VLAN in the allowed VLAN list. For this mode to take effect, the global VLAN mode should be non-VLAN transparent.
  - This option is used for bridging applications such as forwarding traffic between two MAPs resident on separate buildings within a campus.
- The switch port connected to the RAP must be a trunk.
  - The trunk port on the switch and the RAP trunk port must match.
- A configured VLAN on a MAP Ethernet port cannot function as a Management VLAN.

- The RAP must always connect to the native VLAN (ID 1) on a switch.
  - The RAP's primary Ethernet interface is by default the native VLAN of 1.

Note You cannot bridge VLAN ID 1 when using VLAN-Opaque Ethernet bridging because VLAN 1 is the internal native VLAN within a mesh network. This setting cannot be changed.

Using the GUI to Enable Ethernet Bridging and VLAN Tagging

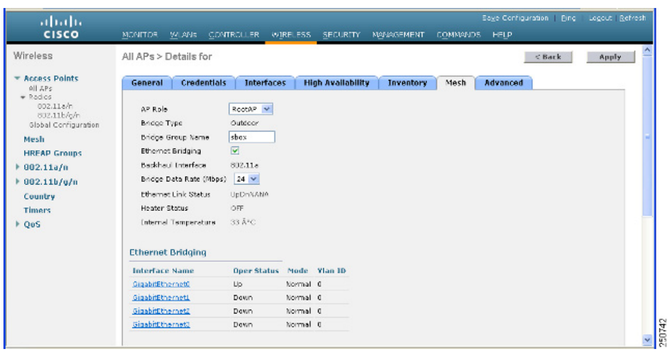
Using the controller GUI, follow these steps to enable Ethernet bridging on a RAP or MAP.

Step 1 Click **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to enable Ethernet bridging.

Step 3 Click the **Mesh** tab to open the All APs > Details for (Mesh) page (see Figure 8-20).

Figure 8-20 All APs > Details for (Mesh) Page



Step 4 Choose one of the following options from the AP Role drop-down box.

- **MeshAP**—Choose this option if the 1520 series access point has a wireless connection to the controller. This is the default setting.
- **RootAP**—Choose this option if the 1520 series access point has a wired connection to the controller.

Note You must set at least one mesh access point to RootAP in the mesh network.

Step 5 To assign this access point to a bridge group, enter a name for the group in the Bridge Group Name field.

Step 6 Check the **Ethernet Bridging** check box to enable Ethernet bridging or uncheck it to disable this feature.

Step 7 Select the appropriate backhaul rate for the 802.11a backhaul interface from the **Bridge Data Rate** drop-down menu. Cisco recommends setting the backhaul rate to **auto**.

When the bridge data rate is set to **auto**, the mesh backhaul picks the highest rate where the next higher rate cannot be used due to unsuitable conditions for that specific rate (and not because of conditions that affect all rates).

Step 8 Click **Apply** to commit your changes. An Ethernet Bridging section appears at the bottom of the page listing each of the Ethernet ports of the mesh access point.

Step 9 You can perform one of the following procedures to configure the Ethernet Ports. The options are as follows:

- Configure the Ethernet Port as the Access Port
- Configure the Ethernet Port as the Trunk Port

Configure the Ethernet Port as the Access Port

To configure the ethernet port as the access port, follow these steps:

a. Click **gigabitEthernet1** (port 1-PoE out).

b. Select **access** from the mode drop-down menu.

c. Enter a VLAN ID. The VLAN ID can be any value between 2 and 4095.

> **Note** You cannot bridge VLAN ID 1 when using VLAN-Opaque Ethernet bridging because VLAN 1 is the internal native VLAN within a mesh network. This setting cannot be changed.

> **Note** A maximum of 16 VLANs are supported across all of a RAP's subordinate MAPs.

Configure the Ethernet Port as the Trunk Port

To configure the ethernet port as the trunk port, follow these steps:

a. Click **gigabitEthernet1** (port 0-PoE in), **gigabitEthernet1**(port 1-PoE out), or **gigabitEthernet1** (port 3- fiber).

b. Select **trunk** from the mode drop-down menu.

c. Enter a native VLAN ID for *incoming* traffic. The native VLAN ID can be any value between 2 and 4095. Do not assign any value assigned to a user-VLAN (access).

d. Enter a trunk VLAN ID for *outgoing* packets:

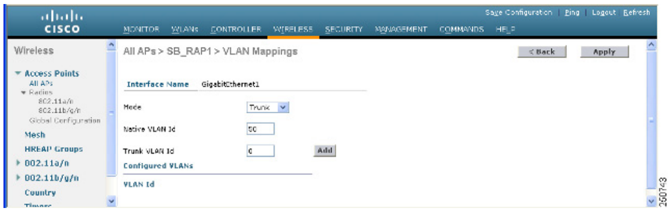
e. If forwarding *untagged* packets, do not change the default trunk VLAN ID value of zero. (MAP-to-MAP bridging, campus environment)

f. If forwarding *tagged* packets, enter a VLAN ID (2 to 4095) that is not already assigned. (RAP to switch on wired network).

g. Click **Add** to add the trunk VLAN ID to the allowed VLAN list. The newly added VLAN displays under the Configured VLANs section on the window.

> **Note** To remove a VLAN from the list, select the Remove option from the arrow drop-down to the right of the desired VLAN.

Figure 8-21 All APs > AP > VLAN Mappings Page



Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Table 8-6 describes display-only parameters on the mesh page.

Table 8-6 Display Parameters for Access Points

Parameter	Description
Bridge type	Displays either outdoor (152x access points) or indoor (1130 or 1240 access points)
Backhaul Interface	Displays the radio band that this MAP uses to transfer data to other MAPs. The only possible value is 802.11a.
Ethernet Link Status	Displays the up or down status of the Ethernet link of the AP152x. The Up or Down (Dn) status of the four Ethernet ports is reported in the following format: port0:port1:port2:port3. For example, *UpDnDnDn* indicates that port0 is Up and ports 1, 2, and 3 are Down (Dn). **Note** If *NA* displays in the status string, then the port has no wired connection to that port.
Heater Status	Displays status of either ON or OFF.
Internal Temperature	Displays the internal temperature of the 1522 and 1524PS/1524SB.

Using the CLI to Configure Ethernet Bridging Parameters

Using the controller CLI, follow these steps to configure Ethernet bridging on a RAP or MAP.

Step 1 To specify that your AP152x has bridge functionality, enter this command:

config ap mode bridge *Cisco_AP*

Step 2 To specify the role of this access point in the mesh network, enter this command:

config ap role {**rootAP** | **meshAP**} *Cisco_AP*

Use the **meshAP** parameter if the access point has a wireless connection to the controller or use the **rootAP** parameter if the access point has a wired connection to the controller.

Note The default access point role is **meshAP**.

Step 3 To assign the access point to a bridge group, enter this command:

config ap bridgegroupname set *groupname Cisco_AP*

Step 4 To enable Ethernet bridging on the access point, enter this command:

config mesh ethernet-bridging vlan transparent *disable*

Step 5 To specify the rate (in Mb/s) at which data is shared between access points on the backhaul interface, enter this command:

config ap bhrate {*rate* | **auto**} *Cisco_AP*

When the bridge data rate is set to **auto**, the mesh backhaul picks the highest rate where the next higher rate cannot be used due to unsuitable conditions for that rate (and not because of conditions that affect all rates).

Step 6 To save your settings, enter this command:

save config

Using the CLI to Configure Ethernet VLAN Tagging

VLAN ID 1 is not reserved as the default VLAN.

A maximum of 16 VLANs are supported across all of a RAP's subordinate MAPs.

A VLAN ID can be any value between 1 and 4095. Do not assign any value assigned to another VLAN.

- To configure a MAP access port, enter this command:

  config ap ethernet 1 mode access enable *AP1520-MAP 50*

  where *AP1520-MAP* is the variable *Cisco_AP* and *50* is the variable *access_vlan ID*

- To configure a RAP or MAP trunk port, enter this command:

  config ap ethernet 0 mode trunk enable *AP1520-MAP 60*

  where *AP1520-MAP* is the variable *Cisco_AP* and *60* is the variable *native_vlan ID*

  – To add a VLAN to the VLAN allowed list of the native VLAN, enter this command:

    config ap ethernet 0 mode trunk add *AP1522-MAP3 65*

    where *AP1522-MAP 3* is the variable *Cisco_AP* and *65* is the variable *vlan ID*

Configuring Advanced Features

- Configuring Voice Parameters in Mesh Networks, page 8-38
- Enabling Mesh Multicast Containment for Video, page 8-44

Configuring Voice Parameters in Mesh Networks

You can configure call admission control (CAC) and QoS on the controller to manage voice quality on the mesh network.

Note Voice is supported only on indoor mesh networks (1130 and 1240 access points).

CAC

CAC enables an access point to maintain controlled quality of service (QoS) when the wireless LAN is experiencing congestion. The Wi-Fi Multimedia (WMM) protocol deployed in CCXv3 ensures sufficient QoS as long as the wireless LAN is not congested. However, in order to maintain QoS under different network loads, CAC in CCXv4 or later is required.

Note CAC is supported in Cisco Compatible Extensions (CCX) v4 or later. See the "Configuring Cisco Client Extensions" section on page 6-19 for more information on CCX.

All calls on a mesh access point use bandwidth-based CAC. Load-based CAC is not supported.

Bandwidth-based, or static CAC enables the client to specify how much bandwidth or shared medium time is required to accept a new call. Each access point determines whether it can accommodate a particular call by looking at the bandwidth available and compares it against the bandwidth required for the call. If not enough bandwidth is available to maintain the maximum allowed number of calls with acceptable quality, the access point rejects the call.

QoS and DSCP Marking

QoS 802.11e is supported on the access and backhaul radios of mesh access points. MAPs can prioritize client traffic based on the QoS setting defined on the controller. CAC is implemented on the backhaul.

Mesh access points recognize DSCP markings from devices. DSCP is performed on the originating Cisco 7920 voice handset (client) and the terminating voice handset or terminal. No DSCP marking is performed on the controller, MAP or CAC.

Note QoS only is relevant when there is congestion on the network.

You can configure bandwidth-based CAC and QoS for mesh networks using the controller GUI or CLI. The instructions for configuring these features is the same for both mesh and non-mesh networks with the exception of QoS settings.

- Follow the instructions in the "Configuring Voice and Video Parameters" section on page 4-73 to configure voice and video parameters.
  - Refer to the "Guidelines for Using Voice on the Mesh Network" section on page 8-39 for mesh-specific configuration guidelines for voice including QoS.

The instructions for viewing voice and video details using the CLI are different for mesh and non-mesh access points.

- Follow the instructions in the "Using the CLI to View Voice Details for Mesh Networks" section on page 8-41 to view details for mesh access points.

Guidelines for Using Voice on the Mesh Network

- Voice is only supported on indoor mesh access points, 1130 and 1240.
- When voice is operating on a mesh network, calls must not traverse more than two hops.
  - Each sector must be configured to require no more than two hops for voice.

- On the **802.11a** or **802.11b/g/n >** *Global* parameters window:
  - Enable dynamic target power control (DTPC)
  - Disable all data rates less than 11 Mbps
- On the **802.11a** or **802.11b/g/n >** *Voice* parameters window:
  - Load-based CAC must be disabled
  - Enable admission control (ACM) for CCXv4 or v5 clients that have WMM enabled. Otherwise, bandwidth-based CAC does not operate properly.
  - Set the maximum RF bandwidth to 50%
  - Set the reserved roaming bandwidth to 6%
  - Enable traffic stream metrics
- On the **802.11a** or **802.11b/g/n >** *EDCA* parameters window:
  - Set the EDCA profile for the interface as voice optimized
  - Disable low latency MAC
- On the **QoS >** *Profile* window:
  - Create a voice profile and select 802.1q as the wired QoS protocol type
- On the **WLANs >** *Edit* > *QoS* window:
  - Select a QoS of platinum for voice and gold for video on the backhaul
  - Select allowed as the WMM policy
- On the **WLANs >** *Edit* > *QoS* window:
  - Select CCKM for authorization (*auth*) key management (*mgmt*) if you want to support fast roaming. Refer to the "Client Roaming" section on page 8-30
- On the **x >** ***y*** window:
  - Disable voice active detection (VAD)

Voice Call Support in a Mesh Network

Table 8-7 lists a projected minimum and maximum of voice calls supported by radio type and mesh access point role (RAP or MAP) for planning purposes.

Table 8-7 Projected Voice Call Support on a Mesh Network

Mesh Access Point Role	Radio	Minimum Calls Supported[1]	Maximum Calls Supported[2]
RAP	802.11a	14	18
	802.11b/g/n	14	18
MAP1	802.11a	6	9
	802.11b/g/n	11	18
MAP2	802.11a	4	7
	802.11b/g/n	5	9

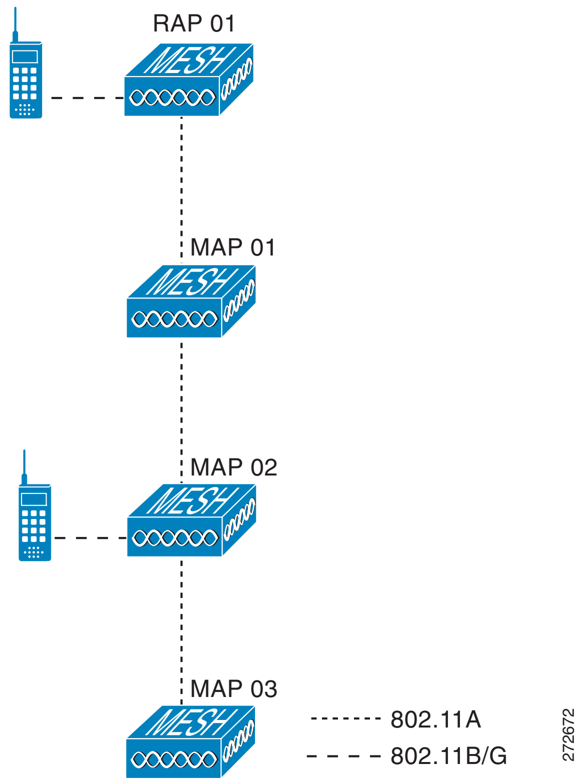
1. Bandwidth of 855 transmit units (TUs) with 50% of the bandwidth reserved for voice calls.
2. Bandwidth of 1076 TUs with 50% of the bandwidth reserved for voice calls.

Using the CLI to View Voice Details for Mesh Networks

Use the commands in this section to view details on voice calls on the mesh network.

Refer to Figure 8-22 when using the CLI commands and viewing their output.

Figure 8-22 Mesh Network Example



- To view the total number of voice calls and the bandwidth used for voice calls on each root access point, enter this command:

  show mesh cac summary

  Information similar to the following appears:

```
AP Name          Slot#   Radio  BW Used/Max  Calls
------------    -------  -----  -----------  -----
SB_RAP1              0   11b/g     0/23437     0
                     1   11a       0/23437     2
SB_MAP1              0   11b/g     0/23437     0
                     1   11a       0/23437     0
SB_MAP2              0   11b/g     0/23437     0
                     1   11a       0/23437     0
SB_MAP3              0   11b/g     0/23437     0
                     1   11a       0/23437     0
```

- To view the mesh tree topology for the network and the bandwidth utilization (used/maximum available) of voice calls and video links for each access point and radio, enter this command:

  show mesh cac bwused {**voice** | **video**} *Cisco_AP*

Information similar to the following appears:

```
AP Name       Slot#    Radio      BW Used/Max
------------- -------  -----      -----------
SB_RAP1         0      11b/g       1016/23437
                1      11a         3048/23437
|SB_MAP1        0      11b/g       0/23437
                1      11a         3048/23437
||   SB_MAP2    0      11b/g       2032/23437
                1      11a         3048/23437
|||  SB_MAP3    0      11b/g       0/23437
                1      11a         0/23437
```

Note The bars (|) to the left of the AP Name field indicate the number of hops that the mesh access point is away from its root access point (RAP).

Note When the radio type is the same, the backhaul bandwidth used (bw used/max) at each hop is identical. For example, mesh access points *map1*, *map2*, *map3*, and *rap1* are all on the same radio backhaul (802.11a) and are using the same bandwidth (3048). All of the calls are in the same interference domain. A call placed anywhere in that domain affects the others.

- To view the mesh tree topology for the network and display the number of voice calls that are in progress by access point radio, enter this command:

  show mesh cac access *Cisco_AP*

```
Information similar to the following appears:

AP Name             Slot#   Radio     Calls
-------------      -------  -----     -----
SB_RAP1               0      11b/g      0
                      1      11a        0
|    SB_MAP1          0      11b/g      0
                      1      11a        0
||   SB_MAP2          0      11b/g      1
                      1      11a        0
|||  SB_MAP3          0      11b/g      0
                      1      11a        0
```

Note Each call received by an access point radio causes the appropriate calls summary column to increment by one. For example, if a call is received on the 802.11b/g radio on *map2*, then a value of one is added to the existing value in that radio's calls column. In this case, the new call is the only active call on the 802.11b/g radio of *map2*. If one call is active when a new call is received, the resulting value is two.

- To view the mesh tree topology for the network and display the voice calls that are in progress, enter this command:

  show mesh cac callpath *Cisco_AP*

Information similar to the following appears:

```
AP Name             Slot#   Radio     Calls
-------------      -------  -----     -----
SB_RAP1               0     11b/g      0
                      1     11a        1
|   SB_MAP1           0     11b/g      0
                      1     11a        1
||  SB_MAP2           0     11b/g      1
                      1     11a        1
||| SB_MAP3           0     11b/g      0
                      1     11a        0
```

Note The *calls* column for each mesh access point radio in a call path increments by one. For example, for a call that initiates at *map2* (**show mesh cac call path** *SB_MAP2*) and terminates at *rap1* by way of *map1,* one call is added to the *map2* 802.11b/g and 802.11a radio *calls* column*,* one call to the *map1* 802.11a backhaul radio *calls* column, and one call to the *rap1* 802.11a backhaul radio *calls* column.

- To view the mesh tree topology of the network, the voice calls that are rejected at the access point radio because of insufficient bandwidth, and the corresponding access point radio where the rejection occurred, enter this command:

  show mesh cac rejected *Cisco_AP*

  Information similar to the following appears:

```
AP Name             Slot#   Radio     Calls
-------------      -------  -----     -----
SB_RAP1               0     11b/g      0
                      1     11a        0
|   SB_MAP1           0     11b/g      0
                      1     11a        0
||  SB_MAP2           0     11b/g      1
                      1     11a        0
||| SB_MAP3           0     11b/g      0
                      1     11a        0
```

Note If a call is rejected at the *map2* 802.11b/g radio, its *calls* column increments by one.

- To view the number of bronze, silver, gold, platinum, and management queues active on the specified access point. The peak and average length of each queue are shown as well as the overflow count.

  show mesh queue-stats {*Cisco_AP* | **all**}

  Information similar to the following appears:

```
Queue Type  Overflows  Peak length  Average length
 ----------  ---------  -----------  --------------
 Silver      0          1            0.000
 Gold        0          4            0.004
 Platinum    0          4            0.001
 Bronze      0          0            0.000
 Management  0          0            0.000
```

Overflows—The total number of packets dropped because of queue overflow.

Peak Length—The peak number of packets waiting in the queue during the defined statistics time interval.

Average Length—The average number of packets waiting in the queue during the defined statistics time interval.

Enabling Mesh Multicast Containment for Video

You can use the controller CLI to configure three mesh multicast modes to manage video camera broadcasts on all mesh access points. When enabled, these modes reduce unnecessary multicast transmissions within the mesh network and conserve backhaul bandwidth.

Mesh multicast modes determine how bridging-enabled access points [mesh access points (MAPs) and root access points (RAPs)] send multicasts among Ethernet LANs within a mesh network. Mesh multicast modes manage non-CAPWAP multicast traffic only. CAPWAP multicast traffic is governed by a different mechanism.

The three mesh multicast modes are:

- **Regular mode**—Data is multicast across the entire mesh network and all its segments by bridging-enabled RAPs and MAPs.
- **In mode**—Multicast packets received from the Ethernet by a MAP are forwarded to the RAP's Ethernet network. No additional forwarding occurs, which ensures that non-CAPWAP multicasts received by the RAP are not sent back to the MAP Ethernet networks within the mesh network (their point of origin), and MAP-to-MAP multicasts do not occur because they are filtered out. In mode is the default mode.
- **In-out mode**—The RAP and MAP both multicast but in a different manner:
  - If multicast packets are received at a MAP over Ethernet, they are sent to the RAP; however, they are not sent to other MAP Ethernets, and the MAP-to-MAP packets are filtered out of the multicast.
  - If multicast packets are received at a RAP over Ethernet, they are sent to all the MAPs and their respective Ethernet networks. When the in-out mode is in operation, it is important to properly partition your network to ensure that a multicast sent by one RAP is not received by another RAP on the same Ethernet segment and then sent back into the network.

Note If 802.11b clients need to receive CAPWAP multicasts, then multicast must be enabled globally on the controller as well as on the mesh network (using the **config network multicast global enable** CLI command). If multicast does not need to extend to 802.11b clients beyond the mesh network, the global multicast parameter should be disabled (using the **config network multicast global disable** CLI command).

Using the CLI to Enable Multicast on the Mesh Network

- To enable multicast mode on the mesh network to receive multicasts from beyond the mesh networks, enter these commands:

  config network multicast global enable

  config mesh multicast {**regular** | **in** | **in-out**}

- To enable multicast mode only the mesh network (multicasts do not need to extend to 802.11b clients beyond the mesh network), enter these commands:

  config network multicast global disable

  config mesh multicast {**regular** | **in** | **in-out**}

Note Multicast for mesh networks cannot be enabled using the controller GUI.

Backhaul Client Access (Universal Access) for Indoor and Outdoor Mesh Access Points

You can configure the backhaul for mesh access points (1524SB, 1522, 1240 and 1130) to accept client traffic. When this feature is enabled, mesh access points allow wireless client association over the 802.11a radio. This universal access allows an access point to carry both backhaul traffic and 802.11a client traffic over the same 802.11a radio. When this feature is disabled, backhaul traffic is only transmitted over the 802.11a radio and client association is only allowed over the 802.11b/g radio.

After this feature is enabled, all mesh access points reboot.

Default: Disabled.

Note This parameter applies to mesh access points with two or more radios (1524SB, 1522, 1240 and 1130) *excluding* the 1524PS.

To enable this feature on the controller, check the **Backhaul Client Access** check box on the Wireless > Mesh window. Refer to the "Configuring Global Mesh Parameters" section on page 8-22.

Viewing Mesh Statistics and Reports

Viewing Mesh Statistics for an Access Point

This section explains how to use the controller GUI or CLI to view mesh statistics for specific access points.

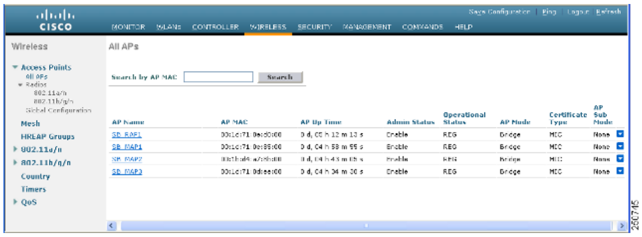
Note You can modify the Statistics Timer interval setting on the All APs > Details page of the controller GUI.

Using the GUI to View Mesh Statistics for an Access Point

Follow these steps to view mesh statistics for a specific access point using the controller GUI.

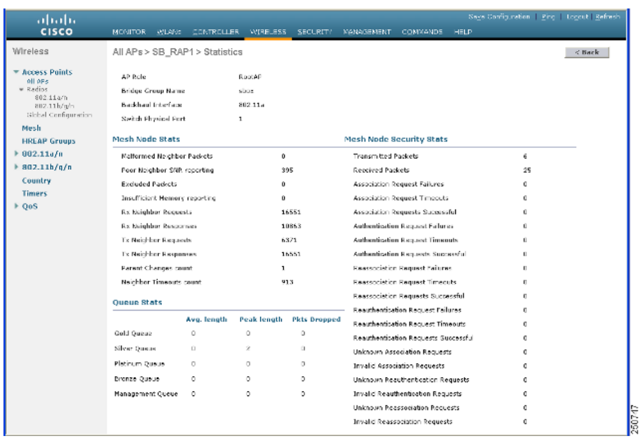
Step 1 Click **Wireless** > **Access Points** > **All APs** to open the All APs page (see Figure 8-23).

Figure 8-23 All APs Page



Step 2 To view statistics for a specific access point, hover your cursor over the blue drop-down arrow for the desired access point and choose **Statistics**. The All APs > *Access Point Name* > Statistics page for the access point appears (see Figure 8-24).

Figure 8-24 All APs > Access Point Name > Statistics Page



This page shows the role of the access point in the mesh network, the name of the bridge group to which the access point belongs, the backhaul interface on which the access point operates, and the number of the physical switch port. It also displays a variety of mesh statistics for this access point. Table 8-8 describes each of the statistics.

Table 8-8 Mesh Access Point Statistics

Statistics	Parameter	Description
Mesh Node Stats	Malformed Neighbor Packets	The number of malformed packets received from the neighbor. Examples of malformed packets include malicious floods of traffic such as malformed or short DNS packets and malformed DNS replies.
	Poor Neighbor SNR Reporting	The number of times the signal-to-noise ratio falls below 12 dB on the backhaul link.
	Excluded Packets	The number of packets received from excluded neighbor mesh access points.
	Insufficient Memory Reporting	The number of insufficient memory conditions.
	Rx Neighbor Requests	The number of broadcast and unicast requests received from the neighbor mesh access points.
	Rx Neighbor Responses	The number of responses received from the neighbor mesh access points.
	Tx Neighbor Requests	The number of unicast and broadcast requests sent to the neighbor mesh access points.
	Tx Neighbor Responses	The number of responses sent to the neighbor mesh access points.
	Parent Changes Count	The number of times a mesh access point (child) moves to another parent.
	Neighbor Timeouts Count	The number of neighbor timeouts.
Queue Stats	Gold Queue	The average and peak number of packets waiting in the gold (video) queue during the defined statistics time interval.
	Silver Queue	The average and peak number of packets waiting in the silver (best effort) queue during the defined statistics time interval.
	Platinum Queue	The average and peak number of packets waiting in the platinum (voice) queue during the defined statistics time interval.
	Bronze Queue	The average and peak number of packets waiting in the bronze (background) queue during the defined statistics time interval.
	Management Queue	The average and peak number of packets waiting in the management queue during the defined statistics time interval.

Table 8-8 Mesh Access Point Statistics (continued)

Statistics	Parameter	Description
Mesh Node Security Stats	Transmitted Packets	The number of packets transmitted during security negotiations by the selected mesh access point.
	Received Packets	The number of packets received during security negotiations by the selected mesh access point.
	Association Request Failures	The number of association request failures that occur between the selected mesh access point and its parent.
	Association Request Timeouts	The number of association request timeouts that occur between the selected mesh access point and its parent.
	Association Requests Successful	The number of successful association requests that occur between the selected mesh access point and its parent.
	Authentication Request Failures	The number of failed authentication requests that occur between the selected mesh access point and its parent.
	Authentication Request Timeouts	The number of authentication request timeouts that occur between the selected mesh access point and its parent.
	Authentication Requests Successful	The number of successful authentication requests between the selected mesh access point and its parent.
	Reassociation Request Failures	The number of failed reassociation requests between the selected mesh access point and its parent.
	Reassociation Request Timeouts	The number of reassociation request timeouts between the selected mesh access point and its parent.
	Reassociation Requests Successful	The number of successful reassociation requests between the selected mesh access point and its parent.
	Reauthentication Request Failures	The number of failed reauthentication requests between the selected mesh access point and its parent.
	Reauthentication Request Timeouts	The number of reauthentication request timeouts that occur between the selected mesh access point and its parent.
	Reauthentication Requests Successful	The number of successful reauthentication requests that occur between the selected mesh access point and its parent.
	Unknown Association Requests	The number of unknown association requests received by the parent mesh access point from its child. The unknown association requests often occur when a child is an unknown neighbor mesh access point.
	Invalid Association Requests	The number of invalid association requests received by the parent mesh access point from the selected child mesh access point. This state may occur when the selected child is a valid neighbor but is not in a state that allows association.

Table 8-8 Mesh Access Point Statistics (continued)

Statistics	Parameter	Description
Mesh Node Security Stats (continued)	Unknown Reauthentication Requests	The number of unknown reauthentication requests received by the parent mesh access point node from its child. This state may occur when a child mesh access point is an unknown neighbor.
	Invalid Reauthentication Requests	The number of invalid reauthentication requests received by the parent mesh access point from a child. This state may occur when a child is a valid neighbor but is not in a proper state for reauthentication.
	Unknown Reassociation Requests	The number of unknown reassociation requests received by the parent mesh access point from a child. This state may occur when a child mesh access point is an unknown neighbor.
	Invalid Reassociation Requests	The number of invalid reassociation requests received by the parent mesh access point from a child. This state may occur when a child is a valid neighbor but is not in a proper state for reassociation.

Using the CLI to View Mesh Statistics for an Access Point

Use these commands to view mesh statistics for a specific access point using the controller CLI.

- To view packet error statistics; a count of failures, timeouts, association and authentication successes; and reassociations and reauthentications for a specific access point, enter this command:

  show mesh security-stats {*Cisco_AP* | **all**}

  Information similar to the following appears:

```
AP MAC : 00:0B:85:5F:FA:F0
Packet/Error Statistics:
-----------------------------
x Packets 14, Rx Packets 19, Rx Error Packets 0

Parent-Side Statistics:
--------------------------
Unknown Association Requests 0
Invalid Association Requests 0
Unknown Re-Authentication Requests 0
Invalid Re-Authentication Requests 0
Unknown Re-Association Requests 0
Invalid Re-Association Requests 0
Unknown Re-Association Requests 0
Invalid Re-Association Requests 0

Child-Side Statistics:
--------------------------
Association Failures 0
Association Timeouts 0
Association Successes 0
Authentication Failures 0
Authentication Timeouts 0
Authentication Successes 0
Re-Association Failures 0
Re-Association Timeouts 0
```

```
Re-Association Successes 0
Re-Authentication Failures 0
Re-Authentication Timeouts 0
Re-Authentication Successes 0
```

- To view the number of packets in the queue by type, enter this command:

  show mesh queue-stats *Cisco_AP*

  Information similar to the following appears:

```
Queue Type  Overflows  Peak length  Average length
 ----------  ---------  -----------  --------------
 Silver      0          1            0.000
 Gold        0          4            0.004
 Platinum    0          4            0.001
 Bronze      0          0            0.000
 Management  0          0            0.000
```

  Overflows—The total number of packets dropped because of queue overflow.

  Peak Length—The peak number of packets waiting in the queue during the defined statistics time interval.

  Average Length—The average number of packets waiting in the queue during the defined statistics time interval.

Viewing Neighbor Statistics for an Access Point

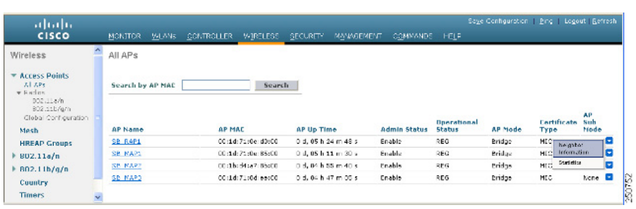
This section explains how to use the controller GUI or CLI to view neighbor statistics for a selected access point. It also describes how to run a link test between the selected access point and its parent.

Using the GUI to View Neighbor Statistics for an Access Point

Using the controller GUI, follow these steps to view neighbor statistics for an access point.

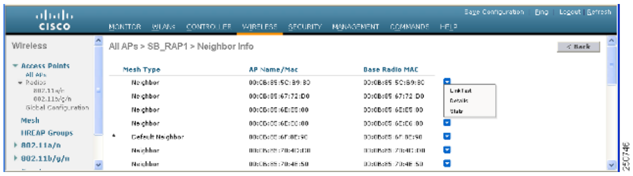
Step 1 Click **Wireless** > **Access Points** > **All APs** to open the All APs page (see Figure 8-25).

Figure 8-25 All APs Page



Step 2 To view neighbor statistics for a specific access point, hover your cursor over the blue drop-down arrow for the desired access point and choose **Neighbor Information**. The All APs > *Access Point Name* > Neighbor Info page for the access point appears (see Figure 8-26).

Figure 8-26 All APs > Access Point Name > Neighbor Info Page



This page lists the parent, children, and neighbors of the access point. It provides each access point's name and radio MAC address.

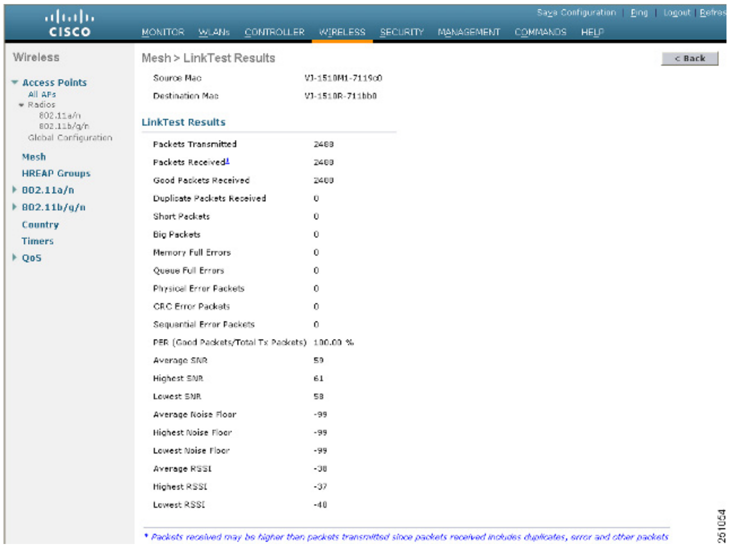
Step 3 To perform a link test between the access point and its parent or children, follow these steps:

a. Hover your cursor over the blue drop-down arrow of the parent or child and choose **LinkTest**. A pop-up window appears (see Figure 8-27).

Figure 8-27 Link Test Window

b. Click **Submit** to start the link test. The link test results appear on the Mesh > LinkTest Results page (see Figure 8-28).

Figure 8-28 Mesh > LinkTest Results Page



c. Click **Back** to return to the All APs > *Access Point Name* > Neighbor Info page.

Step 4 To view the details for any of the access points on this page, follow these steps:

a. Hover your cursor over the blue drop-down arrow for the desired access point and choose **Details**. The All APs > *Access Point Name* > Link Details > *Neighbor Name* page appears (see Figure 8-29).

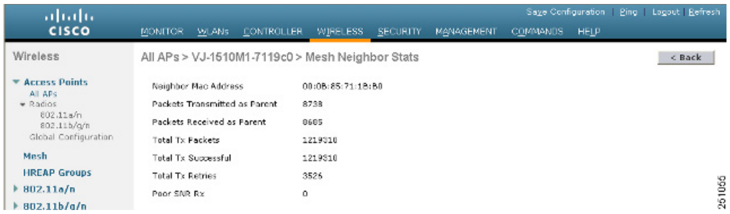
Figure 8-29 All APs > Access Point Name > Link Details > Neighbor Name Page

b. Click **Back** to return to the All APs > *Access Point Name* > Neighbor Info page.

Step 5 To view statistics for any of the access points on this page, follow these steps:

a. Hover your cursor over the blue drop-down arrow for the desired access point and choose **Stats**. The All APs > *Access Point Name* > Mesh Neighbor Stats page appears (see Figure 8-30).

Figure 8-30 All APs > Access Point Name > Mesh Neighbor Stats Page



b. Click **Back** to return to the All APs > *Access Point Name* > Neighbor Info page.

Using the CLI to View Neighbor Statistics for an Access Point

Use these commands to view neighbor statistics for a specific access point.

- To view the mesh neighbors for a specific access point, enter this command:

  show mesh neigh {detail | summary} {*Cisco_AP* | **all**}

  Information similar to the following appears when you request a summary display:

```
AP Name/Radio Mac  Channel Snr-Up Snr-Down Link-Snr Flags State
-----------------  ------- ------ -------- -------- ------ -------
mesh-45-rap1       165     15     18       16       0x86b  UPDATED NEIGH PARENT BEACON
00:0B:85:80:ED:D0  149      5      6        5       0x1a60 NEED UPDATE BEACON DEFAULT
00:17:94:FE:C3:5F  149      7      0       0       0x860     BEACON
```

- To view the channel and signal-to-noise ratio (SNR) details for a link between an access point and its neighbor, enter this command:

  show mesh path *Cisco_AP*

  Information similar to the following appears:

```
AP Name/Radio Mac  Channel Snr-Up Snr-Down Link-Snr Flags State
-----------------  ------- ------ -------- -------- ------ -------
mesh-45-rap1       165     15     18       16       0x86b UPDATED NEIGH PARENT BEACON
mesh-45-rap1 is a Root AP.
```

- To view the percentage of packet errors for packets transmitted by the neighbor mesh access point, enter this command:

  show mesh per-stats {*Cisco_AP* | **all**}

  Information similar to the following appears:

```
Neighbor MAC Address 00:0B:85:5F:FA:F0
Total Packets transmitted: 104833
Total Packets transmitted successfully: 104833
Total Packets retried for transmission: 33028
Neighbor MAC Address 00:0B:85:80:ED:D0
Total Packets transmitted: 0
Total Packets transmitted successfully: 0
Total Packets retried for transmission: 0
```

```
Neighbor MAC Address 00:17:94:FE:C3:5F
Total Packets transmitted: 0
Total Packets transmitted successfully: 0
Total Packets retried for transmission: 0
```

Note Packet error rate percentage = 1 – (number of successfully transmitted packets/number of total packets transmitted).

Converting Indoor Access Points to Mesh Access Points (1130AG, 1240AG)

Before you can install an 1130AG or 1240AG indoor access point into an indoor mesh deployment, you must do the following.

1. Convert the autonomous access point (k9w7 image) to a lightweight access point.

   A detailed explanation of this process is located at:

   http://www.cisco.com/en/US/products/hw/wireless/ps430/prod_technical_reference09186a00804fc3dc.html

2. Convert the lightweight access point to either a mesh access point (MAP) or root access point (RAP).

   Indoor mesh access points (1130 and 1240) can function as either a RAP or a MAP. By default, all are configured as MAPs.

   At least one access point within a mesh network must be configured to function as a RAP.

   - To convert the access point to a mesh access point using the CLI, perform one of the following:
     - To convert from a lightweight access point to a mesh access point, enter the following CLI commands:

       config ap mode bridge *Cisco_AP*

       The mesh access point reloads.
     - To convert from a lightweight access point to a RAP, enter the following CLI commands:

       config ap mode bridge *Cisco_AP*

       config ap role rootAP *Cisco_AP*

       The mesh access point reloads and is configured to operate as a RAP.
   - To convert the access point to a mesh access point using the GUI, follow these steps:

     a. Choose **Wireless** and click on the AP Name link for the 1130 or 1240 indoor access point you want to convert.

     b. At the General Properties panel, choose **Bridge** from the AP Mode drop-down menu.

        The access point reboots.

     c. At the Mesh panel, select either RootAP or MeshAP from the AP Role drop- down menu.

     d. Click **Apply** and **Save Configuration**.

Changing MAP and RAP Roles for Indoor Mesh Access Points (1130AG, 1240AG)

Cisco 1130 and 1240 series indoor mesh access points can function as either RAPs or MAPs.

Using the GUI to Change MAP and RAP Roles for Indoor Mesh Access Points

Using the controller GUI, follow these steps to change an indoor mesh access point from one role to another.

Step 1 Click **Wireless > Access Points > All APs** to open the All APs page.

Step 2 Click the name of the 1130 or 1240 series access point that you want to change.

Step 3 Click the **Mesh** tab.

Step 4 From the AP Role drop-down box, choose **MeshAP** or **RootAP** to specify this access point as a MAP or RAP, respectively.

Step 5 Click **Apply** to commit your changes. The access point reboots.

Step 6 Click **Save Configuration** to save your changes.

Note Cisco recommends a Fast Ethernet connection between the MAP and controller when changing from a MAP to RAP.

Note After a RAP-to-MAP conversion, the MAP's connection to the controller is a wireless backhaul rather than a Fast Ethernet connection. It is the responsibility of the user to ensure that the Fast Ethernet connection of the RAP being converted is disconnected before the MAP starts up so that the MAP can join over the air.

Note The recommended power source for MAPs is either a power supply or power injector. PoE is not a recommended power source for MAPs.

Using the CLI to Change MAP and RAP Roles for Indoor Mesh Access Points

Using the controller CLI, follow these steps to change an indoor mesh access point from one role to another.

Step 1 To change the role of an indoor access point from MAP to RAP or from RAP to MAP, enter this command:

config ap role {**rootAP** | **meshAP**} *Cisco_AP*

The access point reboots after you change the role.

Step 2 To save your changes, enter this command:

save config

Converting Indoor Mesh Access Points to Non-Mesh Lightweight Access Points (1130AG, 1240AG)

The access point reboots after entry of the conversion commands (noted below).

Note A Fast Ethernet connection to the controller for the conversion from a mesh (bridge) to non-mesh (local) access point is recommended. If the backhaul is a radio, after the conversion you must enable Ethernet and then reload the access image. After the reload and reboot the backhaul is Fast Ethernet.

Note When a root access point is converted back to a lightweight access point, all of its subordinate mesh access points lose connectivity to the controller. Consequently, a mesh access point is unable to service its clients until the mesh access point is able to connect to a different root access point in the vicinity. Likewise, clients might connect to a different mesh access point in the vicinity to maintain connectivity to the network.

- To convert an indoor mesh access point (MAP or RAP) to a non-mesh lightweight access point using the CLI, enter the following command.

  config ap mode local *Cisco_AP*

  The access point reloads.
- To convert an indoor mesh access point (MAP or RAP) to a non-mesh lightweight access point using the GUI, follow these steps:
  a. Click **Wireless** and click on the AP Name link for the 1130 or 1240 indoor access point you want to convert.
  b. At the General Properties panel, select **Local** from the AP Mode drop-down menu.
  c. Click **Apply** and **Save Configuration**.
- To convert an indoor mesh access point (MAP or RAP) to a non-mesh lightweight access point using Cisco WCS, follow these steps:
  a. Click **Configure > Access Points** and click on the AP Name link for the 1130 or 1240 indoor access point you want to convert.
  b. At the General Properties panel, select **Local** as the AP Mode (left side).
  c. Click **Save**.

Configuring Mesh Access Points to Operate with Cisco 3200 Series Mobile Access Routers

Outdoor access points (1522, 1524PS) can interoperate with the Cisco 3200 Series Mobile Access Router (MAR) on the public safety channel (4.9 GHz) as well as the 2.4-GHz access and 5.8-GHz backhaul.

The Cisco 3200 creates an *in-vehicle network* in which devices such as PCs, surveillance cameras, digital video recorders, printers, PDAs, and scanners can share wireless networks such as cellular or WLAN-based services back to the main infrastructure. This allows data collected from in-vehicle deployments such as a police cars to be integrated into the overall wireless infrastructure. For specific interoperability details between series 1130, 1240, and 1520 mesh access points and series 3200 mobile access routers, refer to Table 8-9.

Table 8-9 Mesh Access Points and MAR 3200 Interoperability

Mesh Access Point Model	MAR Model
1522[1]	c3201[2], c3202[3], c3205[4]
1524PS	c3201, c3202
1130, 1240 configured as indoor mesh access points with universal access	c3201, c3205

1. Universal access must be enabled on the 1522 if connecting to a MAR on the 802.11a radio or 4.9-GHz band.
2. Model c3201 is a MAR with a 802.11b/g radio (2.4 GHz).
3. Model c3202 is a MAR with a 4-9-GHz sub-band radio.
4. Model c3205 is a MAR with a 802.11a radio (5.8-GHz sub-band).

Configuration Guidelines

For the 1522 or 1524PS mesh access point and Cisco MAR 3200 to interoperate on the public safety network, the following configuration guidelines must be met:

- Client access must be enabled on the backhaul (Mesh global parameter).
- Public Safety must be enabled globally on all mesh access points (MAPs) in the mesh network.
- Channel number assignments on the 1522 or 1524PS must match those on the Cisco 3200 radio interfaces.
  - Channels 20 (4950 GHz) through 26 (4980 GHz) and sub-band channels 1 through 19 (5 and 10 MHz) are used for MAR interoperability. This configuration change is made on the controller. No changes are made to the access point configuration.
  - Channel assignments are made only to the RAP. Updates to the MAP are propagated by the RAP.

The default channel width for MAR 3200s is 5 MHz. You must do one of the following:

- Change the channel width to 10 or 20 MHz to enable WGBs to associate with series 1520 mesh access points
- Change the channel on the 1522 or 1524PS to a channel in the 5-MHz (channels 1 to 10) or 10-MHz band (channels 11 through 19).
  - When using the CLI, you must disable the 802.11a radio prior to configuring its channels. You re-enable the radio after the channels are configured.

- When using the GUI, enabling and disabling of the 802.11a radio for channel configuration is not required.
- Cisco MAR 3200s can scan channels *within* but not across the 5-, 10-, or 20-MHz bands.

Using the GUI to Enable Mesh Access Points to Operate with Cisco 3200 Series Mobile Access Routers

Using the controller GUI, follow these steps to enable the 1522 and 1524PS mesh access points to associate to the Cisco 3200 series MAR.

Step 1 To enable the backhaul for client access, click **Wireless** > **Mesh** to open the Mesh page.

Step 2 Check the **Backhaul Client Access** check box to allow wireless client association over the 802.11a radio.

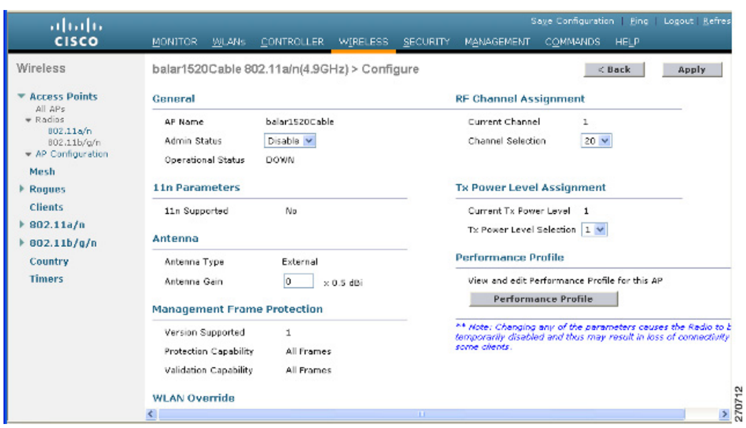
Step 3 Click **Apply** to commit your changes.

Step 4 When prompted to allow a reboot of all the mesh access points on the network, click **OK**.

Step 5 Click **Wireless** > **Access Points** > **Radios** > **802.11a/n** to open the 802.11a/n Radios page.

Step 6 Hover your cursor over the blue drop-down arrow for the appropriate RAP and choose **Configure**. The 802.11a/n (4.9 GHz) > Configure page appears (see Figure 8-31).

Figure 8-31 802.11 a/n (4.9GHz) > Configure Page



Step 7 Under the RF Channel Assignment section, choose the **Custom** option for Assignment Method and select a channel between 1 and 26.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Enable Mesh Access Points to Operate with Cisco 3200 Series Mobile Access Routers

Using the controller CLI, follow these steps to enable the 1522 and 1524PS mesh access points to associate to the Cisco 3200 series MAR.

Step 1 To enable client access mode on the 1522 and 1524PS mesh access points, enter this command:

config mesh client-access enable

Step 2 To enable public safety on a global basis, enter this command:

config mesh public-safety enable *all*

Step 3 To enable the public safety channels, enter these commands:

- For the 1522 access point, enter these commands:

  config 802.11a disable *Cisco_MAP*

  config 802.11a channel ap *Cisco_MAP channel_number*

  config 802.11a enable *Cisco_MAP*

- For the 1524PS, enter these commands:

  config 802.11–a49 disable *Cisco_MAP*

  config 802.11–a49 channel ap *Cisco_MAP channel_number*

  config 802.11–a49 enable *Cisco_MAP*

Note Enter **config 802.11–a58 enable** *Cisco_MAP* to enable a 5.8-GHz radio.

Note For both the 1522 and 1524PS mesh access points, valid values for the channel number is 1 through 26.

Step 4 To save your changes, enter this command:

save config

Step 5 To verify your configuration, enter these commands:

show mesh public-safety

show mesh client-access

show ap config 802.11a summary (for 1522 access points only)

show ap config 802.11–a49 summary (for 1524PS access points only)

Note Enter **show config 802.11-a58 summary** to view configuration details for a 5.8-GHz radio.

Managing Controller Software and Configurations

This chapter describes how to manage configurations and software versions on the controllers. It contains these sections:

Upgrading Controller Software

When you upgrade the controller's software, the software on the controller's associated access points is also automatically upgraded. When an access point is loading software, each of its LEDs blinks in succession. Up to 10 access points can be concurrently upgraded from the controller.

Note The 5500 series controllers can download the 6.0 software to 100 access points simultaneously.

Caution Do not power down the controller or any access point during this process; otherwise, you might corrupt the software image! Upgrading a controller with a large number of access points can take as long as 30 minutes, depending on the size of your network. However, with the increased number of concurrent access point upgrades supported in software release 4.0.206.0 and later, the upgrade time should be significantly reduced. The access points must remain powered, and the controller must not be reset during this time.

Note In controller software release 5.2 or later, the WLAN override feature has been removed from both the controller GUI and CLI. If your controller is configured for WLAN override and you upgrade to controller software release 5.2 or later, the controller deletes the WLAN configuration and broadcasts all WLANs. You can specify that only certain WLANs be transmitted by configuring access point groups. Each access point advertises only the enabled WLANs that belong to its access point group. Access point groups do not enable WLANs to be transmitted on per radio interface of AP.

Guidelines for Upgrading Controller Software

Follow these guidelines before upgrading your controller to software release 6.0:

- Make sure you have a TFTP or FTP server available for the software upgrade. Keep these guidelines in mind when setting up a TFTP or FTP server:
  - Controller software release 6.0 is greater than 32 MB; therefore, you must make sure that your TFTP server supports files that are larger than 32 MB. Some TFTP servers that support files of this size are tftpd32 and the TFTP server within WCS. If you attempt to download the 6.0 controller software and your TFTP server does not support files of this size, the following error message appears: "TFTP failure while storing in flash."
  - If you are upgrading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
  - If you are upgrading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
  - A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.
- You can upgrade or downgrade the controller software only between certain releases. In some instances, you must first install an intermediate release prior to upgrading to software release 6.0. Table 9-1 shows the upgrade path that you must follow prior to downloading software release 6.0.

Table 9-1 Upgrade Path to Controller Software Release 6.0

Current Software Release	Upgrade Path to 6.0 Software
3.2.78.0 or later 3.2 release	First upgrade to a 4.1 release and then upgrade to 4.2.176.0 before upgrading to 6.0.
4.0.155.5 or later 4.0 release	Upgrade to 4.2.176.0 before upgrading to 6.0.
4.1.171.0 or later 4.1 release	Upgrade to 4.2.176.0 before upgrading to 6.0.
4.1.191.xM	Upgrade to 4.1.192.35M before upgrading to 6.0.
4.1.192.xM	You can upgrade directly to 6.0.
4.2.130.0 or earlier 4.2 release	Upgrade to 4.2.176.0 before upgrading to 6.0.
4.2.173.0 or later 4.2 release	You can upgrade directly to 6.0.
5.0.148.0 or later 5.0 release	You can upgrade directly to 6.0.
5.1.151.0 or later 5.1 release	You can upgrade directly to 6.0.
5.2.157.0 or later 5.2 release	You can upgrade directly to 6.0.

Note The 5500 series controllers can run only controller software release 6.0 or later.

Note When you upgrade the controller to an intermediate software release, wait until all of the access points joined to the controller are upgraded to the intermediate release before you install the 6.0 software. In large networks, it may take some time to download the software on each access point.

- In software releases 6.0.186.0 and later, you can download the upgrade image to the controller, then download the image to the access points while the network is still up. New CLI and controller GUI functionality allow you to specify the boot image for both devices and to reset the access points when the controller resets. When both devices are up, the access points discover and rejoin the controller. See the "Predownloading an Image to an Access Point" section on page 9-11 for more information about predownloading images to access points.
- Cisco recommends that you install the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file on all controller platforms. This file resolves CSCsm03461 and is necessary to view the version information for ER.aes files in the output of the **show sysinfo** CLI command. If you do not install this ER.aes file, your controller does not obtain the fix for this defect, and "N/A" appears in the Field Recovery Image Version or Emergency Image Version field in the output of this command.

Note The ER .aes files are independent from the controller software files. You can run any controller software file with any ER.aes file. However, installing the latest boot software file (5.2.157.0 ER.aes) ensures that the boot software modifications in all of the previous and current boot software ER.aes files are installed.

Caution If you require a downgrade from one release to another, you may lose the configuration from your current release. The workaround is to reload the previous controller configuration files saved on the backup server or to reconfigure the controller.

Guidelines for Upgrading to Controller Software 6.0 in Mesh Networks

Caution Before upgrading your controller to software release 6.0 in a mesh network, you must comply with the following rules.

Upgrade Compatibility Matrix

Table 2 outlines the upgrade compatibility of controller mesh and non-mesh releases and indicates the intermediate software releases required as part of the upgrade path.

Software Upgrade Notes

- You can upgrade from all mesh releases to controller software release 6.0 without any configuration file loss. See Table 2 for the available upgrade paths.

  Note If you downgrade to a mesh release, you must then reconfigure the controller. Cisco recommends that you save the configuration from the mesh release before upgrading to release 6.0 for the first time. Then you can reapply the configuration if you need to downgrade.

- You cannot downgrade from controller software release 6.0 to a mesh release (4.1.190.5, 4.1.191.22M, or 4.1.192.xxM) without experiencing a configuration loss.
- Configuration files are in the binary state immediately after upgrade from a mesh release to controller software release 6.0. After reset, the XML configuration file is selected.
- Do not edit XML files.
- Any field with an invalid value is filtered out and set to default by the XML validation engine. Validation occurs during bootup.

Table 2 Upgrade Compatibility Matrix for Controller Mesh and Non-Mesh Releases

Upgrade to	6.0	5.2	4.1.192.35M	4.1.191.24M	4.1.190.5	4.1.185.0	4.1.171.0	4.0.219.0	4.0.217.204	4.0.217.0	4.0.216.0	4.0.206.0	4.0.179.11	4.0.179.8	4.0.155.5	4.0.155.0	3.2.195.10	3.2.193.5	3.2.171.6	3.2.171.5	3.2.150.10	3.2.150.6	3.2.116.21	3.2.78.0	3.1.111.0	3.1.105.0
Upgrade from																										
4.1.192.35M	Y	Y																								
4.1.192.22M	Y	Y	Y																							
4.1.191.24M			Y	–																						
4.1.190.5			Y[1]	Y	–																					
4.1.185.0				Y	Y[2]	–																				
4.1.181.0					Y[2]	Y[2]																				
4.1.171.0					Y[2]	Y[2]	–																			
4.0.219.0						Y[2]	Y[2]	–																		
4.0.217.204				Y[2]		Y[2]	Y[2]	Y[2]	–																	
4.0.217.0						Y[2]	Y[2]	Y[2]	Y[3]	–																
4.0.216.0						Y[2]	Y[2]	Y[2]	Y[3]	Y	–															
4.0.206.0						Y[2]	Y[2]	Y[2]	Y[3]	Y		–														
4.0.179.11										Y		Y[4]	–													
4.0.179.8										Y		Y[4]	Y	–												
4.0.155.5										Y		Y[4]	Y	Y	–											
4.0.155.0										Y		Y[4]	Y	Y	Y	–										
3.2.195.10										Y		Y[4]	Y	Y	Y		–									
3.2.193.5										Y		Y[4]	Y	Y	Y		Y	–								
3.2.171.6										Y		Y[4]	Y	Y	Y		Y		–							
3.2.171.5										Y		Y[4]	Y	Y	Y		Y		Y	–						

Table 2 Upgrade Compatibility Matrix for Controller Mesh and Non-Mesh Releases (continued)

Upgrade to	6.0	5.2	4.1.192.35M	4.1.191.24M	4.1.190.5	4.1.185.0	4.1.171.0	4.0.219.0	4.0.217.204	4.0.217.0	4.0.216.0	4.0.206.0	4.0.179.11	4.0.179.8	4.0.155.5	4.0.155.0	3.2.195.10	3.2.193.5	3.2.171.6	3.2.171.5	3.2.150.10	3.2.150.6	3.2.116.21	3.2.78.0	3.1.111.0	3.1.105.0
3.2.150.10										Y		Y [4]	Y	Y	Y		Y		Y		–					
3.2.150.6										Y		Y [4]	Y	Y	Y		Y		Y		Y	–				
3.2.116.21										Y		Y [4]	Y	Y	Y		Y		Y		Y		–			
3.2.78.0										Y		Y [4]	Y	Y	Y		Y		Y		Y		Y	–		
3.1.111.0																	Y		Y		Y		Y	Y	–	
3.1.105.0																	Y		Y		Y		Y	Y	Y	–
3.1.59.24																	Y		Y		Y		Y	Y	Y	Y

1. You can upgrade directly from software release 4.1.190.5 to 4.1.192.35M; however, upgrading to 4.1.191.24M before upgrading to 4.1.192.35M is highly recommended.
2. CUSTOMERS WHO REQUIRE DYNAMIC FREQUENCY SELECTION (DFS) FUNCTIONALITY SHOULD NOT USE THIS RELEASE. This release does not provide DFS functionality fixes found in release 4.0.217.204. Additionally, this release is not supported in ETSI-compliant countries or Singapore.
3. Release 4.0.217.204 provides fixes for DFS on 1510 series access points. This functionality is needed only in countries where DFS rules apply.
4. An upgrade to 4.0.206.0 is not allowed in the following country codes when operating with the following access points: Australia (1505 and 1510), Brazil (1505 and 1510), Hong Kong (1505 and 1510), India (1505 and 1510), Japan (1510), Korea (1505 and 1510), Mexico (1505 and 1510), New Zealand (1505 and 1510), and Russia (1505 and 1510). Note: The 1505 mesh access point is not supported in release 5.0 and later. The 1510 mesh access point is supported only in mesh releases 4.1.190.5, 4.1.191.22M, and 4.1.192.xxM.

Using the GUI to Upgrade Controller Software

Using the controller GUI, follow these steps to upgrade the controller software.

Note Do not install the 6.0 controller software file and the 5.2.157.0 ER.aes boot software file at the same time. Install one file and reboot the controller; then install the other file and reboot the controller.

Step 1 Upload your controller configuration files to a server to back them up.

Note Cisco highly recommends that you back up your controller's configuration files prior to upgrading the controller software. See the "Uploading and Downloading Configuration Files" section on page 9-26 for instructions.

Step 2 Follow these steps to obtain the 6.0 controller software and the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file from the Software Center on Cisco.com:

a. Go to the Cisco Product Support & Downloads page:

http://www.cisco.com/c/en/us/support/index.html

b. Navigate to the controller model page.

c. Choose a controller software release. The software releases are labeled as follows to help you determine which release to download:
   - **Early Deployment (ED)**—These software releases provide new features and new hardware platform support as well as bug fixes.
   - **Maintenance Deployment (MD)**—These software releases provide bug fixes and ongoing software maintenance.
   - **Deferred (DF)**—These software releases have been deferred. Cisco recommends that you migrate to an upgraded release.

d. Choose a software release number.

e. Click the filename (*filename*.aes).

f. Click **Download**.

g. Read Cisco's End User Software License Agreement and then click **Agree**.

h. Save the file to your hard drive.

i. Repeat steps *a* through *h* to download the remaining file (either the 6.0 controller software or the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file).

Step 3 Copy the controller software file (*filename*.aes) and the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file to the default directory on your TFTP or FTP server.

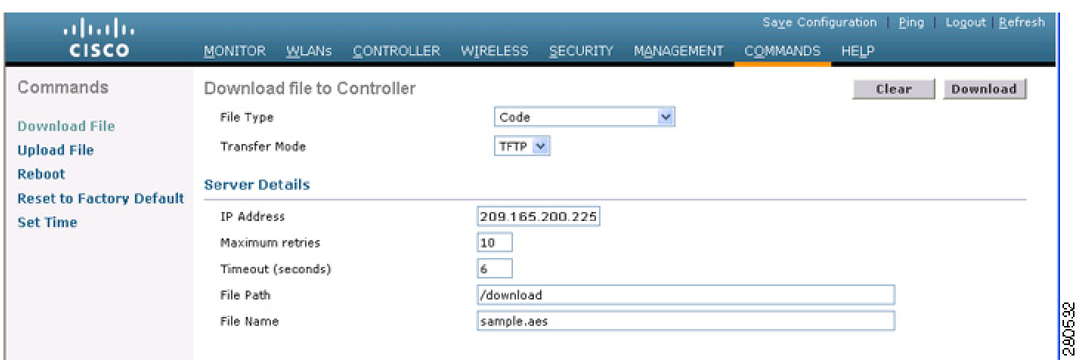
Step 4 Disable the controller 802.11a and 802.11b/g networks.

Step 5 For Cisco WiSMs, shut down the controller port channel on the Catalyst switch to allow the controller to reboot before the access points start downloading the software.

Step 6 Disable any WLANs on the controller.

Step 7 Choose **Commands** > **Download File** to open the Download File to Controller page (see Figure 9-1).

Figure 9-1 Download File to Controller Page



Step 8 From the File Type drop-down box, choose **Code**.

Step 9 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 10 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 11 If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout fields should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software in the Maximum Retries field and the amount of time (in seconds) that the TFTP server attempts to download the software in the Timeout field.

Step 12 In the File Path field, enter the directory path of the software.

Step 13 In the File Name field, enter the name of the controller software file (*filename*.aes).

Step 14 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 15 Click **Download** to download the software to the controller. A message appears indicating the status of the download.

Step 16 After the download is complete, click **Reboot**.

Step 17 If prompted to save your changes, click **Save and Reboot**.

Step 18 Click **OK** to confirm your decision to reboot the controller.

Note Do not wait to reboot the controller. Reboot it immediately after downloading the software. Otherwise, the access points might start downloading the software before the controller is running it.

Step 19 After the controller reboots, repeat Step 7 to Step 18 to install the remaining file (either the 6.0 controller software or the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file).

Step 20 Re-enable the WLANs.

Step 21 For Cisco WiSMs, re-enable the controller port channel on the Catalyst switch.

Step 22 Re-enable your 802.11a and 802.11b/g networks.

Step 23 If desired, reload your latest configuration file to the controller.

Step 24 To verify that the 6.0 controller software is installed on your controller, choose **Monitor** on the controller GUI and look at the Software Version field under Controller Summary.

Step 25 To verify that the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file is installed on your controller, choose **Monitor** to open the Summary page and look at the Field Recovery Image Version or Emergency Image Version field.

Note If a Cisco Unified Wireless Network Controller Boot Software ER.aes file is not installed, the Field Recovery Image Version or Emergency Image Version field shows “N/A.”

Using the CLI to Upgrade Controller Software

Using the controller CLI, follow these steps to upgrade the controller software.

Note Do not install the 6.0 controller software file and the 5.2.157.0 ER.aes boot software file at the same time. Install one file and reboot the controller; then install the other file and reboot the controller.

Step 1 Upload your controller configuration files to a server to back them up.

Note Cisco highly recommends that you back up your controller's configuration files prior to upgrading the controller software. See the "Uploading and Downloading Configuration Files" section on page 9-26 for instructions.

Step 2 Follow these steps to obtain the 6.0 controller software and the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file from the Software Center on Cisco.com:

- **a.** Go to http://www.cisco.com/c/en/us/support/index.html.
- **b.** Navigate to the Cisco WLC model of your choice.
- **c.** Choose a controller software release.
- **d.** Click the filename (*filename*.aes).
- **e.** Click **Download**.
- **f.** Read Cisco's End User Software License Agreement and then click **Agree**.
- **g.** Save the file to your hard drive.
- **h.** Repeat steps a. to g. to download the remaining file (either the 6.0 controller software or the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file).

Step 3 Copy the controller software file (*filename*.aes) and the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file to the default directory on your TFTP or FTP server.

Step 4 Disable the controller 802.11a and 802.11b/g networks.

Step 5 For Cisco WiSMs, shut down the controller port channel on the Catalyst switch to allow the controller to reboot before the access points start downloading the software.

Step 6 Disable any WLANs on the controller (using the **config wlan disable** *wlan_id* command).

Step 7 Log into the controller CLI.

Step 8 Enter **ping** *server-ip-address* to verify that the controller can contact the TFTP or FTP server.

Step 9 Enter **transfer download start** and answer **n** to the prompt to view the current download settings. Information similar to the following appears:

```
Mode........................................... TFTP
Data Type...................................... Code
TFTP Server IP................................. xxx.xxx.xxx.xxx
TFTP Packet Timeout............................. 6
TFTP Max Retries................................ 10
TFTP Path...................................... <directory path>
TFTP Filename.................................. xxx.aes

This may take some time.
Are you sure you want to start? (y/N) n
Transfer Canceled
```

Step 10 Enter these commands to change the download settings, if necessary:

- **transfer download mode** {**tftp** | **ftp**}
- **transfer download datatype code**
- **transfer download serverip** *server-ip-address*
- **transfer download filename** *filename*
- **transfer download path** *server-path-to-file*

Note Pathnames on a TFTP or FTP server are relative to the server's default or root directory. For example, in the case of the Solarwinds TFTP server, the path is "/".

If you are using a TFTP server, also enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

If you are using an FTP server, also enter these commands:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 11 Enter **transfer download start** to view the updated settings and answer **y** to the prompt to confirm the current download settings and start the software download. Information similar to the following appears:

```
Mode......................................... TFTP
Data Type.................................... Code
TFTP Server IP.................................. xxx.xxx.xxx.xxx
TFTP Packet Timeout............................. 6
TFTP Max Retries............................ 10
TFTP Path.................................... <directory path>
TFTP Filename.................................. xxx.aes

Are you sure you want to start? (y/n) y
TFTP Code transfer starting.
TFTP receive complete... extracting components.
Writing new bootloader to flash.
Making backup copy of RTOS.
Writing new RTOS to flash.
Making backup copy of Code.
Writing new Code to flash.
TFTP File transfer operation completed successfully.
  Please restart the switch (reset system) for update to complete.
```

Step 12 Enter **reset system** to save the code update to non-volatile NVRAM and reboot the controller. The controller completes the bootup process.

> **Note** Do not wait to reboot the controller. Reboot it immediately after downloading the software. Otherwise, the access points might start downloading the software before the controller is running it.

Step 13 After the controller reboots, repeat Step 9 to Step 12 to install the remaining file (either the 6.0 controller software or the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file).

Step 14 Enter **config wlan enable** *wlan_id* to re-enable the WLANs.

Step 15 For Cisco WiSMs, re-enable the controller port channel on the Catalyst switch.

Step 16 Re-enable your 802.11a and 802.11b/g networks.

Step 17 If desired, reload your latest configuration file to the controller.

Step 18 To verify that the 6.0 controller software is installed on your controller, enter **show sysinfo** and look at the Product Version field.

Step 19 To verify that the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file is installed on your controller, enter the **show sysinfo** command on the controller CLI and look at the Field Recovery Image Version or Emergency Image Version field.

> **Note** If a Cisco Unified Wireless Network Controller Boot Software ER.aes file is not installed, the Field Recovery Image Version or Emergency Image Version field shows "N/A."

Predownloading an Image to an Access Point

To minimize a network outages, you can now download an upgrade image to the access point from the controller without resetting the access point or losing network connectivity. Previously, you would download an upgrade image to the controller and reset it, which causes the access point to go into discovery mode. After the access point discovers the controller with the new image, the access point downloads the new image, resets, goes into discovery mode, and rejoins the controller.

You can now download the upgrade image to the controller then download the image to the access point while the network is still up. You can also schedule a reboot of the controller and access points, either after a specified amount of time or at a specific date and time. When both devices are up, the access point will discover and rejoin the controller.

> **Note** These access point models do not support predownloading of images: 1120, 1230, and 1310.

Guidelines and Limitations for Predownloading Images

Keep these guidelines in mind when you use image predownloading:

- Maximum predownload limit: The maximum number of concurrent predownloads is limited to half the number of concurrent normal image downloads on 4400 series controllers; it is limited to 25 concurrent downloads on 5500 series controllers. This limitation allows new access points to join the controller during image downloading.

If you reach the predownload limit, access points that cannot get an image back off and wait for a time between 180 to 600 seconds and then re-attempt the predownload.

- For predownloading to be effective, all controllers (primary, secondary, and tertiary) that your access points can join should use the same images for primary and backup images. For example, if you have three controllers, all three should use software release x as the primary image and release y as the backup image. This concistency is important because some controllers reboot more slowly than others, and access points rejoin a controller as soon as they reboot. If a 4400 controller reboots before a 5500 controller, it is important that both controllers are running the same images in case an access point joins one rather than the other.
- Before you enter the predownload command, Cisco recommends that you change the active controller boot image to the backup image. This step ensures that if the controller reboots for some reason, it comes back up with the earlier running image, not the partially downloaded upgrade image.
- Access points with 16MB total available memory (1130 and 1240 access points) sometimes do not have enough free memory to download an upgrade image, and they automatically delete crash info files, radio files, and any backup images to free up space. However, this limitation does not affect the predownload process because the predownload image replaces any backup image on the access point.

Using the CLI to Predownload an Image to Access Points

Using the CLI, you can predownload an image to a specific access point or to all access points. The process includes these steps:

- Predownload the upgrade image to the controller.
- Predownload the upgrade image to the access points.
- Upgrade images on the controller and access points.
- Set a reboot time for the controller and the access points.

Predownload the Upgrade Image to the Controller

To obtain an upgrade image, follow Step 1 through Step 10 in the "Using the CLI to Upgrade Controller Software" section on page 9-9.

On the controller CLI, enter **transfer download start** to view the updated settings and answer **y** to the prompt to confirm the current download settings and start the software download. Information similar to the following appears:

```
Mode......................................... TFTP
Data Type.................................... Code
TFTP Server IP.................................. xxx.xxx.xxx.xxx
TFTP Packet Timeout............................. 6
TFTP Max Retries............................. 10
TFTP Path.................................... <directory path>
TFTP Filename................................ xxx.aes

Are you sure you want to start? (y/n) y
TFTP Code transfer starting.
TFTP receive complete... extracting components.
Writing new bootloader to flash.
Making backup copy of RTOS.
Writing new RTOS to flash.
Making backup copy of Code.
Writing new Code to flash.
```

```
TFTP File transfer operation completed successfully.
  Please restart the switch (reset system) for update to complete.
```

Enter **show boot** on the controller. The new image is listed as the primary image and the old image is listed as the backup. However, you should switch the primary and backup images to ensure that if the controller resets before or during the upgrade the network still comes up with the existing image.

Enter **config boot backup** to change the controller active boot image to the existing image (which is now the backup).

Enter **show boot** again to make sure the images are set up correctly.

Predownload the Image to the Access Points

To predownload the image to the access point Flash memory, enter this command on the controller CLI:

config ap image predownload {**primary** | **backup**} {*ap_name* | **all**}

The primary image is the new image; the backup image is the existing image. Access points always boot with the primary image.

To swap an access point's primary and backup images, enter this command:

config ap image swap {*ap_name* | **all**}

Upgrade Images on the Controller and Access Points

To display detailed information on access points specified for predownload, enter this command:

show ap image {**all** | *ap-name*}

Output for the command:

```
Total number of APs............................ 7
Number of APs
        Initiated...................................... 4
        Predownloading................................. 0
        Completed predownloading....................... 3
        Not Supported.................................. 0
        Failed to Predownload.......................... 0

                                                     Predownload     Predownload
AP Name            Primary Image  Backup Image   Status          Version        Next Retry Time  Retry Count
------------------ -------------- -------------- --------------- -------------- ---------------- ------------
AP1140-1           7.0.56.0       6.0.183.38     Complete        6.0.183.38     NA               NA
AP1140-2           7.0.56.0       6.0.183.58     Initiated       6.0.183.38     23:46:43         1
AP1130-2           7.0.56.0       6.0.183.38     Complete        6.0.183.38     NA               NA
AP1130-3           7.0.56.0       6.0.183.58     Initiated       6.0.183.38     23:43:25         1
AP1130-4           7.0.56.0       6.0.183.38     Complete        6.0.183.38     NA               NA
AP1130-5           7.0.56.0       6.0.183.58     Initiated       6.0.183.38     23:43:00         1
AP1130-6           7.0.56.0       6.0.183.58     Initiated       6.0.183.38     23:41:33         1
```

The output lists access points specified for predownloading and provides, for each access point, primary and secondary image versions, the version of the predownload image, the predownload retry time (if necessary), and the number of predownload attempts. The output also includes the predownload status for each device. Statuses include:

- None—the access point is not scheduled for predownload.
- Predownloading—the access point is predownloading the image.
- Not supported—the access point (1120, 1230, and 1310) does not support predownloading.

- Initiated—the access point is waiting to get the predownload image because the conccurent download limit has been reached.
- Failed—the access point has failed 64 predownload attempts.
- Complete—the access point has completed predownloading.

Set a Reboot Time

Using the CLI, enter one of the following commands to schedule a reboot of the controller and access points. The network comes back up without going through an image download phase.

- **reset system in** *HH*:*MM*:*SS* **image** {**swap** | **no-swap**} **reset-aps** [**save-config**]

  This command lets you specify the amount of time delay before the devices reboot. The controller sends a reset mesage to all joined access points, then the controller resets. Use the **swap** keyword to swap the primary and backup images on the access point.

  This output appears on the console after you enter the command:

```
System reset is scheduled for Jan 12 18:12:9 2010.
Current local time and date is Jan 12 12:53:35 2010.
A trap will be generated 10 minutes before each scheduled system reset.
Use 'reset system cancel' to cancel.
Configuration will be saved before the system reset.
```

- **reset system at** *YYYY-MM-DD HH*:*MM*:*SS* **image** {**swap** | **no-swap**} **reset-aps** [**save-config**]

  This command lets you specify a date and time that the devices will reboot. The controller sends a reset mesage to all joined access points, and then the controller resets. Use the **swap** keyword to swap the primary and backup images on the access point.

- **reset system notify-time** *minutes*

  This optional command sets up an SNMP trap message that announces the upcoming reset. The controller sends the announcement trap the configured number of minutes before the reset.

  This output appears on the console after you enter the command:

```
System reset is scheduled for Jan 12 18:12:9 2010.
Current local time and date is Jan 12 12:53:35 2010.
A trap will be generated 10 minutes before each scheduled system reset.
Use 'reset system cancel' to cancel.
Configuration will be saved before the system reset.
```

To cancel the scheduled reboot, enter the **reset system cancel** command.

Note If you configure reset times and then use the **config time** command to change the system time on the controller, the controller notifies you that any scheduled reset times will be cancelled and must be reconfigured after you set the system time.

Use the **show reset** command to display scheduled resets. Sample output for the command:

```
System reset is scheduled for Oct 10 01:01:01 2009.
Current local time and date is Oct 07 02:57:44 2009.
A trap will be generated 10 minutes before each scheduled system reset.
Use 'reset system cancel' to cancel the reset.
Configuration will be saved before the system reset.
```

If any access points are downloading the image from the controller at the scheduled reset time, the reset is cancelled and this message appears on the controller console:

```
%OSAPI-3-RESETSYSTEM_FAILED: osapi_task.c:4458 System will not reset as software is being
upgraded.
```

Transferring Files to and from a Controller

Controllers have built-in utilities for uploading and downloading various files. Follow the instructions in these sections to import files using either the controller GUI or CLI:

- Downloading a Login Banner File, page 9-15
- Downloading Device Certificates, page 9-18
- Downloading CA Certificates, page 9-21
- Uploading PACs, page 9-23
- Uploading and Downloading Configuration Files, page 9-26

Downloading a Login Banner File

In controller software release 6.0 or later, you can download a login banner file using either the GUI or the CLI. The login banner is the text that appears on the screen before user authentication when you access the controller GUI or CLI using Telnet, SSH, or a console port connection.

You save the login banner information as a text (*.txt) file. The text file cannot be larger than 1500 bytes and cannot have more than 18 lines of text.

Note The ASCII character set consists of printable and non-printable characters. The login banner supports only printable characters.

Here is an example of a login banner:

```
Welcome to the Cisco Wireless Controller!
Unauthorized access prohibited.
Contact sysadmin@corp.com for access.
```

Follow the instructions in this section to download a login banner to the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the file download. Keep these guidelines in mind when setting up a TFTP or FTP server:

- If you are downloading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Note Clearing the controller configuration does not remove the login banner. See the "Clearing the Login Banner" section on page 9-18 for information about clearing the login banner using the controller GUI or CLI.

Note The controller can have only one login banner file. If you download another login banner file to the controller, the first login banner file is overwritten.

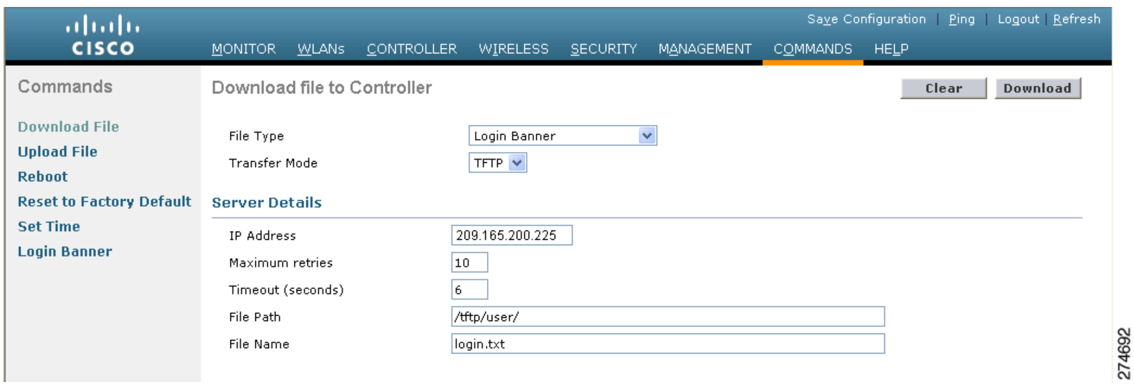
Using the GUI to Download a Login Banner File

Using the controller GUI, follow these steps to download a login banner file to the controller.

Step 1 Copy the login banner file to the default directory on your TFTP or FTP server.

Step 2 Choose **Commands** > **Download File** to open the Download File to Controller page (see Figure 9-2).

Figure 9-2 Download File to Controller Page



Step 3 From the File Type drop-down box, choose **Login Banner**.

Step 4 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 5 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 6 If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout fields should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the certificate in the Maximum Retries field and the amount of time (in seconds) that the TFTP server attempts to download the certificate in the Timeout field.

Step 7 In the File Path field, enter the directory path of the login banner file.

Step 8 In the File Name field, enter the name of the login banner text (*.txt) file.

Step 9 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 10 Click **Download** to download the login banner file to the controller. A message appears indicating the status of the download.

Using the CLI to Download a Login Banner File

Using the controller CLI, follow these steps to download a login banner file to the controller.

Step 1 Log into the controller CLI.

Step 2 Enter **transfer download mode** {**tftp** | **ftp**}.

Step 3 Enter **transfer download datatype login-banner**.

Step 4 Enter **transfer download serverip** *server-ip-address*.

Step 5 Enter **transfer download path** *server-path-to-file*.

Step 6 Enter **transfer download filename** *filename***.txt**.

Step 7 If you are using a TFTP server, enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

Step 8 If you are using an FTP server, enter these commands:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 9 Enter **transfer download start** to view the updated settings; then answer **y** when prompted to confirm the current settings and start the download process. This example shows the download command output:

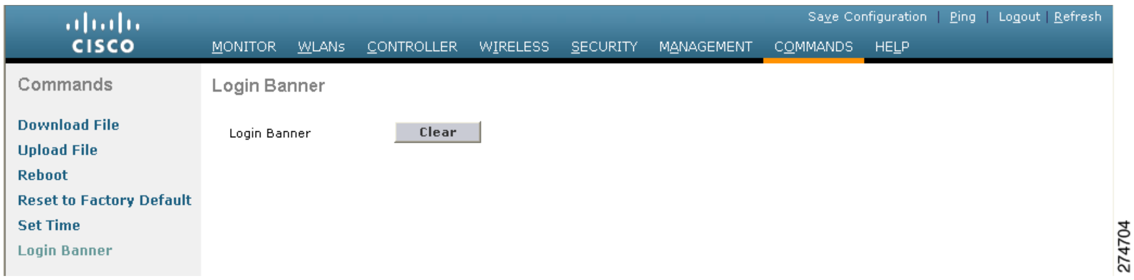
```
Mode............................................. TFTP
Data Type........................................ Login Banner
TFTP Server IP................................... 10.10.10.10
TFTP Packet Timeout.............................. 6
TFTP Max Retries................................. 10
TFTP Path........................................ /
TFTP Filename.................................... banner.txt

This may take some time.
Are you sure you want to start? (y/N) y

TFTP Login Banner transfer starting.

TFTP receive complete... checking login banner.

Successfully installed new login banner file
```

Clearing the Login Banner

Using the controller GUI, follow these steps to clear the login banner from the controller.

Step 1 Choose **Commands** > **Login Banner** to open the Login Banner page (see Figure 9-3).

Figure 9-3 Login Banner Page



Step 2 Click the **Clear** button.

Step 3 When prompted, click **OK** to clear the banner.

To clear the login banner from the controller using the controller CLI, enter the **clear login-banner** command.

Downloading Device Certificates

Each wireless device (controller, access point, and client) has its own device certificate. For example, the controller is shipped with a Cisco-installed device certificate. This certificate is used by EAP-FAST (when not using PACs), EAP-TLS, PEAP-GTC, and PEAP-MSCHAPv2 to authenticate wireless clients during local EAP authentication. However, if you wish to use your own vendor-specific device certificate, it must be downloaded to the controller.

Note See the "Configuring Local EAP" section on page 5-40 for information on configuring local EAP.

Follow the instructions in this section to download a vendor-specific device certificate to the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the certificate download. Keep these guidelines in mind when setting up a TFTP or FTP server:

- If you are downloading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Note All certificates downloaded to the controller must be in PEM format.

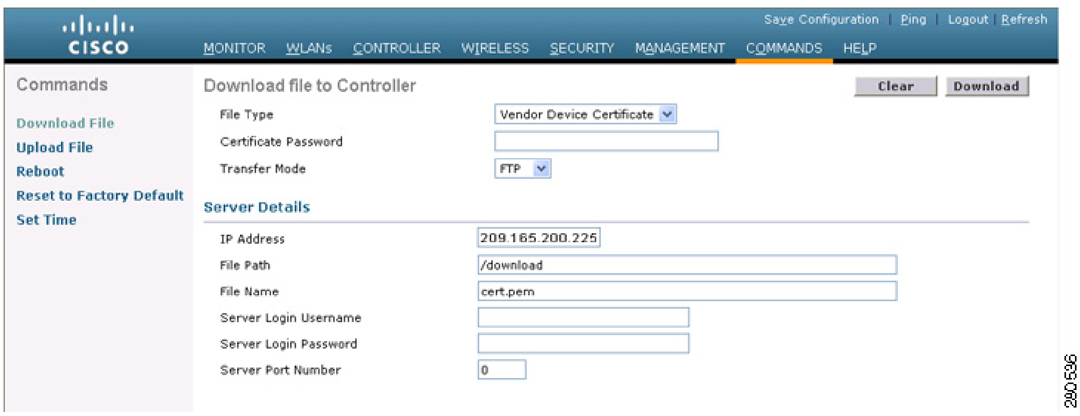
Using the GUI to Download Device Certificates

Using the controller GUI, follow these steps to download a device certificate to the controller.

Step 1 Copy the device certificate to the default directory on your TFTP or FTP server.

Step 2 Choose **Commands** > **Download File** to open the Download File to Controller page (see Figure 9-4).

Figure 9-4 Download File to Controller Page



Step 3 From the File Type drop-down box, choose **Vendor Device Certificate**.

Step 4 In the Certificate Password field, enter the password that was used to protect the certificate.

Step 5 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 6 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 7 If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout fields should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the certificate in the Maximum Retries field and the amount of time (in seconds) that the TFTP server attempts to download the certificate in the Timeout field.

Step 8 In the File Path field, enter the directory path of the certificate.

Step 9 In the File Name field, enter the name of the certificate.

Step 10 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 11 Click **Download** to download the device certificate to the controller. A message appears indicating the status of the download.

Step 12 After the download is complete, choose **Commands** > **Reboot** > **Reboot**.

Step 13 If prompted to save your changes, click **Save and Reboot**.

Step 14 Click **OK** to confirm your decision to reboot the controller.

Using the CLI to Download Device Certificates

Using the controller CLI, follow these steps to download a device certificate to the controller.

Step 1 Log into the controller CLI.

Step 2 Enter **transfer download mode** {**tftp | ftp**}.

Step 3 Enter **transfer download datatype eapdevcert**.

Step 4 Enter **transfer download certpassword** *password*.

Step 5 Enter **transfer download serverip** *server-ip-address*.

Step 6 Enter **transfer download path** *server-path-to-file*.

Step 7 Enter **transfer download filename** *filename*.pem.

Step 8 If you are using a TFTP server, enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

Step 9 If you are using an FTP server, enter these commands:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 10 Enter **transfer download start** to view the updated settings; then answer **y** when prompted to confirm the current settings and start the download process. This example shows the download command output:

```
Mode......................................... TFTP
Data Type.................................. Vendor Dev Cert
TFTP Server IP............................. 10.10.10.4
TFTP Packet Timeout........................... 6
TFTP Max Retries.............................. 10
TFTP Path.................................. /tftpboot/username/
TFTP Filename.............................. filename.pem

This may take some time.
Are you sure you want to start? (y/N) y
```

```
TFTP EAP Dev cert transfer starting.

Certificate installed.
Reboot the switch to use the new certificate.
```

Step 11 Enter **reset system** to reboot the controller.

Downloading CA Certificates

Controllers and access points have a Certificate Authority (CA) certificate that is used to sign and validate device certificates. The controller is shipped with a Cisco-installed CA certificate. This certificate may be used by EAP-FAST (when not using PACs), EAP-TLS, PEAP-GTC, and PEAP-MSCHAPv2 to authenticate wireless clients during local EAP authentication. However, if you wish to use your own vendor-specific CA certificate, it must be downloaded to the controller.

Note See the "Configuring Local EAP" section on page 5-40 for information on configuring local EAP.

Follow the instructions in this section to download CA certificates to the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the certificate download. Keep these guidelines in mind when setting up a TFTP or FTP server:

- If you are downloading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Note All certificates downloaded to the controller must be in PEM format.

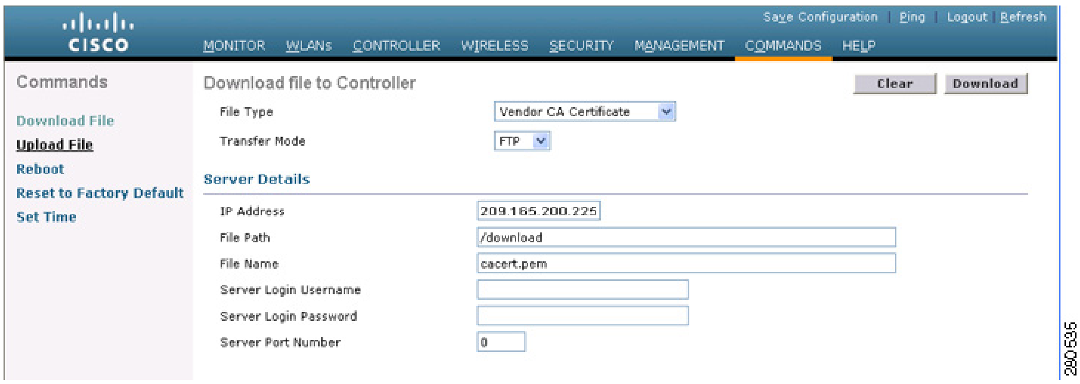
Using the GUI to Download CA Certificates

Using the controller GUI, follow these steps to download a CA certificate to the controller.

Step 1 Copy the CA certificate to the default directory on your TFTP or FTP server.

Step 2 Choose **Commands > Download File** to open the Download File to Controller page (see Figure 9-5).

Figure 9-5 Download File to Controller Page



Step 3 From the File Type drop-down box, choose **Vendor CA Certificate**.

Step 4 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 5 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 6 If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout fields should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the certificate in the Maximum Retries field and the amount of time (in seconds) that the TFTP server attempts to download the certificate in the Timeout field.

Step 7 In the File Path field, enter the directory path of the certificate.

Step 8 In the File Name field, enter the name of the certificate.

Step 9 If you are using an FTP server, follow these steps:

- **a.** In the Server Login Username field, enter the username to log into the FTP server.
- **b.** In the Server Login Password field, enter the password to log into the FTP server.
- **c.** In the Server Port Number field, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 10 Click **Download** to download the CA certificate to the controller. A message appears indicating the status of the download.

Step 11 After the download is complete, choose **Commands > Reboot > Reboot**.

Step 12 If prompted to save your changes, click **Save and Reboot**.

Step 13 Click **OK** to confirm your decision to reboot the controller.

Using the CLI to Download CA Certificates

Using the controller CLI, follow these steps to download a CA certificate to the controller.

Step 1 Log into the controller CLI.

Step 2 Enter **transfer download mode** {**tftp** | **ftp**}.

Step 3 Enter **transfer download datatype eapcacert**.

Step 4 Enter **transfer download serverip** *server-ip-address*.

Step 5 Enter **transfer download path** *server-path-to-file*.

Step 6 Enter **transfer download filename** *filename*.pem.

Step 7 If you are using a TFTP server, enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

Step 8 If you are using an FTP server, enter these commands:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 9 Enter **transfer download start** to view the updated settings; then answer **y** when prompted to confirm the current settings and start the download process. This example shows the download command output:

```
Mode......................................... TFTP
Data Type................................. Vendor CA Cert
TFTP Server IP............................ 10.10.10.4
TFTP Packet Timeout.......................... 6
TFTP Max Retries............................. 10
TFTP Path................................. /tftpboot/username/
TFTP Filename............................. filename.pem

This may take some time.
Are you sure you want to start? (y/N) y

TFTP EAP CA cert transfer starting.

Certificate installed.
Reboot the switch to use the new certificate.
```

Step 10 Enter **reset system** to reboot the controller.

Uploading PACs

Protected access credentials (PACs) are credentials that are either automatically or manually provisioned and used to perform mutual authentication with a local EAP authentication server during EAP-FAST authentication. When manual PAC provisioning is enabled, the PAC file is manually generated on the controller.

Note See the "Configuring Local EAP" section on page 5-40 for information on configuring local EAP.

Follow the instructions in this section to generate and load PACs from the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the PAC upload. Keep these guidelines in mind when setting up a TFTP or FTP server:

- If you are uploading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are uploading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Using the GUI to Upload PACs

Using the controller GUI, follow these steps to upload a PAC from the controller.

Step 1 Choose **Commands** > **Upload File** to open the Upload File from Controller page (see Figure 9-6).

Figure 9-6 Upload File from Controller Page

Step 2 From the File Type drop-down box, choose **PAC (Protected Access Credential)**.

Step 3 In the User field, enter the name of the user who will use the PAC.

Step 4 In the Validity field, enter the number days for the PAC to remain valid. The default setting is zero (0).

Step 5 In the Password and Confirm Password fields, enter a password to protect the PAC.

Step 6 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 7 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 8 In the File Path field, enter the directory path of the PAC.

Step 9 In the File Name field, enter the name of the PAC file. PAC files have a .pac extension.

Step 10 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the upload occurs. The default value is 21.

Step 11 Click **Upload** to upload the PAC from the controller. A message appears indicating the status of the upload.

Step 12 Follow the instructions for your wireless client to load the PAC on your client devices. Make sure to use the password that you entered above.

Using the CLI to Upload PACs

Using the controller CLI, follow these steps to upload a PAC from the controller.

Step 1 Log into the controller CLI.

Step 2 Enter **transfer upload mode** {**tftp** | **ftp**}.

Step 3 Enter **transfer upload datatype pac**.

Step 4 Enter **transfer upload pac** *username validity password*.

Step 5 Enter **transfer upload serverip** *server-ip-address*.

Step 6 Enter **transfer upload path** *server-path-to-file*.

Step 7 Enter **transfer upload filename** *manual*.pac.

Step 8 If you are using an FTP server, enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

> **Note** The default value for the *port* parameter is 21.

Step 9 Enter **transfer upload start** to view the updated settings; then answer **y** when prompted to confirm the current settings and start the upload process. This example shows the upload command output:

```
Mode........................................... TFTP
TFTP Server IP................................. 10.10.10.4
TFTP Path...................................... /tftpboot/username/
TFTP Filename.................................... manual.pac
Data Type........................................ PAC
PAC User......................................... username
PAC Validity..................................... 10 days
PAC Password................................... password

Are you sure you want to start? (y/N) y

PAC transfer starting.

File transfer operation completed successfully.
```

Step 10 Follow the instructions for your wireless client to load the PAC on your client devices. Make sure to use the password that you entered above.

Uploading and Downloading Configuration Files

Cisco recommends that you upload your controller's configuration file to a server to back it up. If you ever experience some loss of configuration, you can then download the saved configuration to the controller.

Note Do not download a configuration file to your controller that was uploaded from a different controller platform. For example, a 5500 series controller does not support the configuration file from a 4400 or 2100 series controller.

In controller software release 4.2 or later, the controller's bootup configuration file is stored in an Extensible Markup Language (XML) format rather than in binary format. Therefore, you cannot download a binary configuration file onto a controller running software release 4.2 or later. However, when you upgrade a controller from a previous software release to 4.2 or later, the configuration file is migrated and converted to XML.

Note Controller software release 5.2 or later enables you to read and modify the configuration file. See the "Editing Configuration Files" section on page 9-32 for details. Controller software releases prior to 5.2 do not allow configuration files to be modified. If you attempt to make changes to a 4.2, 5.0, or 5.1 configuration file and then download the file to a controller, the controller displays a cyclic redundancy checksum (CRC) error while it is rebooting and returns the configuration parameters to their default values.

Uploading Configuration Files

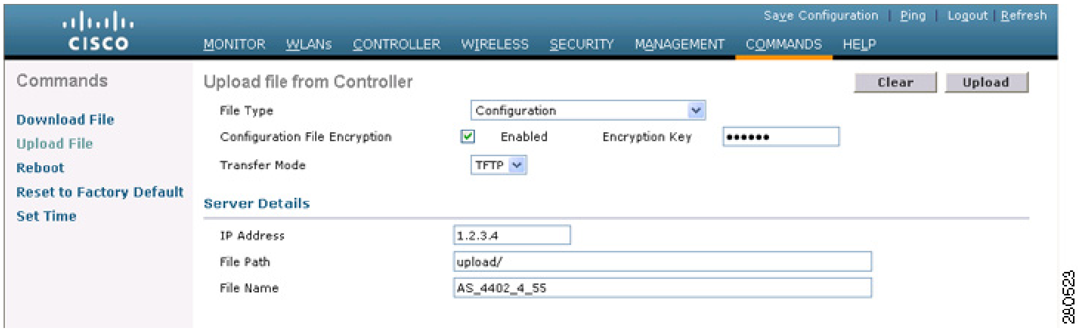
You can upload configuration files using either the GUI or the CLI.

Using the GUI to Upload Configuration Files

Using the controller GUI, follow these steps to upload a configuration file to a server.

Step 1 Choose **Commands** > **Upload File** to open the Upload File from Controller page (see Figure 9-7).

Figure 9-7 Upload File from Controller Page



Step 2 From the File Type drop-down box, choose **Configuration**.

Step 3 To encrypt the configuration file, check the **Configuration File Encryption** check box and enter the encryption key in the Encryption Key field.

Step 4 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 5 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 6 In the File Path field, enter the directory path of the configuration file.

Step 7 In the File Name field, enter the name of the configuration file.

Step 8 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the upload occurs. The default value is 21.

Step 9 Click **Upload** to upload the configuration file to the TFTP or FTP server. A message appears indicating the status of the upload. If the upload fails, repeat this procedure and try again.

Using the CLI to Upload Configuration Files

Using the controller CLI, follow these steps to upload a configuration file to a server.

Step 1 To specify the transfer mode used to upload the configuration file, enter this command:

transfer upload mode {**tftp** | **ftp**}

Step 2 To specify the type of file to be uploaded, enter this command:

transfer upload datatype config

Step 3 To encrypt the configuration file, enter these commands:

- **transfer encrypt enable**
- **transfer encrypt set-key** *key*, where *key* is the encryption key used to encrypt the file

Step 4 To specify the IP address of the TFTP or FTP server, enter this command:

transfer upload serverip *server-ip-address*

Step 5 To specify the directory path of the configuration file, enter this command:

transfer upload path *server-path-to-file*

Step 6 To specify the name of the configuration file to be uploaded, enter this command:

transfer upload filename *filename*

Step 7 If you are using an FTP server, enter these commands to specify the username and password used to log into the FTP server and the port number through which the upload occurs:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 8 To initiate the upload process, enter this command:

transfer upload start

Step 9 When prompted to confirm the current settings, answer **y**. This example shows the upload command output:

```
Mode........................................... TFTP
TFTP Server IP................................. 10.10.10.4
TFTP Path...................................... Config/
TFTP Filename.................................. AS_4402_4_2_55_8_Config.xml
Data Type...................................... Config File
Encryption..................................... Disabled

**************************************************
***  WARNING: Config File Encryption Disabled  ***
**************************************************

Are you sure you want to start? (y/N) y

File transfer operation completed successfully.
```

If the upload fails, repeat this procedure and try again.

Downloading Configuration Files

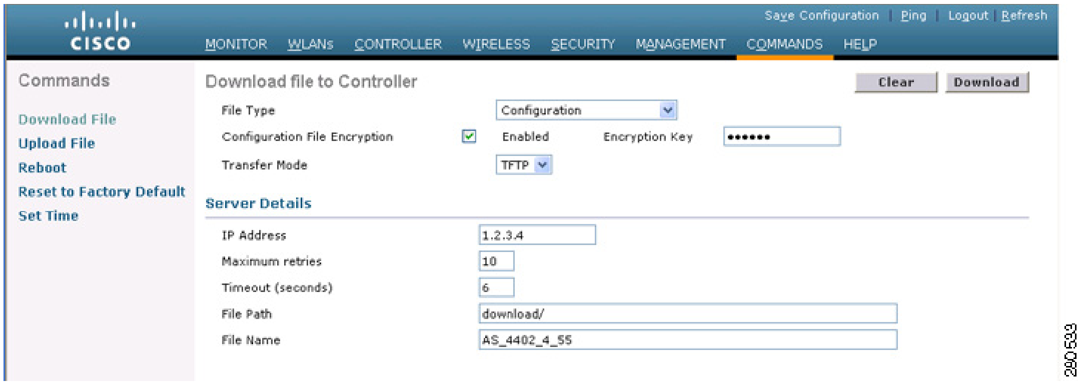
You can download configuration files using either the GUI or the CLI.

Using the GUI to Download Configuration Files

Using the controller GUI, follow these steps to download a configuration file to the controller.

Step 1 Choose **Commands > Download File** to open the Download File to Controller page (see Figure 9-8).

Figure 9-8 Download File to Controller Page



Step 2 From the File Type drop-down box, choose **Configuration**.

Step 3 If the configuration file is encrypted, check the **Configuration File Encryption** check box and enter the encryption key used to decrypt the file in the Encryption Key field.

> **Note** The key that you enter here should match the one entered during the upload process.

Step 4 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 5 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 6 If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout fields should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the configuration file in the Maximum Retries field and the amount of time (in seconds) that the TFTP server attempts to download the configuration file in the Timeout field.

Step 7 In the File Path field, enter the directory path of the configuration file.

Step 8 In the File Name field, enter the name of the configuration file.

Step 9 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 10 Click **Download** to download the file to the controller. A message appears indicating the status of the download, and the controller reboots automatically. If the download fails, repeat this procedure and try again.

Using the CLI to Download Configuration Files

Using the controller CLI, follow these steps to download a configuration file to the controller.

Note The controller does not support incremental configuration downloads. The configuration file contains all mandatory CLIs (all interface address CLIs, mgmtuser with read-write permission CLIs, and interface port or LAG enable or disable CLIs) required to successfully complete the download. For example, if you download only **config time ntp server** *index server_address* as part of the configuration file, the download fails. Only the CLI commands present in the configuration file are applied to the controller, and any configuration in the controller prior to the download is removed.

Step 1 To specify the transfer mode used to download the configuration file, enter this command:

transfer download mode {**tftp** | **ftp**}

Step 2 To specify the type of file to be downloaded, enter this command:

transfer download datatype config

Step 3 If the configuration file is encrypted, enter these commands:

- **transfer encrypt enable**
- **transfer encrypt set-key** *key*, where *key* is the encryption key used to decrypt the file

Note The key that you enter here should match the one entered during the upload process.

Step 4 To specify the IP address of the TFTP or FTP server, enter this command:

transfer download serverip *server-ip-address*

Step 5 To specify the directory path of the configuration file, enter this command:

transfer download path *server-path-to-file*

Step 6 To specify the name of the configuration file to be downloaded, enter this command:

transfer download filename *filename*

Step 7 If you are using a TFTP server, enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

Step 8 If you are using an FTP server, enter these commands to specify the username and password used to log into the FTP server and the port number through which the download occurs:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 9 To view the updated settings, enter this command:

transfer download start

Step 10 When prompted to confirm the current settings and start the download process, answer **y**. This example shows the download command output:

```
Mode........................................... TFTP
TFTP Server IP................................. 10.10.10.4
TFTP Path...................................... Config/
TFTP Filename.................................. AS_4402_4_2_55_8_Config.xml
Data Type...................................... Config File
Encryption..................................... Disabled

**************************************************
***  WARNING: Config File Encryption Disabled  ***
**************************************************

Are you sure you want to start? (y/N) y

File transfer operation completed successfully.
```

If the download fails, repeat this procedure and try again.

Saving Configurations

Controllers contain two kinds of memory: volatile RAM and NVRAM. At any time, you can save the configuration changes from active volatile RAM to non-volatile RAM (NVRAM) using one of these commands:

- **save config**—Saves the configuration from volatile RAM to NVRAM without resetting the controller.
- **reset system**—Prompts you to confirm that you want to save configuration changes before the controller reboots.
- **logout**—Prompts you to confirm that you want to save configuration changes before you log out.

Editing Configuration Files

When you save the controller's configuration, the controller stores it in XML format in flash memory. Controller software release 5.2 or later enables you to easily read and modify the configuration file by converting it to CLI format. When you upload the configuration file to a TFTP or FTP server, the controller initiates the conversion from XML to CLI. You can then read or edit the configuration file in CLI format on the server. When you are finished, you download the file back to the controller, where it is reconverted to XML format and saved.

Follow these steps to edit the controller's configuration file.

Step 1 To upload the configuration file to a TFTP or FTP server, perform one of the following:

- Upload the file using the controller GUI. Follow the instructions in the "Using the GUI to Upload Configuration Files" section on page 9-26.
- Upload the file using the controller CLI. Follow the instructions in the "Using the CLI to Upload Configuration Files" section on page 9-27.

Step 2 Read or edit the configuration file on the server. You can modify or delete existing CLI commands and add new CLI commands to the file.

> **Note** To edit the configuration file, you can use either Notepad or WordPad on Windows or the VI editor on Linux.

Step 3 Save your changes to the configuration file on the server.

Step 4 To download the configuration file to the controller, perform one of the following:

- Download the file using the controller GUI. Follow the instructions in the "Using the GUI to Download Configuration Files" section on page 9-28.
- Download the file using the controller CLI. Follow the instructions in the "Using the CLI to Download Configuration Files" section on page 9-30.

The controller converts the configuration file to XML format, saves it to flash memory, and then reboots using the new configuration. CLI commands with known keywords and proper syntax are converted to XML while improper CLI commands are ignored and saved to flash memory. Any CLI commands that have invalid values are replaced with default values. To see any ignored commands or invalid configuration values, enter this command:

show invalid-config

> **Note** You cannot execute this command after the **clear config** or **save config** command.

Step 5 If the downloaded configuration contains a large number of invalid CLI commands, you might want to upload the invalid configuration to the TFTP or FTP server for analysis. To do so, perform one of the following:

- Upload the invalid configuration using the controller GUI. Follow the instructions in the "Using the GUI to Upload Configuration Files" section on page 9-26 but choose **Invalid Config** from the File Type drop-down box in Step 2 and skip Step 3.
- Upload the invalid configuration using the controller CLI. Follow the instructions in the "Using the CLI to Upload Configuration Files" section on page 9-27 but enter this command in Step 2: **transfer upload datatype invalid-config** and skip Step 3.

Step 6 The controller does not support the uploading and downloading of port configuration CLI commands. If you want to configure the controller ports, enter these commands to do so now:

- **config port linktrap** {*port* | **all**} {**enable** | **disable**}—Enables or disables the up and down link traps for a specific controller port or for all ports.
- **config port adminmode** {*port* | **all**} {**enable** | **disable**}—Enables or disables the administrative mode for a specific controller port or for all ports.

Step 7 To save your changes, enter this command:

save config

Clearing the Controller Configuration

Follow these steps to clear the active configuration in NVRAM.

Step 1 Enter **clear config** and enter **y** at the confirmation prompt to confirm the action.

Step 2 Enter **reset system**. At the confirmation prompt, enter **n** to reboot without saving configuration changes. When the controller reboots, the configuration wizard starts automatically.

Step 3 Follow the instructions in the "Using the Configuration Wizard" section on page 2-2 to complete the initial configuration.

Erasing the Controller Configuration

Follow these steps to reset the controller configuration to default settings.

Step 1 Enter **reset system**. At the confirmation prompt, enter **y** to save configuration changes to NVRAM. The controller reboots.

Step 2 When you are prompted for a username, enter **recover-config** to restore the factory default configuration. The controller reboots and the configuration wizard starts automatically.

Step 3 Follow the instructions in the "Using the Configuration Wizard" section on page 2-2 to complete the initial configuration.

Resetting the Controller

You can reset the controller and view the reboot process on the CLI console using one of the following two methods:

- Turn the controller off and then turn it back on.
- On the CLI, enter **reset system**. At the confirmation prompt, enter **y** to save configuration changes to NVRAM. The controller reboots.

When the controller reboots, the CLI console displays the following reboot information:

- Initializing the system.
- Verifying the hardware configuration.
- Loading microcode into memory.
- Verifying the operating system software load.
- Initializing with its stored configurations.
- Displaying the login prompt.

Managing User Accounts

This chapter explains how to create and manage guest user accounts, describes the web authentication process, and provides instructions for customizing the web authentication login page. It contains these sections:

Creating Guest User Accounts

The controller can provide guest user access on WLANs. The first step in creating guest user accounts is to create a lobby administrator account, also known as a lobby ambassador account. Once this account has been created, a lobby ambassador can create and manage guest user accounts on the controller. The lobby ambassador has limited configuration privileges and access only to the web pages used to manage the guest accounts.

The lobby ambassador can specify the amount of time that the guest user accounts remain active. After the specified time elapses, the guest user accounts expire automatically.

The local user database is limited to a maximum of 2048 entries, which is also the default value (on the Security > AAA > General page). This database is shared by local management users (including lobby ambassadors), local network users (including guest users), MAC filter entries, exclusion list entries, and access point authorization list entries. Together they cannot exceed the configured maximum value.

Creating a Lobby Ambassador Account

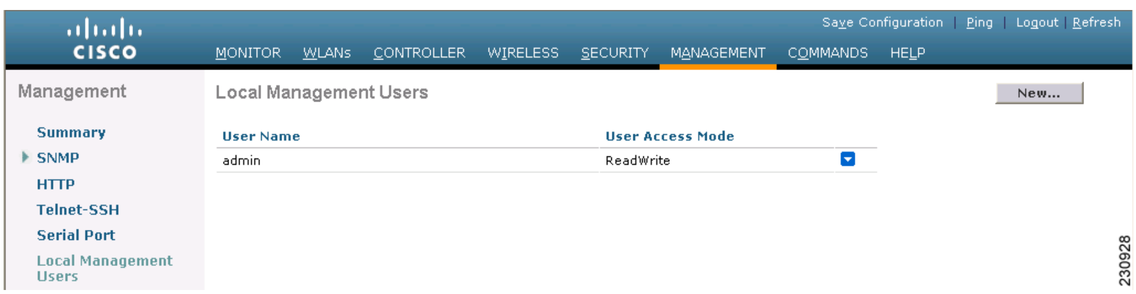
You can create a lobby ambassador account on the controller through either the GUI or the CLI.

Using the GUI to Create a Lobby Ambassador Account

Follow these steps to create a lobby ambassador account using the controller GUI.

Step 1 Choose **Management > Local Management Users** to open the Local Management Users page (see Figure 10-1).

Figure 10-1 Local Management Users Page

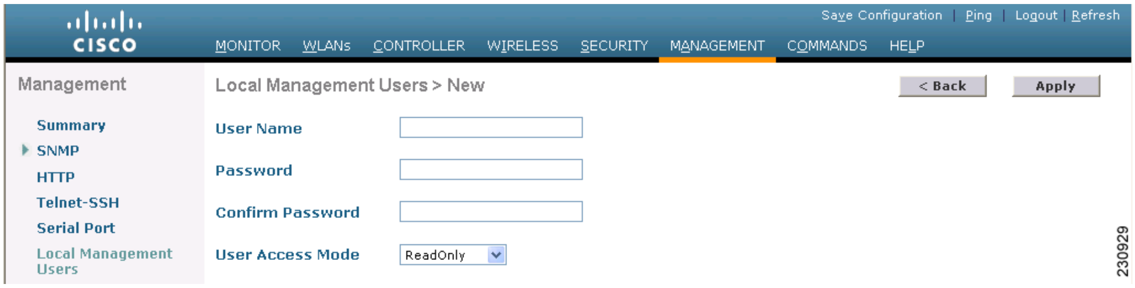


This page lists the names and access privileges of the local management users.

Note If you want to delete any of the user accounts from the controller, hover your cursor over the blue drop-down arrow and choose **Remove**. However, deleting the default administrative user prohibits both GUI and CLI access to the controller. Therefore, you must create a user with administrative privileges (ReadWrite) before you remove the default user.

Step 2 To create a lobby ambassador account, click **New**. The Local Management Users > New page appears (see Figure 10-2).

Figure 10-2 Local Management Users > New Page



Step 3 In the User Name field, enter a username for the lobby ambassador account.

Note Management usernames must be unique because they are stored in a single database.

Step 4 In the Password and Confirm Password fields, enter a password for the lobby ambassador account.

Note Passwords are case sensitive.

Step 5 Choose **LobbyAdmin** from the User Access Mode drop-down box. This option enables the lobby ambassador to create guest user accounts.

Note The **ReadOnly** option creates an account with read-only privileges, and the **ReadWrite** option creates an administrative account with both read and write privileges.

Step 6 Click **Apply** to commit your changes. The new lobby ambassador account appears in the list of local management users.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Create a Lobby Ambassador Account

Enter this command to create a lobby ambassador account using the controller CLI:

config mgmtuser add *lobbyadmin_username lobbyadmin_pwd* **lobby-admin**

Note Replacing **lobby-admin** with **read-only** creates an account with read-only privileges. Replacing **lobby-admin** with **read-write** creates an administrative account with both read and write privileges.

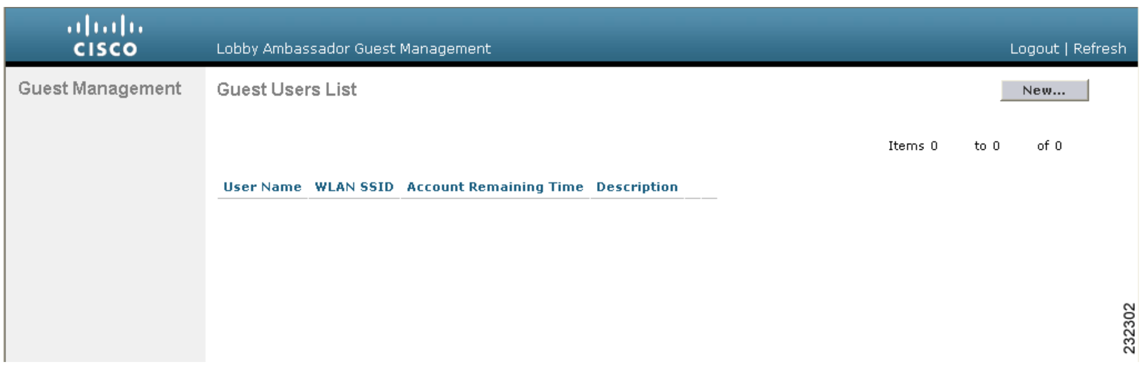
Creating Guest User Accounts as a Lobby Ambassador

A lobby ambassador would follow these steps to create guest user accounts.

> **Note** A lobby ambassador cannot access the controller CLI interface and therefore can create guest user accounts only from the controller GUI.

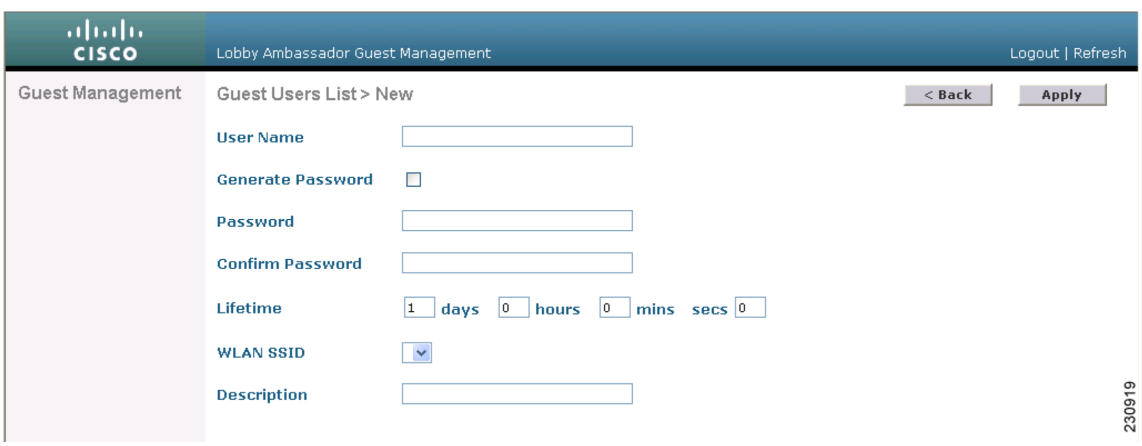
Step 1 Log into the controller as the lobby ambassador, using the username and password specified in the "Creating a Lobby Ambassador Account" section above. The Lobby Ambassador Guest Management > Guest Users List page appears (see Figure 10-3).

Figure 10-3 Lobby Ambassador Guest Management > Guest Users List Page



Step 2 Click **New** to create a guest user account. The Lobby Ambassador Guest Management > Guest Users List > New page appears (see Figure 10-4).

Figure 10-4 Lobby Ambassador Guest Management > Guest Users List > New Page



Step 3 In the User Name field, enter a name for the guest user. You can enter up to 24 characters.

Step 4 Perform one of the following:

- If you want to generate an automatic password for this guest user, check the **Generate Password** check box. The generated password is entered automatically in the Password and Confirm Password fields.
- If you want to create a password for this guest user, leave the **Generate Password** check box unchecked and enter a password in both the Password and Confirm Password fields.

Note Passwords can contain up to 24 characters and are case sensitive.

Step 5 From the Lifetime drop-down boxes, choose the amount of time (in days, hours, minutes, and seconds) that this guest user account is to remain active. A value of zero (0) for all four fields creates a permanent account.

Default: 1 day

Range: 5 minutes to 30 days

Note The smaller of this value or the session timeout for the guest WLAN, which is the WLAN on which the guest account is created, takes precedence. For example, if a WLAN session timeout is due to expire in 30 minutes but the guest account lifetime has 10 minutes remaining, the account is deleted in 10 minutes upon guest account expiry. Similarly, if the WLAN session timeout expires before the guest account lifetime, the client experiences a recurring session timeout that requires reauthentication.

Note You can change a guest user account with a non-zero lifetime to another lifetime value at any time while the account is active. However, to make a guest user account permanent using the controller GUI, you must delete the account and create it again. If desired, you can use the **config netuser lifetime** *user_name* **0** CLI command to make a guest user account permanent without deleting and recreating it.

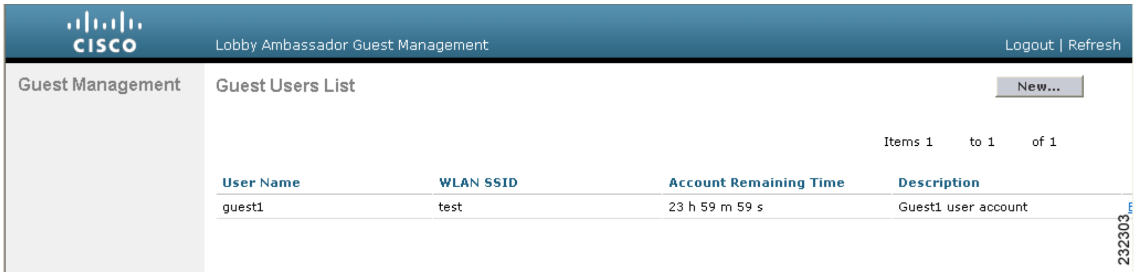
Step 6 From the WLAN SSID drop-down box, choose the SSID that will be used by the guest user. The only WLANs that are listed are those for which Layer 3 web authentication has been configured.

Note Cisco recommends that the system administrator create a specific guest WLAN to prevent any potential conflicts. If a guest account expires and it has a name conflict with an account on the RADIUS server and both are on the same WLAN, the users associated with both accounts are disassociated before the guest account is deleted.

Step 7 In the Description field, enter a description of the guest user account. You can enter up to 32 characters.

Step 8 Click **Apply** to commit your changes. The new guest user account appears in the list of guest users on the Guest Users List page (see Figure 10-5).

Figure 10-5 Lobby Ambassador Guest Management > Guest Users List Page



From this page, you can see all of the guest user accounts, their WLAN SSID, and their lifetime. You can also edit or remove a guest user account. When you remove a guest user account, all of the clients that are using the guest WLAN and are logged in using that account's username are deleted.

Step 9 Repeat this procedure to create any additional guest user accounts.

Viewing Guest User Accounts

After a lobby ambassador has created guest user accounts, the system administrator can view them from the controller GUI or CLI.

Using the GUI to View Guest Accounts

To view guest user accounts using the controller GUI, choose **Security** > **AAA** > **Local Net Users**. The Local Net Users page appears (see Figure 10-6).

Figure 10-6 Local Net Users Page

From this page, the system administrator can see all of the local net user accounts (including guest user accounts) and can edit or remove them as desired. When you remove a guest user account, all of the clients that are using the guest WLAN and are logged in using that account's username are deleted.

Using the CLI to View Guest Accounts

To view all of the local net user accounts (including guest user accounts) using the controller CLI, enter this command:

show netuser summary

Obtaining a Web Authentication Certificate

The controller's operating system automatically generates a fully functional web authentication certificate, so you do not need to do anything in order to use certificates with Layer 3 web authentication. However, if desired, you can prompt the operating system to generate a new web authentication certificate, or you can download an externally generated SSL certificate.

Support for Chained Certificate

In controller versions earlier than 5.1.151.0, web authentication certificates can be only device certificates and should not contain the CA roots chained to the device certificate (no chained certificates).

With controller version 5.1.151.0 and later, the controller allows for the device certificate to be downloaded as a chained certificate (up to a level of 2) for web authentication. For more information about chained certificates, see the *Generate CSR for Third-Party Certificates and Download Chained Certificates to the WLC* document at

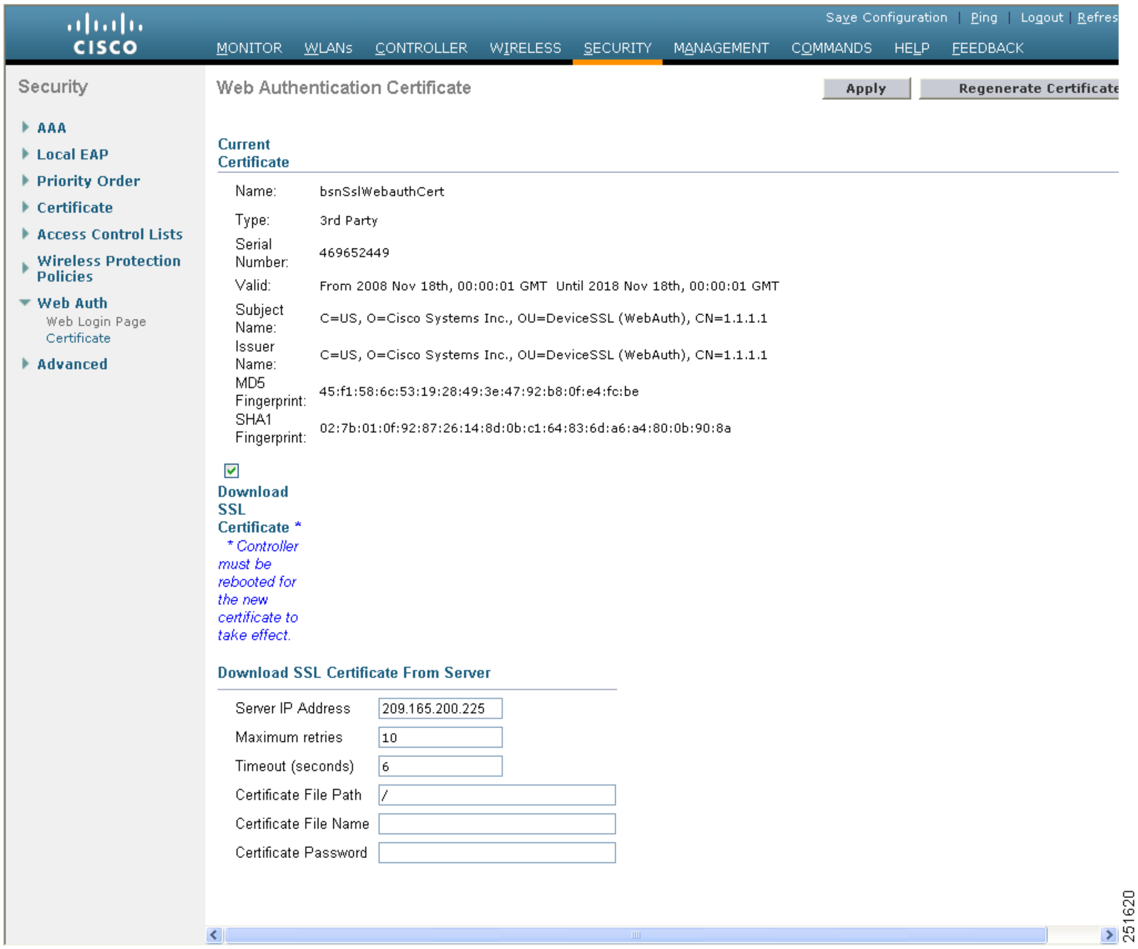
http://www.cisco.com/c/en/us/support/docs/wireless/4400-series-wireless-lan-controllers/109597-csr-chained-certificates-wlc-00.html.

Using the GUI to Obtain a Web Authentication Certificate

Using the controller GUI, follow these steps to view the current web authentication certificate, generate a new certificate, or download an externally generated certificate.

Step 1 Choose **Security** > **Web Auth** > **Certificate** to open the Web Authentication Certificate page (see Figure 10-7).

Figure 10-7 Web Authentication Certificate Page



This page shows the details of the current web authentication certificate.

Step 2 If you want to use a new operating system-generated web authentication certificate, follow these steps:

a. Click **Regenerate Certificate**. The operating system generates a new web authentication certificate, and a successfully generated web authentication certificate message appears.

b. Reboot the controller to register the new certificate.

Step 3 If you prefer to use an externally generated web authentication certificate, follow these steps:

a. Verify that the controller can ping the TFTP server.

b. Check the **Download SSL Certificate** check box.

c. In the Server IP Address field, enter the IP address of the TFTP server.

d. The default values of 10 retries and 6 seconds for the Maximum Retries and Timeout fields should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that each download can be attempted in the Maximum Retries field and the amount of time (in seconds) allowed for each download in the Timeout field.

e. In the Certificate File Path field, enter the directory path of the certificate.

f. In the Certificate File Name field, enter the name of the certificate (*certname*.pem).

g. In the Certificate Password field, enter the password for the certificate.

h. Click **Apply** to commit your changes. The operating system downloads the new certificate from the TFTP server.

i. Reboot the controller to register the new certificate.

Using the CLI to Obtain a Web Authentication Certificate

Using the controller CLI, follow these steps to view the current web authentication certificate, generate a new certificate, or download an externally generated certificate.

Step 1 To see the current web authentication certificate, enter this command:

show certificate summary

Information similar to the following appears:

```
Web Administration Certificate.................. Locally Generated
Web Authentication Certificate.................. Locally Generated
Certificate compatibility mode:............... off
```

Step 2 If you want the operating system to generate a new web authentication certificate, follow these steps:

a. To generate the new certificate, enter this command:

config certificate generate webauth

b. To reboot the controller to register the new certificate, enter this command:

reset system

Step 3 If you prefer to use an externally generated web authentication certificate, follow these steps:

Note Cisco recommends that the Common Name (CN) of the externally generated web authentication certificate be a virtual interface IP address in order for the client's browser to match the domains of the web authentication URL and the web authentication certificate.

a. To specify the name, path, and type of certificate to be downloaded, enter these commands:

transfer download mode tftp

transfer download datatype webauthcert

transfer download serverip *server_ip_address*

transfer download path *server_path_to_file*

transfer download filename *certname*.pem

transfer download certpassword *password*

transfer download tftpMaxRetries *retries*

transfer download tftpPktTimeout *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that each download can be attempted for the *retries* parameter and the amount of time (in seconds) allowed for each download for the *timeout* parameter.

b. To start the download process, enter this command:

transfer download start

c. To reboot the controller to register the new certificate, enter this command:

reset system

Web Authentication Process

Web authentication is a Layer 3 security feature that causes the controller to not allow IP traffic (except DHCP-related packets) from a particular client until that client has correctly supplied a valid username and password. When you use web authentication to authenticate clients, you must define a username and password for each client. Then when the clients attempt to join the wireless LAN, their users must enter the username and password when prompted by a login page.

Note On pure web authentication without any L2 protection, it is possible to do MAC address spoofing and hijack connections. This is a security issue coming from the use of 802.11 open technologies, and not from web authentication itself.
This can be prevented by using 802.11i encryption or VPN IPsec/SSL technologies.
If you are using pure web authentication, you should take measures to ensure that guest access clients cannot access sensitive resources.

When web authentication is enabled (under Layer 3 Security), users might receive a web-browser security alert the first time that they attempt to access a URL. Figure 10-8 shows a typical security alert.

Figure 10-8 Typical Web-Browser Security Alert

After the user clicks **Yes** to proceed (or if the client's browser does not display a security alert), the web authentication system redirects the client to a login page (see Figure 10-9).

To prevent the security alert from appearing, the user can perform these steps:

Step 1 Click **View Certificate** on the Security Alert page.

Step 2 Click **Install Certificate**.

Step 3 When the Certificate Import Wizard appears, click **Next**.

Step 4 Choose **Place all certificates in the following store** and click **Browse**.

Step 5 At the bottom of the Select Certificate Store page, check the **Show Physical Stores** check box.

Step 6 Expand the **Trusted Root Certification Authorities** folder and choose **Local Computer**.

Step 7 Click **OK**.

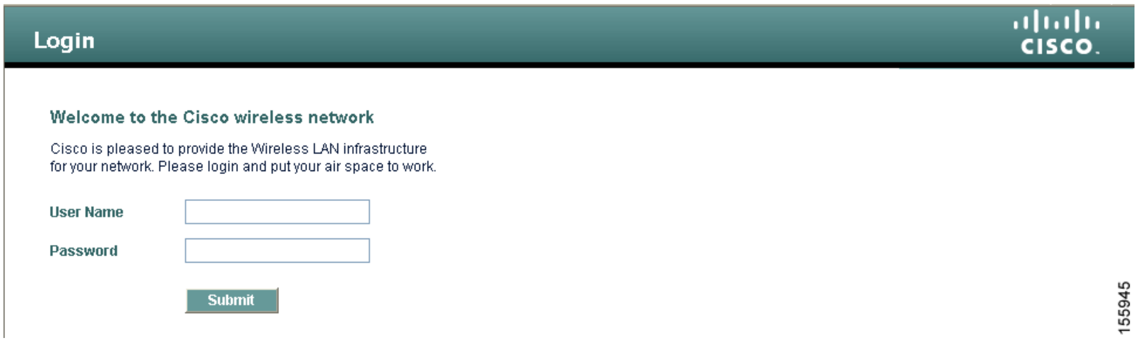
Step 8 Click **Next** > **Finish**.

Step 9 When the "The import was successful" message appears, click **OK**.

Step 10 Because the issuer field is blank on the controller self-signed certificate, open Internet Explorer, choose **Tools** > **Internet Options** > **Advanced**, uncheck the **Warn about Invalid Site Certificates** check box under Security, and click **OK**.

Step 11 Reboot the PC. On the next web authentication attempt, the login page appears (see Figure 10-9).

Figure 10-9 Default Web Authentication Login Page



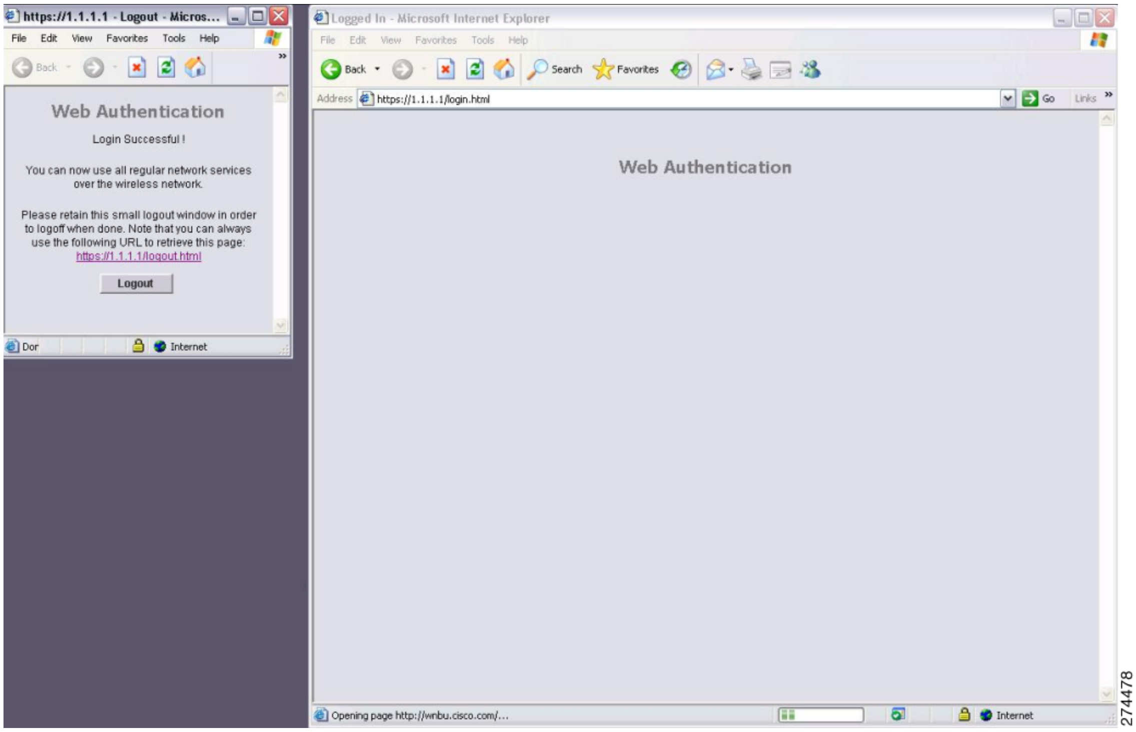
The default login page contains a Cisco logo and Cisco-specific text. You can choose to have the web authentication system display one of the following:

- The default login page
- A modified version of the default login page
- A customized login page that you configure on an external web server
- A customized login page that you download to the controller

The "Choosing the Web Authentication Login Page" section on page 10-13 provides instructions for choosing how the web authentication login page appears.

When the user enters a valid username and password on the web authentication login page and clicks **Submit**, the web authentication system displays a successful login page and redirects the authenticated client to the requested URL. Figure 10-10 shows a typical successful login page.

Figure 10-10 Successful Login Page



The default successful login page contains a pointer to a virtual gateway address URL: https:// /logout.html. The IP address that you set for the controller virtual interface serves as the redirect address for the login page (see the for more information on the virtual interface).

Choosing the Web Authentication Login Page

This section provides instructions for specifying the content and appearance of the web authentication login page. Follow the instructions in one of these sections to choose the web authentication login page using the controller GUI or CLI:

- Choosing the Default Web Authentication Login Page, page 10-14
- Creating a Customized Web Authentication Login Page, page 10-18
- Using a Customized Web Authentication Login Page from an External Web Server, page 10-20
- Downloading a Customized Web Authentication Login Page, page 10-22
- Assigning Login, Login Failure, and Logout Pages per WLAN, page 10-26

Note If you do not want users to connect to a web page using a browser that is configured with SSLv2 only, you can disable SSLv2 for web authentication by entering this command: **config network secureweb cipher-option sslv2 disable**. If you enter this command, users must use a browser that is configured to use a more secure protocol such as SSLv3 or later. The default value is enabled.

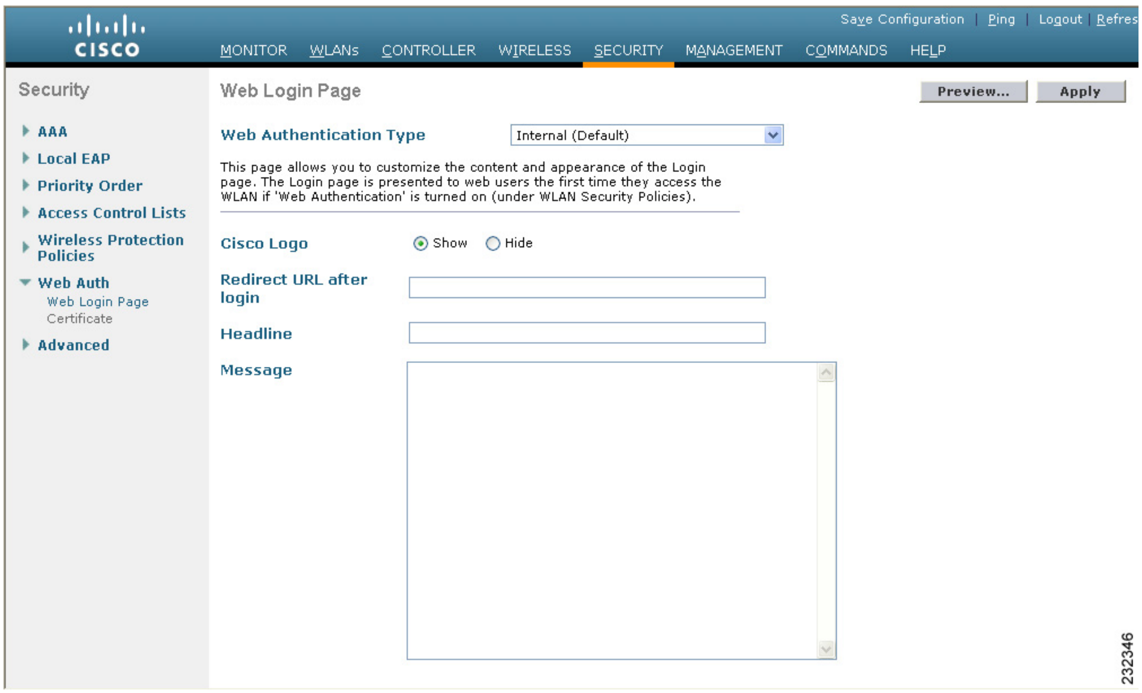
Choosing the Default Web Authentication Login Page

If you want to use the default web authentication login page as is (see Figure 10-9) or with a few modifications, follow the instructions in the GUI or CLI procedure below.

Using the GUI to Choose the Default Web Authentication Login Page

Step 1 Choose **Security** > **Web Auth** > **Web Login Page** to open the Web Login page (see Figure 10-11).

Figure 10-11 Web Login Page



Step 2 From the Web Authentication Type drop-down box, choose **Internal (Default)**.

Step 3 If you want to use the default web authentication login page as is, go to Step 8. If you want to modify the default login page, go to Step 4.

Step 4 If you want to hide the Cisco logo that appears in the top right corner of the default page, choose the Cisco Logo **Hide** option. Otherwise, click the **Show** option.

Step 5 If you want the user to be directed to a particular URL (such as the URL for your company) after login, enter the desired URL (such as www.AcompanyBC.com) in the Redirect URL After Login field. You can enter up to 254 characters.

Note The controller supports web authentication redirects only to HTTP (HTTP over TCP) servers. It does not support web authentication redirects to HTTPS (HTTP over SSL) servers.

Step 6 If you want to create your own headline on the login page, enter the desired text in the Headline field. You can enter up to 127 characters. The default headline is “Welcome to the Cisco wireless network.”

Step 7 If you want to create your own message on the login page, enter the desired text in the Message field. You can enter up to 2047 characters. The default message is “Cisco is pleased to provide the Wireless LAN infrastructure for your network. Please login and put your air space to work.”

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Preview** to view the web authentication login page.

Step 10 If you are satisfied with the content and appearance of the login page, click **Save Configuration** to save your changes. Otherwise, repeat any of the previous steps as necessary to achieve your desired results.

Using the CLI to Choose the Default Web Authentication Login Page

Step 1 To specify the default web authentication type, enter this command:

config custom-web webauth_type internal

Step 2 If you want to use the default web authentication login page as is, go to Step 7. If you want to modify the default login page, go to Step 3.

Step 3 To show or hide the Cisco logo that appears in the top right corner of the default login page, enter this command:

config custom-web weblogo {**enable** | **disable**}

Step 4 If you want the user to be directed to a particular URL (such as the URL for your company) after login, enter this command:

config custom-web redirecturl *url*

You can enter up to 130 characters for the URL. To change the redirect back to the default setting, enter **clear redirecturl**.

Note The controller supports web authentication redirects only to HTTP (HTTP over TCP) servers. It does not support web authentication redirects to HTTPS (HTTP over SSL) servers.

Step 5 If you want to create your own headline on the login page, enter this command:

config custom-web webtitle *title*

You can enter up to 130 characters. The default headline is “Welcome to the Cisco wireless network.” To reset the headline to the default setting, enter **clear webtitle**.

Step 6 If you want to create your own message on the login page, enter this command:

config custom-web webmessage *message*

You can enter up to 130 characters. The default message is “Cisco is pleased to provide the Wireless LAN infrastructure for your network. Please login and put your air space to work.” To reset the message to the default setting, enter **clear webmessage**.

Step 7 Enter **save config t**o save your settings.

Step 8 If you want to import your own logo into the web authentication login page, follow these steps:

a. Make sure that you have a Trivial File Transfer Protocol (TFTP) server available for the file download. Keep these guidelines in mind when setting up a TFTP server:
   - If you are downloading through the service port, the TFTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
   - If you are downloading through the distribution system network port, the TFTP server can be on the same or a different subnet because the distribution system port is routable.
   - A third-party TFTP server cannot run on the same computer as the Cisco WCS because the WCS built-in TFTP server and the third-party TFTP server require the same communication port.

b. Enter **ping ip-address** to ensure that the controller can contact the TFTP server.

c. Copy the logo file (in .jpg, .gif, or .png format) to the default directory on your TFTP server. The maximum file size is 30 kilobits. For an optimal fit, the logo should be approximately 180 pixels wide and 360 pixels high.

d. To specify the download mode, enter **transfer download mode tftp**.

e. To specify the type of file to be downloaded, enter **transfer download datatype image**.

f. To specify the IP address of the TFTP server, enter **transfer download serverip** *tftp-server-ip-address*.

   Note Some TFTP servers require only a forward slash (/) as the TFTP server IP address, and the TFTP server automatically determines the path to the correct directory.

g. To specify the download path, enter **transfer download path** *absolute-tftp-server-path-to-file*.

h. To specify the file to be downloaded, enter **transfer download filename** {*filename.jpg* | *filename.gif* | *filename.png*}.

i. Enter **transfer download start** to view your updated settings and answer **y** to the prompt to confirm the current download settings and start the download. Information similar to the following appears:

```
Mode........................................... TFTP
Data Type...................................... Login Image
TFTP Server IP................................. xxx.xxx.xxx.xxx
TFTP Path...................................... <directory path>
TFTP Filename...................................... <filename.jpg|.gif|.png>
This may take some time.
Are you sure you want to start? (y/n) y
TFTP Image transfer starting.
Image installed.
```

j. Enter **save config** to save your settings.

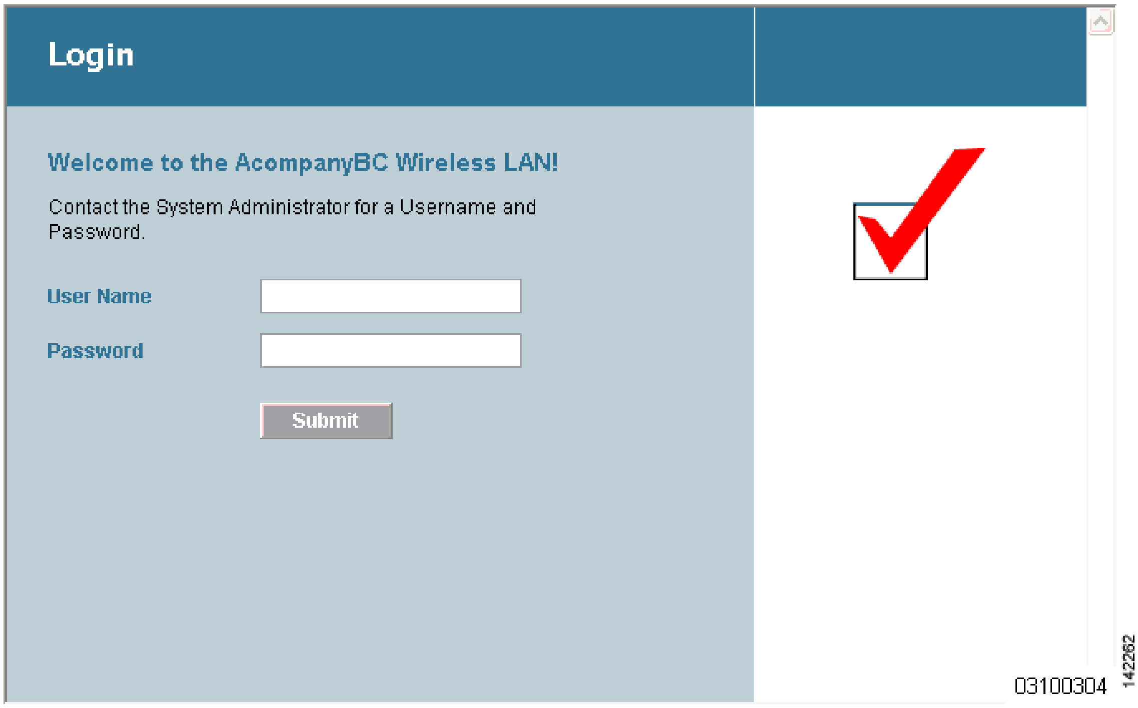
Note If you ever want to remove this logo from the web authentication login page, enter **clear webimage**.

Step 9 Follow the instructions in the "Using the CLI to Verify the Web Authentication Login Page Settings" section on page 10-25 to verify your settings.

Modified Default Web Authentication Login Page Example

Figure 10-12 shows an example of a modified default web authentication login page.

Figure 10-12 Modified Default Web Authentication Login Page Example



These are the CLI commands used to create this login page:

config custom-web weblogo disable

config custom-web webtitle Welcome to the AcompanyBC Wireless LAN!

config custom-web webmessage Contact the System Administrator for a Username and Password.

transfer download start

```
Mode........................................... TFTP
Data Type...................................... Login Image
TFTP Server IP................................. xxx.xxx.xxx.xxx
TFTP Path...................................... /
TFTP Filename...................................... Logo.gif
This may take some time.
Are you sure you want to start? (y/n) y
TFTP Image transfer starting.
Image installed.
```

config custom-web redirecturl http://www.AcompanyBC.com

show custom-web

```
Cisco Logo.................. Disabled
CustomLogo.................. 00_logo.gif
Custom Title................ Welcome to the AcompanyBC Wireless LAN!
Custom Message ............. Contact the System Administrator for a Username and Password.
Custom Redirect URL......... http://www.AcompanyBC.com
Web Authentication Mode..... Disabled
Web Authentication URL........ Disabled
```

Creating a Customized Web Authentication Login Page

This section provides information on creating a customized web authentication login page, which can then be accessed from an external web server.

Here is a web authentication login page template. It can be used as a model when creating your own customized page.

```
<html>
<head>
<meta http-equiv="Pragma" content="no-cache">
<meta HTTP-EQUIV="Content-Type" CONTENT="text/html; charset=iso-8859-1">
<title>Web Authentication</title>
<script>

function submitAction(){
    var link = document.location.href;
    var searchString = "redirect=";
    var equalIndex = link.indexOf(searchString);
    var redirectUrl = "";

    if (document.forms[0].action == "") {
        var url = window.location.href;
        var args = new Object();
        var query = location.search.substring(1);
        var pairs = query.split("&");
        for(var i=0;i<pairs.length;i++){
        var pos = pairs[i].indexOf('=');
            if(pos == -1) continue;
                var argname = pairs[i].substring(0,pos);
                var value = pairs[i].substring(pos+1);
                args[argname] = unescape(value);
        }
            document.forms[0].action = args.switch_url;
        }

      if(equalIndex >= 0) {
        equalIndex += searchString.length;
        redirectUrl = "";
        redirectUrl += link.substring(equalIndex);
        }
        if(redirectUrl.length > 255)
        redirectUrl = redirectUrl.substring(0,255);
        document.forms[0].redirect_url.value = redirectUrl;
        document.forms[0].buttonClicked.value = 4;
        document.forms[0].submit();
}

    function loadAction(){
      var url = window.location.href;
      var args = new Object();
      var query = location.search.substring(1);
      var pairs = query.split("&");
      for(var i=0;i<pairs.length;i++){
          var pos = pairs[i].indexOf('=');
          if(pos == -1) continue;
          var argname = pairs[i].substring(0,pos);
          var value = pairs[i].substring(pos+1);
          args[argname] = unescape(value);
      }
//alert( "AP MAC Address is " + args.ap_mac);
      //alert( "The Switch URL to post user credentials is " + args.switch_url);
      //document.forms[0].action = args.switch_url;
```

```
        // This is the status code returned from webauth login action
        // Any value of status code from 1 to 5 is error condition and user
        // should be shown error as below or modify the message as it suits
        // the customer
        if(args.statusCode == 1){
          alert("You are already logged in. No further action is required on your part.");
        }
        else if(args.statusCode == 2){
          alert("You are not configured to authenticate against web portal. No further
action is required on your part.");
        }
        else if(args.statusCode == 3){
          alert("The username specified cannot be used at this time. Perhaps the username is
already logged into the system?");
        }
        else if(args.statusCode == 4){
          alert("The User has been excluded. Please contact the administrator.");
        }
        else if(args.statusCode == 5){
          alert("Invalid username and password. Please try again.");
        }

}

</script>
</head>
<body topmargin="50" marginheight="50" onload="loadAction();">
<form method="post" action="https://209.165.200.225/login.html">
<input TYPE="hidden" NAME="buttonClicked" SIZE="16" MAXLENGTH="15" value="0">
<input TYPE="hidden" NAME="redirect_url" SIZE="255" MAXLENGTH="255" VALUE="">
<input TYPE="hidden" NAME="err_flag" SIZE="16" MAXLENGTH="15" value="0">

<div align="center">
<table border="0" cellspacing="0" cellpadding="0">
<tr> <td> </td></tr>

<tr align="center"> <td colspan="2"><font size="10" color="#336699">Web
Authentication</font></td></tr>

<tr align="center">

<td colspan="2"> User Name    <input type="TEXT" name="username" SIZE="25"
MAXLENGTH="63" VALUE="">
</td>
</tr>
<tr align="center" >
<td colspan="2"> Password      <input type="Password"
name="password" SIZE="25" MAXLENGTH="24">
</td>
</tr>

<tr align="center">
<td colspan="2"><input type="button" name="Submit" value="Submit" class="button"
onclick="submitAction();">
</td>
</tr>
</table>
</div>

</form>
</body>
</html>
```

These parameters are added to the URL when the user's Internet browser is redirected to the customized login page:

- **ap_mac**—The MAC address of the access point to which the wireless user is associated.
- **switch_url**—The URL of the controller to which the user credentials should be posted.
- **redirect—**The URL to which the user is redirected after authentication is successful.
- **statusCode**—The status code returned from the controller's web authentication server.
- **wlan**—The WLAN SSID to which the wireless user is associated.

These are the available status codes:

- Status Code 1: "You are already logged in. No further action is required on your part."
- Status Code 2: "You are not configured to authenticate against web portal. No further action is required on your part."
- Status Code 3: "The username specified cannot be used at this time. Perhaps the username is already logged into the system?"
- Status Code 4: "You have been excluded."
- Status Code 5: "The User Name and Password combination you have entered is invalid. Please try again."

Note For additional information, refer to the *External Web Authentication with Wireless LAN Controllers Configuration Example* at this URL:

http://www.cisco.com/c/en/us/support/docs/wireless-mobility/wlan-security/71881-ext-web-auth-wlc.html

Using a Customized Web Authentication Login Page from an External Web Server

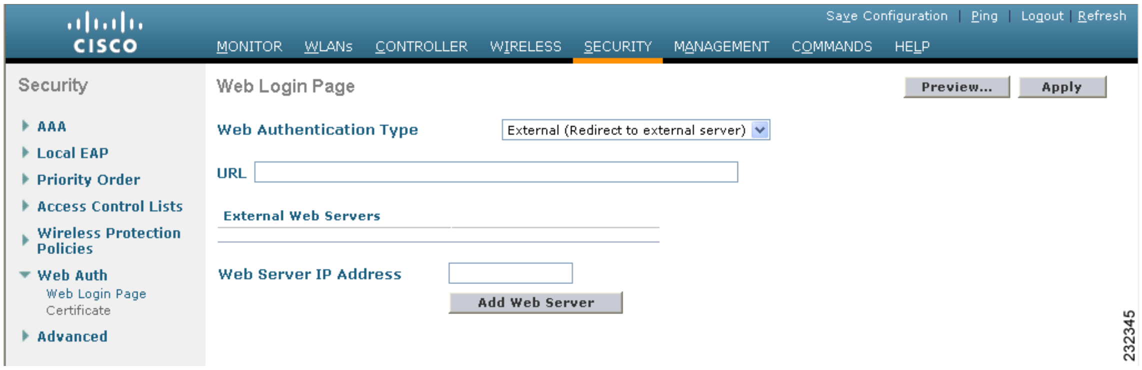
If you want to use a customized web authentication login page that you configured on an external web server, follow the instructions in the GUI or CLI procedure below. When you enable this feature, the user is directed to your customized login page on the external web server.

Note For 5500 series controllers, 2100 series controllers, and controller network modules, you must configure a preauthentication access control list (ACL) on the WLAN for the external web server and then choose this ACL as the WLAN preauthentication ACL under Security Policies > Web Policy on the WLANs > Edit page. See the *Configuring Security Solutions* chapter for more information on ACLs.

Using the GUI to Choose a Customized Web Authentication Login Page from an External Web Server

Step 1 Choose **Security** > **Web Auth** > **Web Login Page** to open the Web Login page (see Figure 10-13).

Figure 10-13 Web Login Page



Step 2 From the Web Authentication Type drop-down box, choose **External (Redirect to external server)**.

Step 3 In the URL field, enter the URL of the customized web authentication login page on your web server. You can enter up to 252 characters.

Step 4 In the Web Server IP Address field, enter the IP address of your web server. Your web server should be on a different network from the controller service port network.

Step 5 Click **Add Web Server**. This server now appears in the list of external web servers.

Step 6 Click **Apply** to commit your changes.

Step 7 If you are satisfied with the content and appearance of the login page, click **Save Configuration** to save your changes.

Using the CLI to Choose a Customized Web Authentication Login Page from an External Web Server

Step 1 To specify the web authentication type, enter this command:

config custom-web webauth_type external

Step 2 To specify the URL of the customized web authentication login page on your web server, enter this command:

config custom-web ext-webauth-url *url*

You can enter up to 252 characters for the URL.

Step 3 To specify the IP address of your web server, enter this command:

config custom-web ext-webserver {**add** | **delete**} *server_IP_address*

Step 4 Enter **save config** to save your settings.

Step 5 Follow the instructions in the "Using the CLI to Verify the Web Authentication Login Page Settings" section on page 10-25 to verify your settings.

Downloading a Customized Web Authentication Login Page

You can compress the page and image files used for displaying a web authentication login page into a .tar file for download to a controller. These files are known as the *webauth bundle*. The maximum allowed size of the files in their uncompressed state is 1 MB. When the .tar file is downloaded from a local TFTP server, it enters the controller's file system as an untarred file.

Note If you load a webauth bundle with a .tar compression application that is not GNU compliant, the controller cannot extract the files in the bundle and the following error messages appear: "Extracting error" and "TFTP transfer failed." Therefore, Cisco recommends that you use an application that complies with GNU standards, such as PicoZip, to compress the .tar file for the webauth bundle.

Note Configuration backups do not include extra files or components, such as the webauth bundle or external licenses, that you download and store on your controller, so you should manually save external backup copies of those files or components.

Follow these guidelines when preparing the customized login page:

- Name the login page "login.html." The controller prepares the web authentication URL based on this name. If the server does not find this file after the webauth bundle has been untarred, the bundle is discarded, and an error message appears.
- Include input fields for both a username and password.
- Retain the redirect URL as a hidden input item after extracting from the original URL.
- Extract and set the action URL in the page from the original URL.
- Include scripts to decode the return status code.
- Make sure that all paths used in the main page (to refer to images, for example) are of relative type.
- Ensure that no filenames within the bundle are greater than 30 characters.

You can download a login page example from Cisco WCS and use it as a starting point for your customized login page. Refer to the "Downloading a Customized Web Auth Page" section in the Using Templates chapter of the *Cisco Wireless Control System Configuration Guide, Release 6.0* for instructions.

If you want to download a customized web authentication login page to the controller, follow the instructions in the GUI or CLI procedure below.

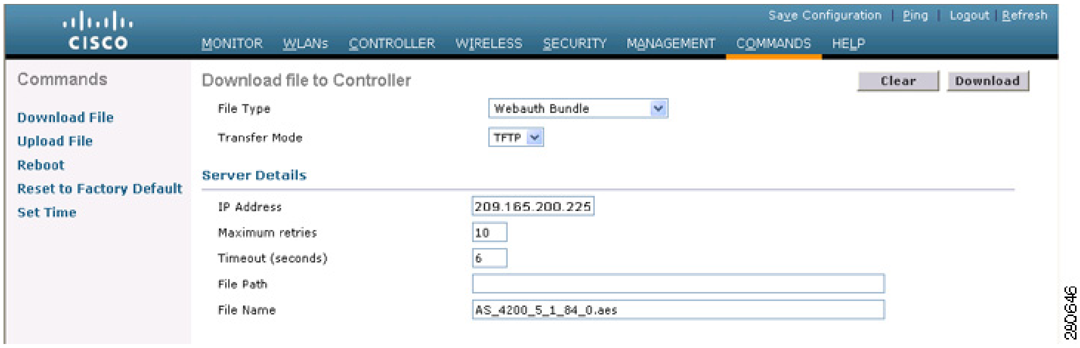
Using the GUI to Download a Customized Web Authentication Login Page

Step 1 Make sure that you have a TFTP server available for the file download. See the guidelines for setting up a TFTP server in Step 8 of the "Using the CLI to Choose the Default Web Authentication Login Page" section on page 10-15.

Step 2 Copy the .tar file containing your login page to the default directory on your TFTP server.

Step 3 Choose **Commands > Download File** to open the Download File to Controller page (see Figure 10-14).

Figure 10-14 Download File to Controller Page



Step 4 From the File Type drop-down box, choose **Webauth Bundle**.

Step 5 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 6 In the IP Address field, enter the IP address of the TFTP server.

Step 7 If you are using a TFTP server, enter the maximum number of times the controller should attempt to download the .tar file in the Maximum Retries field.

Range: 1 to 254

Default: 10

Step 8 If you are using a TFTP server, enter the amount of time in seconds before the controller times out while attempting to download the *.tar file in the Timeout field.

Range: 1 to 254 seconds

Default: 6 seconds

Step 9 In the File Path field, enter the path of the .tar file to be downloaded. The default value is "/."

Step 10 In the File Name field, enter the name of the .tar file to be downloaded.

Step 11 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 12 Click **Download** to download the .tar file to the controller.

Step 13 Choose **Security** > **Web Auth** > **Web Login Page** to open the Web Login page.

Step 14 From the Web Authentication Type drop-down box, choose **Customized (Downloaded)**.

Step 15 Click **Apply** to commit your changes.

Step 16 Click **Preview** to view your customized web authentication login page.

Step 17 If you are satisfied with the content and appearance of the login page, click **Save Configuration** to save your changes.

Using the CLI to Download a Customized Web Authentication Login Page

Step 1 Make sure that you have a TFTP server available for the file download. See the guidelines for setting up a TFTP server in Step 8 of the "Using the CLI to Choose the Default Web Authentication Login Page" section on page 10-15.

Step 2 Copy the .tar file containing your login page to the default directory on your TFTP server.

Step 3 To specify the download mode, enter **transfer download mode tftp**.

Step 4 To specify the type of file to be downloaded, enter **transfer download datatype webauthbundle**.

Step 5 To specify the IP address of the TFTP server, enter **transfer download serverip** *tftp-server-ip-address*.

Note Some TFTP servers require only a forward slash (/) as the TFTP server IP address, and the TFTP server automatically determines the path to the correct directory.

Step 6 To specify the download path, enter **transfer download path** *absolute-tftp-server-path-to-file*.

Step 7 To specify the file to be downloaded, enter **transfer download filename** *filename.tar*.

Step 8 Enter **transfer download start** to view your updated settings and answer **y** to the prompt to confirm the current download settings and start the download.

Step 9 To specify the web authentication type, enter **config custom-web webauth_type customized**.

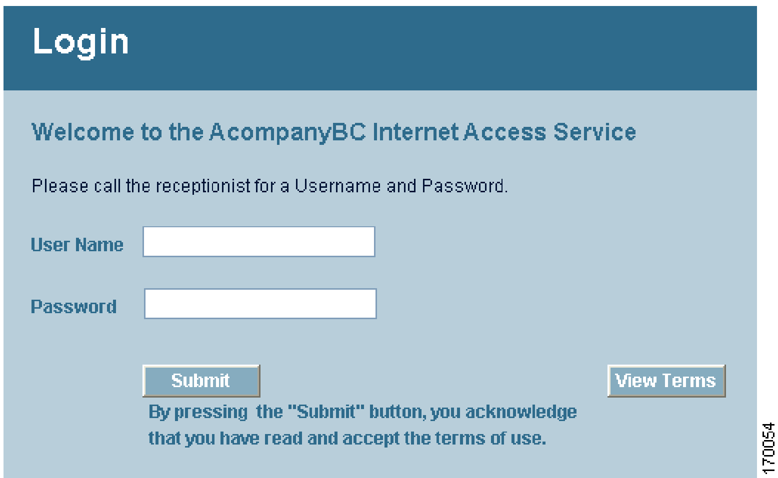
Step 10 Enter **save config** to save your settings.

Step 11 Follow the instructions in the "Using the CLI to Verify the Web Authentication Login Page Settings" section on page 10-25 to verify your settings.

Customized Web Authentication Login Page Example

Figure 10-15 shows an example of a customized web authentication login page.

Figure 10-15 Customized Web Authentication Login Page Example



Using the CLI to Verify the Web Authentication Login Page Settings

Enter **show custom-web** to verify your changes to the web authentication login page. This example shows the information that appears when the configuration settings are set to default values:

```
Cisco Logo.................................... Enabled
CustomLogo.................................... Disabled
Custom Title.................................. Disabled
Custom Message................................ Disabled
Custom Redirect URL........................... Disabled
Web Authentication Mode....................... Disabled
Web Authentication URL........................ Disabled
```

This example shows the information that appears when the configuration settings have been modified:

```
Cisco Logo.................................... Disabled
CustomLogo.................................... 00_logo.gif
Custom Title.................................. Welcome to the AcompanyBC Wireless LAN!
Custom Message................................ Contact the System Administrator for a
                                                Username and Password.
Custom Redirect URL........................... http://www.AcompanyBC.com
Web Authentication Mode....................... Internal
Web Authentication URL............................ Disabled
```

Assigning Login, Login Failure, and Logout Pages per WLAN

You can display different web authentication login, login failure, and logout pages to users per WLAN. This feature enables user-specific web authentication pages to be displayed for a variety of network users, such as guest users or employees within different departments of an organization.

Different login pages are available for all web authentication types (internal, external, and customized). However, different login failure and logout pages can be specified only when you choose customized as the web authentication type.

Using the GUI to Assign Login, Login Failure, and Logout Pages per WLAN

Using the controller GUI, follow these steps to assign web login, login failure, and logout pages to a WLAN.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN to which you want to assign a web login, login failure, or logout page.

Step 3 Choose **Security** > **Layer 3**.

Step 4 Make sure that **Web Policy** and **Authentication** are selected.

Step 5 To override the global authentication configuration web authentication pages, check the **Override Global Config** check box.

Step 6 When the Web Auth Type drop-down box appears, choose one of the following options to define the web authentication pages for wireless guest users:

- **Internal**—Displays the default web login page for the controller. This is the default value.
- **Customized**—Displays custom web login, login failure, and logout pages. If you choose this option, three separate drop-down boxes appear for login, login failure, and logout page selection. You do not need to define a customized page for all three options. Choose **None** from the appropriate drop-down box if you do not want to display a customized page for that option.

  Note These optional login, login failure, and logout pages are downloaded to the controller as webauth.tar files. For details on downloading custom pages, refer to the "Downloading a Customized Web Authentication Login Page" section on page 10-22.

- **External**—Redirects users to an external server for authentication. If you choose this option, you must also enter the URL of the external server in the URL field.

  You can select specific RADIUS or LDAP servers to provide external authentication on the WLANs > Edit (Security > AAA Servers) page. Additionally, you can define the priority in which the servers provide authentication.

Step 7 If you chose External as the web authentication type in Step 6, choose **AAA Servers** and choose up to three RADIUS and LDAP servers using the drop-down boxes.

Note The RADIUS and LDAP external servers must already be configured in order to be selectable options on the WLANs > Edit (Security > AAA Servers) page. You can configure these servers on the RADIUS Authentication Servers page and LDAP Servers page.

Step 8 To establish the priority in which the servers are contacted to perform web authentication, follow these steps. The default order is local, RADIUS, LDAP.

a. Highlight the server type (local, RADIUS, or LDAP) that you want to be contacted first in the box next to the Up and Down buttons.

b. Click the **Up** and **Down** buttons until the desired server type is at the top of the box.

c. Click the **<** arrow to move the server type to the priority box on the left.

d. Repeat these steps to assign priority to the other servers.

Step 9 Click **Apply** to commit your changes.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Assign Login, Login Failure, and Logout Pages per WLAN

Using the controller CLI, follow these steps to assign web login, login failure, and logout pages to a WLAN.

Step 1 To determine the ID number of the WLAN to which you want to assign a web login, login failure, or logout page, enter this command:

show wlan summary

Step 2 If you want wireless guest users to log into a customized web login, login failure, or logout page, enter these commands to specify the filename of the web authentication page and the WLAN for which it should display:

- **config wlan custom-web login-page** *page_name wlan_id*—Defines a customized login page for a given WLAN.
- **config wlan custom-web loginfailure-page** *page_name wlan_id*—Defines a customized login failure page for a given WLAN.

> **Note** To use the controller's default login failure page, enter this command: **config wlan custom-web loginfailure-page none** *wlan_id*.

- **config wlan custom-web logout-page** *page_name wlan_id*—Defines a customized logout page for a given WLAN.

> **Note** To use the controller's default logout page, enter this command: **config wlan custom-web logout-page none** *wlan_id*.

Step 3 If you want wireless guest users to be redirected to an external server before accessing the web login page, enter this command to specify the URL of the external server:

config wlan custom-web ext-webauth-url *ext_web_url wlan_id*

Step 4 If you want to define the order in which web authentication servers are contacted, enter this command:

config wlan security web-auth server-precedence *wlan_id* {**local** | **ldap** | **radius**} {**local** | **ldap** | **radius**} {**local** | **ldap** | **radius**}

The default order of server web authentication is local, RADIUS, LDAP.

> **Note** All external servers must be pre-configured on the controller. You can configure them on the RADIUS Authentication Servers page and the LDAP Servers page.

Step 5 To define which web authentication page displays for a wireless guest user, enter this command:

config wlan custom-web webauth-type {**internal** | **customized** | **external**} *wlan_id*

where

- **internal** displays the default web login page for the controller. This is the default value.
- **customized** displays the custom web login page that was configured in Step 2.

  > **Note** You do not need to define the web authentication type in Step 5 for the login failure and logout pages as they are always customized.

- **external** redirects users to the URL that was configured in Step 3.

Step 6 To use a WLAN-specific custom web configuration rather than a global custom web configuration, enter this command:

config wlan custom-web global disable *wlan_id*

> **Note** If you enter the **config wlan custom-web global enable** *wlan_id* command, the custom web authentication configuration at the global level is used.

Step 7 To save your changes, enter this command:

save config

Configuring Wired Guest Access

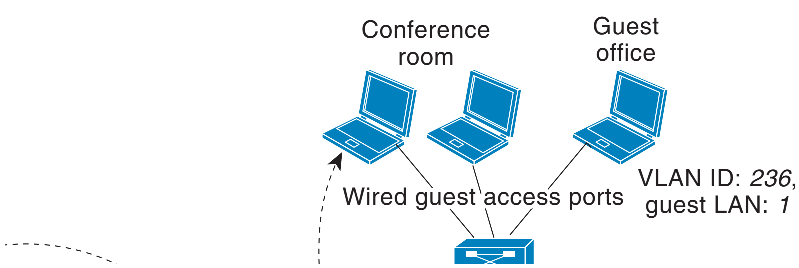
Wired guest access enables guest users to connect to the guest access network from a wired Ethernet connection designated and configured for guest access. Wired guest access ports might be available in a guest office or through specific ports in a conference room. Like wireless guest user accounts, wired guest access ports are added to the network using the lobby ambassador feature.

Wired guest access can be configured in a standalone configuration or in a dual-controller configuration that uses both an anchor controller and a foreign controller. This latter configuration is used to further isolate wired guest access traffic but is not required for deployment of wired guest access.

Wired guest access ports initially terminate on a Layer 2 access switch or switch port configured with VLAN interfaces for wired guest access traffic. The wired guest traffic is then trunked from the access switch to a controller. This controller is configured with an interface that is mapped to a wired guest access VLAN on the access switch. See Figure 10-16.

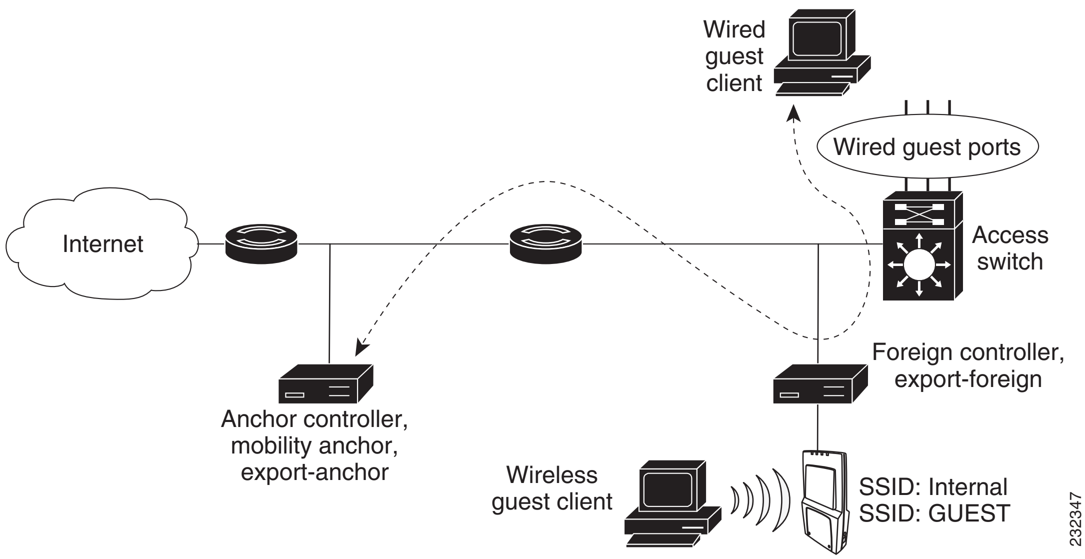
Note The DMZ controller set to *local* for mobility anchor should not have an ingress interface set. You cannot enable the WLAN if the ingress interface is not set to *none* and is changed to an ingress interface (defined under the Controller > Interface tab). You should recreate the mobility anchor and WLAN if the ingress interface is changed.

Figure 10-16 Wired Guest Access Example with One Controller



If two controllers are being used, the foreign controller, which receives the wired guest traffic from the access switch, forwards it to the anchor controller. A bidirectional EoIP tunnel is established between the foreign and anchor controllers to handle this traffic. See Figure 10-17.

Figure 10-17 Wired Guest Access Example with Two Controllers



Note Although wired guest access is managed by anchor and foreign anchors when two controllers are deployed, mobility is not supported for wired guest access clients. In this case, DHCP and web authentication for the client are handled by the anchor controller.

Note You can specify the amount of bandwidth allocated to a wired guest user in the network by configuring a QoS role and a bandwidth contract. For details on configuring these features, refer to the "Configuring Quality of Service Roles" section on page 4-70.

Configuration Overview

To configure wired guest access on a wireless network, you will perform the following:

1. Configure a dynamic interface (VLAN) for wired guest user access
2. Create a wired LAN for guest user access
3. Configure the controller
4. Configure the anchor controller (if terminating traffic on another controller)
5. Configure security for the guest LAN
6. Verify the configuration

Configuration Guidelines

Follow these guidelines before using wired guest access on your network:

- Wired guest access is supported only on the following controllers: 5500 and 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Integrated Wireless LAN Controller Switch.
- Wired guest access interfaces must be tagged.

- Wired guest access ports must be in the same Layer 2 network as the foreign controller.
- Up to five wired guest access LANs can be configured on a controller.
- Layer 3 web authentication and web passthrough are supported for wired guest access clients. Layer 2 security is not supported.
- Do not attempt to trunk a guest VLAN on the Catalyst 3750G Integrated Wireless LAN Controller Switch to multiple controllers. Redundancy cannot be achieved by doing so.

Using the GUI to Configure Wired Guest Access

Using the controller GUI, follow these steps to configure wired guest user access on your network.

Step 1 To create a dynamic interface for wired guest user access, choose **Controller** > **Interfaces**. The Interfaces page appears.

Step 2 Click **New** to open the Interfaces > New page.

Step 3 Enter a name and VLAN ID for the new interface.

Step 4 Click **Apply** to commit your changes.

Step 5 In the Port Number text box, enter a valid port number. You can enter a number between 0 and 25 (inclusive).

Step 6 Check the **Guest LAN** check box.

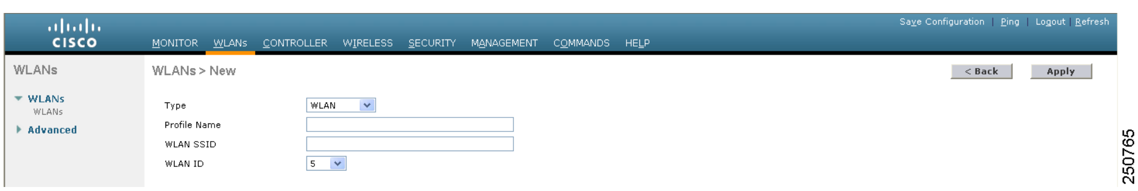
Step 7 Enter an IP address for the primary DHCP server.

Step 8 Click **Apply** to commit your changes.

Step 9 To create a wired LAN for guest user access, choose **WLANs**.

Step 10 On the WLANs page, choose **Create New** from the drop-down box and click **Go**. The WLANs > New page appears (see Figure 10-18).

Figure 10-18 WLANs > New Page



Step 11 From the Type drop-down box, choose **Guest LAN**.

Step 12 In the Profile Name field, enter a name that identifies the guest LAN. Do not use any spaces.

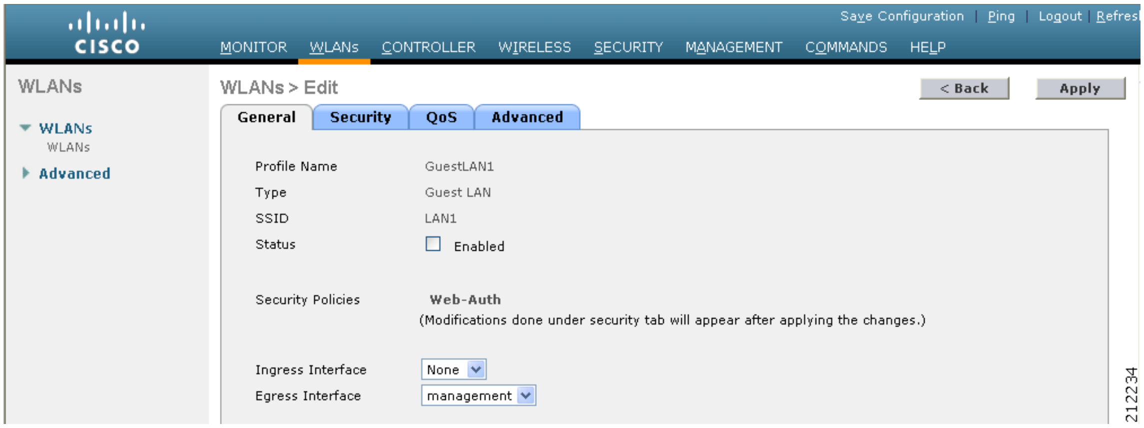
Step 13 In the WLAN SSID field, enter an SSID that identifies the guest LAN. Do not use any spaces.

Step 14 From the WLAN ID drop-down box, choose the ID number for this guest LAN.

Note You can create up to five guest LANs, so the WLAN ID options are 1 through 5 (inclusive).

Step 15 Click **Apply** to commit your changes. The WLANs > Edit page appears (see Figure 10-19).

Figure 10-19 WLANs > Edit Page



Step 16 Check the **Enabled** check box for the Status parameter.

Step 17 Web authentication (Web-Auth) is the default security policy. If you want to change this to web passthrough, choose the **Security** tab after completing Step 18 and Step 19.

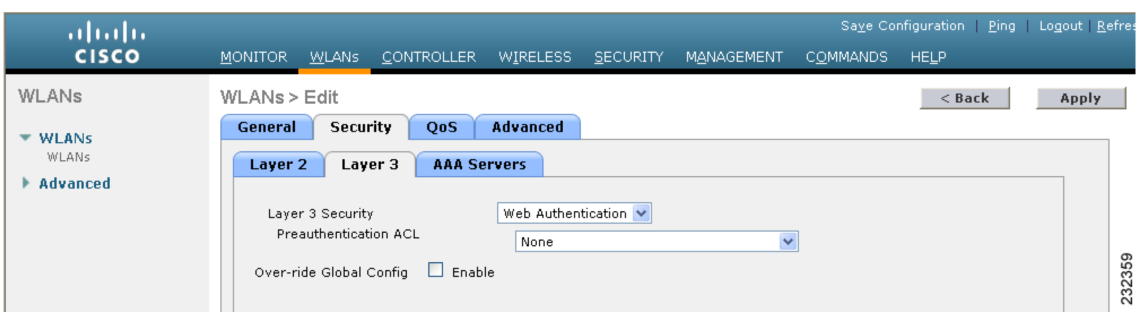
Step 18 From the Ingress Interface drop-down box, choose the VLAN that you created in Step 3. This VLAN provides a path between the wired guest client and the controller by way of the Layer 2 access switch.

Step 19 From the Egress Interface drop-down box, choose the name of the interface. This WLAN provides a path out of the controller for wired guest client traffic.

Note If you have only one controller in the configuration, choose **management** from the Egress Interface drop-down box.

Step 20 If you want to change the authentication method (for example, from web authentication to web passthrough), choose **Security > Layer 3**. The WLANs > Edit (Security > Layer 3) page appears (see Figure 10-20).

Figure 10-20 WLANs > Edit (Security > Layer 3) Page



Step 21 From the Layer 3 Security drop-down box, choose one of the following:

- **None**—Layer 3 security is disabled.
- **Web Authentication**—Causes users to be prompted for a username and password when connecting to the wireless network. This is the default value.
- **Web Passthrough**—Allows users to access the network without entering a username and password.

Step 22 If you choose the Web Passthrough option, an **Email Input** check box appears. Check this check box if you want users to be prompted for their email address when attempting to connect to the network.

Step 23 To override the global authentication configuration set on the Web Login page, check the **Override Global Config** check box.

Step 24 When the Web Auth Type drop-down box appears, choose one of the following options to define the web authentication pages for wired guest users:

- **Internal**—Displays the default web login page for the controller. This is the default value.
- **Customized**—Displays custom web login, login failure, and logout pages. If you choose this option, three separate drop-down boxes appear for login, login failure, and logout page selection. You do not need to define a customized page for all three options. Choose **None** from the appropriate drop-down box if you do not want to display a customized page for that option.

  Note These optional login, login failure, and logout pages are downloaded to the controller as webauth.tar files.

- **External**—Redirects users to an external server for authentication. If you choose this option, you must also enter the URL of the external server in the URL field.

  You can select specific RADIUS or LDAP servers to provide external authentication on the WLANs > Edit (Security > AAA Servers) page. Additionally, you can define the priority in which the servers provide authentication.

Step 25 If you chose External as the web authentication type in Step 24, choose **AAA Servers** and choose up to three RADIUS and LDAP servers using the drop-down boxes.

Note The RADIUS and LDAP external servers must already be configured in order to be selectable options on the WLANs > Edit (Security > AAA Servers) page. You can configure these servers on the RADIUS Authentication Servers page and LDAP Servers page.

Step 26 To establish the priority in which the servers are contacted to perform web authentication, follow these steps. The default order is local, RADIUS, LDAP.

a. Highlight the server type (local, RADIUS, or LDAP) that you want to be contacted first in the box next to the Up and Down buttons.

b. Click the **Up** and **Down** buttons until the desired server type is at the top of the box.

c. Click the **<** arrow to move the server type to the priority box on the left.

d. Repeat these steps to assign priority to the other servers.

Step 27 Click **Apply** to commit your changes.

Step 28 Click **Save Configuration** to save your changes.

Step 29 Repeat this process if a second (anchor) controller is being used in the network.

Using the CLI to Configure Wired Guest Access

Using the controller CLI, follow these steps to configure wired guest user access on your network.

Step 1 To create a dynamic interface (VLAN) for wired guest user access, enter this command:

config interface create *interface_name vlan_id*

Step 2 If a link aggregation trunk is not configured, enter this command to map a physical port to the interface:

config interface port *interface_name primary_port* {*secondary_port*}

Step 3 To enable or disable the guest LAN VLAN, enter this command:

config interface guest-lan *interface_name* {**enable** | **disable**}

This VLAN is later associated with the ingress interface created in Step 5.

Step 4 To create a wired LAN for wired client traffic and associate it to an interface, enter this command:

config guest-lan create *guest_lan_id interface_name*

The guest LAN ID must be a value between 1 and 5 (inclusive).

Note To delete a wired guest LAN, enter this command: **config guest-lan delete** *guest_lan_id*

Step 5 To configure the wired guest VLAN's ingress interface, which provides a path between the wired guest client and the controller by way of the Layer 2 access switch, enter this command:

config guest-lan ingress-interface *guest_lan_id interface_name*

Step 6 To configure an egress interface to transmit wired guest traffic out of the controller, enter this command:

config guest-lan interface *guest_lan_id interface_name*

Note If the wired guest traffic is terminating on another controller, repeat Step 4 and Step 6 for the terminating (anchor) controller and Step 1 through Step 5 for the originating (foreign) controller. Additionally, configure the following command for both controllers:
config mobility group anchor add {**guest-lan** *guest_lan_id* | **wlan** *wlan_id*} *IP_address*

Step 7 To configure the security policy for the wired guest LAN, enter this command:

config guest-lan security {**web-auth enable** *guest_lan_id* | **web-passthrough enable** *guest_lan_id*}

Note Web authentication is the default setting.

Step 8 To enable or disable a wired guest LAN, enter this command:

config guest-lan {**enable** | **disable**} *guest_lan_id*

Step 9 If you want wired guest users to log into a customized web login, login failure, or logout page, enter these commands to specify the filename of the web authentication page and the guest LAN for which it should display:

- **config guest-lan custom-web login-page** *page_name guest_lan_id*—Defines a web login page.
- **config guest-lan custom-web loginfailure-page** *page_name guest_lan_id*—Defines a web login failure page.

  Note To use the controller's default login failure page, enter this command: **config guest-lan custom-web loginfailure-page none** *guest_lan_id*.

- **config guest-lan custom-web logout-page** *page_name guest_lan_id*—Defines a web logout page.

Note To use the controller's default logout page, enter this command: **config guest-lan custom-web logout-page none** *guest_lan_id*.

Step 10 If you want wired guest users to be redirected to an external server before accessing the web login page, enter this command to specify the URL of the external server:

config guest-lan custom-web ext-webauth-url *ext_web_url guest_lan_id*

Step 11 If you want to define the order in which local (controller) or external (RADIUS, LDAP) web authentication servers are contacted, enter this command:

config wlan security web-auth server-precedence *wlan_id* {**local** | **ldap** | **radius**} {**local** | **ldap** | **radius**} {**local** | **ldap** | **radius**}

The default order of server web authentication is local, RADIUS, LDAP.

Note All external servers must be pre-configured on the controller. You can configure them on the RADIUS Authentication Servers page or the LDAP Servers page.

Step 12 To define the web login page for wired guest users, enter this command:

config guest-lan custom-web webauth-type {**internal** | **customized** | **external**} *guest_lan_id*

where

- **internal** displays the default web login page for the controller. This is the default value.
- **customized** displays the custom web pages (login, login failure, or logout) that were configured in Step 9.
- **external** redirects users to the URL that was configured in Step 10.

Step 13 To use a guest-LAN specific custom web configuration rather than a global custom web configuration, enter this command:

config guest-lan custom-web global disable *guest_lan_id*

Note If you enter the **config guest-lan custom-web global enable** *guest_lan_id* command, the custom web authentication configuration at the global level is used.

Step 14 To save your changes, enter this command:

save config

Note Information on the configured web authentication appears in both the **show run-config** and **show running-config** commands.

Step 15 To display the customized web authentication settings for a specific guest LAN, enter this command:

show custom-web {**all** | **guest-lan** *guest_lan_id*}

Note If internal web authentication is configured, the Web Authentication Type displays as internal rather than external (controller level) or customized (WLAN profile level).

Information similar to the following appears for the **show custom-web all** command:

```
Radius Authentication Method..................... PAP
Cisco Logo....................................... Enabled
CustomLogo....................................... None
Custom Title..................................... None
Custom Message................................... None
Custom Redirect URL.............................. None
Web Authentication Type...............            External
External Web Authentication URL............       http:\\9.43.0.100\login.html

External Web Server list
Index IP Address
----- ---------------
1       9.43.0.100
2       0.0.0.0
3       0.0.0.0
4       0.0.0.0
5       0.0.0.0
...
20      0.0.0.0

Configuration Per Profile:

WLAN ID: 1
    WLAN Status.................................. Enabled
    Web Security Policy.......................... Web Based Authentication
    Global Status................................ Disabled
    WebAuth Type................................. Customized
    Login Page................................... login1.html
    Loginfailure page name...................... loginfailure1.html
    Logout page name............................ logout1.html
```

```
WLAN ID: 2
WLAN Status.................................. Enabled
    Web Security Policy.......................... Web Based Authentication
    Global Status............................... Disabled
    WebAuth Type................................ Internal
    Loginfailure page name....................... None
    Logout page name............................. None

WLAN ID: 3
WLAN Status.................................. Enabled
    Web Security Policy.......................... Web Based Authentication
    Global Status............................... Disabled
    WebAuth Type................................ Customized
    Login Page.................................. login.html
    Loginfailure page name....................... LF2.html
    Logout page name............................. LG2.html
```

Information similar to the following appears for the **show custom-web guest-lan** *guest_lan_id* command:

```
Guest LAN ID: 1
Guest LAN Status............................. Disabled
Web Security Policy.......................... Web Based Authentication
Global Status............................... Enabled
WebAuth Type................................ Internal
Loginfailure page name....................... None
Logout page name............................. None
```

Step 16 To display a summary of the local interfaces, enter this command:

show interface summary

Information similar to the following appears:

```
Interface Name                   Port Vlan Id  IP Address      Type    Ap Mgr Guest
-------------------------------- ---- -------- --------------- ------- ------ -----
ap-manager                       1    untagged 1.100.163.25    Static  Yes    No

management                       1    untagged 1.100.163.24    Static  No     No

service-port                     N/A  N/A      172.19.35.31    Static  No     No

virtual                          N/A  N/A  209.165.200.225 Static  No     No

wired                            1    20       10.20.20.8      Dynamic No     No

wired-guest                      1  236     10.20.236.50  Dynamic No    Yes
```

Note The interface name of the wired guest LAN in this example is *wired-guest* and its VLAN ID is 236.

Step 17 To display detailed interface information, enter this command:

show interface detailed *interface_name*

Information similar to the following appears:

```
Interface Name................................. wired-guest
MAC Address.................................... 00:1a:6d:dd:1e:40
IP Address..................................... 0.0.0.0
DHCP Option 82................................. Disabled
Virtual DNS Host Name.......................... Disabled
AP Manager..................................... No
Guest Interface................................ No
```

Step 18 To display the configuration of a specific wired guest LAN, enter this command:

show guest-lan *guest_lan_id*

Information similar to the following appears:

```
Guest LAN Identifier........................... 1
Profile Name................................... guestlan
Network Name (SSID)............................ guestlan
Status......................................... Enabled
AAA Policy Override............................ Disabled
Number of Active Clients....................... 1
Exclusionlist Timeout.......................... 60 seconds
Session Timeout................................ Infinity
Interface...................................... wired
Ingress Interface.............................. wired-guest
WLAN ACL....................................... unconfigured
DHCP Server.................................... 10.20.236.90
DHCP Address Assignment Required............... Disabled
Quality of Service............................. Silver (best effort)
Security
    Web Based Authentication..................... Enabled
    ACL.......................................... Unconfigured
    Web-Passthrough.............................. Disabled
    Conditional Web Redirect..................... Disabled
    Auto Anchor.................................. Disabled
Mobility Anchor List
GLAN ID IP Address Status
------- -------------- ------
```

Note Enter **show guest-lan summary** to view all wired guest LANs configured on the controller.

Step 19 To display the active wired guest LAN clients, enter this command:

show client summary guest-lan

Information similar to the following appears:

```
Number of Clients................................ 1
MAC Address       AP Name Status     WLAN  Auth Protocol  Port Wired
----------------- ------- ----------- ----- ----- --------- ----- ------
00:16:36:40:ac:58   N/A   Associated   1    No    802.3     1    Yes
```

Step 20 To display detailed information for a specific client, enter this command:

show client detail *client_mac*

Information similar to the following appears:

```
Client MAC Address............................... 00:40:96:b2:a3:44
Client Username ................................. N/A
AP MAC Address................................... 00:18:74:c7:c0:90
Client State..................................... Associated
Wireless LAN Id.................................. 1
BSSID............................................ 00:18:74:c7:c0:9f
Channel.......................................... 56
IP Address....................................... 192.168.10.28
Association Id................................... 1
Authentication Algorithm......................... Open System
Reason Code...................................... 0
Status Code...................................... 0
Session Timeout.................................. 0
Client CCX version............................... 5
Client E2E version............................... No E2E support
Diagnostics Capability........................... Supported
S69 Capability................................... Supported
Mirroring........................................ Disabled
QoS Level........................................ Silver
...
```

Configuring Radio Resource Management

This chapter describes radio resource management (RRM) and explains how to configure it on the controllers. It contains these sections:

Overview of Radio Resource Management

The radio resource management (RRM) software embedded in the controller acts as a built-in RF engineer to consistently provide real-time RF management of your wireless network. RRM enables controllers to continually monitor their associated lightweight access points for the following information:

- **Traffic load**—The total bandwidth used for transmitting and receiving traffic. It enables wireless LAN managers to track and plan network growth ahead of client demand.
- **Interference—**The amount of traffic coming from other 802.11 sources.
- **Noise—**The amount of non-802.11 traffic that is interfering with the currently assigned channel.
- **Coverage**—The received signal strength (RSSI) and signal-to-noise ratio (SNR) for all connected clients.
- **Other** —The number of nearby access points.

Using this information, RRM can periodically reconfigure the 802.11 RF network for best efficiency. To do this, RRM performs these functions:

- Radio resource monitoring
- Transmit power control
- Dynamic channel assignment
- Coverage hole detection and correction

Radio Resource Monitoring

RRM automatically detects and configures new controllers and lightweight access points as they are added to the network. It then automatically adjusts associated and nearby lightweight access points to optimize coverage and capacity.

Lightweight access points can simultaneously scan all valid 802.11a/b/g channels for the country of operation as well as for channels available in other locations. The access points go “off-channel” for a period not greater than 60 ms to monitor these channels for noise and interference. Packets collected during this time are analyzed to detect rogue access points, rogue clients, ad-hoc clients, and interfering access points.

Note In the presence of voice traffic (in the last 100 ms), the access points defer off-channel measurements.

Each access point spends only 0.2 percent of its time off-channel. This activity is distributed across all access points so that adjacent access points are not scanning at the same time, which could adversely affect wireless LAN performance. In this way, administrators gain the perspective of every access point, thereby increasing network visibility.

Transmit Power Control

The controller dynamically controls access point transmit power based on real-time wireless LAN conditions. Normally, power can be kept low to gain extra capacity and reduce interference. The controller attempts to balance the access points’ transmit power according to how the access points are seen by their third strongest neighbor.

The transmit power control (TPC) algorithm both increases and decreases an access point's power in response to changes in the RF environment. In most instances TPC will seek to lower an access point's power to reduce interference, but in the case of a sudden change in the RF coverage—for example, if an access point fails or becomes disabled—TPC can also increase power on surrounding access points. This feature is different from Coverage Hole Detection, explained below. Coverage hole detection is primarily concerned with clients, while TPC is tasked with providing enough RF power to achieve desired coverage levels while avoiding channel interference between access points.

Note See Step 7 on page 11-31 for an explanation of the transmit power levels.

Dynamic Channel Assignment

Two adjacent access points on the same channel can cause either signal contention or signal collision. In the case of a collision, data is simply not received by the access point. This functionality can become a problem, for example, when someone reading e-mail in a café affects the performance of the access point in a neighboring business. Even though these are completely separate networks, someone sending traffic to the café on channel 1 can disrupt communication in an enterprise using the same channel. Controllers address this problem by dynamically allocating access point channel assignments to avoid conflict and to increase capacity and performance. Channels are "reused" to avoid wasting scarce RF resources. In other words, channel 1 is allocated to a different access point far from the café, which is more effective than not using channel 1 altogether.

The controller's dynamic channel assignment (DCA) capabilities are also useful in minimizing adjacent channel interference between access points. For example, two overlapping channels in the 802.11b/g band, such as 1 and 2, cannot both simultaneously use 11/54 Mbps. By effectively reassigning channels, the controller keeps adjacent channels separated, thereby avoiding this problem.

The controller examines a variety of real-time RF characteristics to efficiently handle channel assignments. These include:

- **Access point received energy**—The received signal strength measured between each access point and its nearby neighboring access points. Channels are optimized for the highest network capacity.
- **Noise**—Noise can limit signal quality at the client and access point. An increase in noise reduces the effective cell size and degrades user experience. By optimizing channels to avoid noise sources, the controller can optimize coverage while maintaining system capacity. If a channel is unusable due to excessive noise, that channel can be avoided.
- **802.11 Interference**—Interference is any 802.11 traffic that is not part of your wireless LAN, including rogue access points and neighboring wireless networks. Lightweight access points constantly scan all channels looking for sources of interference. If the amount of 802.11 interference exceeds a predefined configurable threshold (the default is 10 percent), the access point sends an alert to the controller. Using the RRM algorithms, the controller may then dynamically rearrange channel assignments to increase system performance in the presence of the interference. Such an adjustment could result in adjacent lightweight access points being on the same channel, but this setup is preferable to having the access points remain on a channel that is unusable due to an interfering foreign access point.

  In addition, if other wireless networks are present, the controller shifts the usage of channels to complement the other networks. For example, if one network is on channel 6, an adjacent wireless LAN is assigned to channel 1 or 11. This arrangement increases the capacity of the network by limiting the sharing of frequencies. If a channel has virtually no capacity remaining, the controller may choose to avoid this channel. In very dense deployments in which all non-overlapping channels are occupied, the controller does its best, but you must consider RF density when setting expectations.

- **Utilization**—When utilization monitoring is enabled, capacity calculations can consider that some access points are deployed in ways that carry more traffic than other access points (for example, a lobby versus an engineering area). The controller can then assign channels to improve the access point with the worst performance (and therefore utilization) reported.
- **Load**—Load is taken into account when changing the channel structure to minimize the impact on clients currently in the wireless LAN. This metric keeps track of every access point's transmitted and received packet counts to determine how busy the access points are. New clients avoid an overloaded access point and associate to a new access point. This parameter is disabled by default.

The controller combines this RF characteristic information with RRM algorithms to make system-wide decisions. Conflicting demands are resolved using soft-decision metrics that guarantee the best choice for minimizing network interference. The end result is optimal channel configuration in a three-dimensional space, where access points on the floor above and below play a major factor in an overall wireless LAN configuration.

In controller software releases prior to 5.1, only radios using 20-MHz channels are supported by DCA. In controller software release 5.1 or later, DCA is extended to support 802.11n 40-MHz channels in the 5-GHz band. 40-MHz channelization allows radios to achieve higher instantaneous data rates (potentially 2.25 times higher than 20-MHz channels). In controller software release 5.1 or later, you can choose between DCA working at 20 or 40 MHz.

Note Radios using 40-MHz channels in the 2.4-GHz band are not supported by DCA.

Coverage Hole Detection and Correction

The RRM coverage hole detection algorithm is designed to detect areas of radio coverage in a wireless LAN that are below the level needed for robust radio performance. This feature can alert you to the need for an additional (or relocated) lightweight access point.

If clients on a lightweight access point are detected at threshold levels (RSSI, failed client count, percentage of failed packets, and number of failed packets) lower than those specified in the RRM configuration, the access point sends a "coverage hole" alert to the controller. The alert indicates the existence of an area where clients are continually experiencing poor signal coverage, without having a viable access point to which to roam. The controller discriminates between coverage holes that can and cannot be corrected. For coverage holes that can be corrected, the controller mitigates the coverage hole by increasing the transmit power level for that specific access point. The controller does not mitigate coverage holes caused by clients that are unable to increase their transmit power or are statically set to a power level because increasing their downstream transmit power is not a remedy for poor upstream performance and might increase interference in the network.

Note While transmit power control and DCA can operate in multi-controller environments (based on RF domains), coverage hole detection is performed on a per-controller basis. In controller software release 5.2 or later, you can disable coverage hole detection on a per-WLAN basis. See the "Disabling Coverage Hole Detection per WLAN" section on page 6-65 for more information.

RRM Benefits

RRM produces a network with optimal capacity, performance, and reliability while enabling you to avoid the cost of laborious historical data interpretation and individual lightweight access point reconfiguration. It also frees you from having to continually monitor the network for noise and interference problems, which can be transient and difficult to troubleshoot. Finally, RRM ensures that clients enjoy a seamless, trouble-free connection throughout the Cisco unified wireless network.

RRM uses separate monitoring and control for each deployed network: 802.11a and 802.11b/g. That is, the RRM algorithms run separately for each radio type (802.11a and 802.11b/g). RRM uses both measurements and algorithms. RRM measurements can be adjusted using monitor intervals, but they cannot be disabled. RRM algorithms, on the other hand, are enabled automatically but can be disabled by statically configuring channel and power assignment. The RRM algorithms run at a specified updated interval, which is 600 seconds by default.

Overview of RF Groups

An RF group, also known as an RF domain, is a cluster of controllers that coordinates its RRM calculations on a per 802.11-network basis. An RF group exists for each 802.11 network type. Clustering controllers into RF groups enables the RRM algorithms to scale beyond a single controller.

Lightweight access points periodically send out neighbor messages over the air. Access points using the the same RF group name are able to validate messages from each other. When access points on different controllers hear validated neighbor messages at a signal strength of –80 dBm or stronger, the controllers dynamically form an RF group.

Note RF groups and mobility groups are similar in that they both define clusters of controllers, but they are different in terms of their use. These two concepts are often confused because the mobility group name and RF group name are configured to be the same in the Startup Wizard. Most of the time, all of the controllers in an RF group are also in the same mobility group and vice versa. However, an RF group facilitates scalable, system-wide dynamic RF management while a mobility group facilitates scalable, system-wide mobility and controller redundancy. Refer to the *Configuring Mobility Groups* chapter for more information on mobility groups.

Controller software release 4.2.99.0 or later supports up to 20 controllers and 1000 access points in an RF group. For example, a Cisco WiSM controller supports up to 150 access points, so you can have up to 6 WiSM controllers in an RF group (150 access points x 6 controllers = 900 access points, which is less than 1000). Similarly, a 4404 controller supports up to 100 access points, so you can have up to 10 4404 controllers in an RF group (100 x 10 = 1000). The 2100-series-based controllers support a maximum of 25 access points, so you can have up to 20 of these controllers in an RF group.

Note In controller software release 4.2.61.0 or earlier, RRM supports no more than five 4400-series-based controllers in an RF group.

RF Group Leader

The members of an RF group elect an RF group leader to maintain a "master" power and channel scheme for the group. The RF grouping algorithm dynamically chooses the RF group leader and ensures that an RF group leader is always present. Group leader assignments can and do change (for instance, if the current RF group leader becomes inoperable or if RF group members experience major changes).

The RF group leader analyzes real-time radio data collected by the system, calculates the power and channel assignments, and sends them to each of the controllers in the RF group. The RRM algorithms ensure system-wide stability and restrain channel and power scheme changes to the appropriate local RF neighborhoods.

In controller software releases prior to 6.0, the dynamic channel assignment (DCA) search algorithm attempts to find a good channel plan for the radios associated to controllers in the RF group, but it does not adopt a new channel plan unless it is considerably better than the current plan. The channel metric of the worst radio in both plans determines which plan is adopted. Using the worst-performing radio as the single criterion for adopting a new channel plan can result in pinning or cascading problems.

Pinning occurs when the algorithm could find a better channel plan for some of the radios in an RF group but is prevented from pursuing such a channel plan change because the worst radio in the network does not have any better channel options. That is, the worst radio in the RF group could potentially prevent other radios in the group from seeking better channel plans. The larger the network, the more likely pinning becomes.

Cascading occurs when one radio's channel change results in successive channel changes to optimize the remaining radios in the RF neighborhood. Optimizing these radios could lead to their neighbors and their neighbors' neighbors having a suboptimal channel plan and triggering their channel optimization. This effect could propagate across multiple floors or even multiple buildings, if all the access point radios belong to the same RF group. This kind of domino effect in channel changes often results in considerable client confusion and network instability.

The main cause of both pinning and cascading is the way in which the search for a new channel plan is performed and the fact that any potential channel plan changes are controlled by the RF circumstances of a single radio. In controller software release 6.0, the DCA algorithm has been redesigned to prevent both pinning and cascading. The following changes have been implemented:

- **Multiple local searches**—The DCA search algorithm performs multiple local searches initiated by different radios within the same DCA run rather than performing a single global search driven by a single radio. This change addresses both pinning and cascading while maintaining the desired flexibility and adaptability of DCA and without jeopardizing stability.
- **Multiple channel plan change initiators (CPCIs)**—Previously, the single worst radio was the sole initiator of a channel plan change. Now each radio within the RF group is evaluated and prioritized as a potential initiator. Intelligent randomization of the resulting list ensures that every radio is eventually evaluated, which eliminates the potential for pinning.
- **Limiting the propagation of channel plan changes (Localization)—**For each CPCI radio, the DCA algorithm performs a local search for a better channel plan, but only the CPCI radio itself and its one-hop neighboring access points are actually allowed to change their current transmit channels. Thus, the impact of an access point triggering a channel plan change is felt only to within two RF hops from that access point, and the actual channel plan changes are confined to within a one-hop RF neighborhood. Because this limitation applies across all CPCI radios, cascading cannot occur.
- **Non-RSSI-based cumulative cost metric**—A cumulative cost metric measures how well an entire region, neighborhood, or network performs with respect to a given channel plan. That is, the individual cost metrics of all access points in that area are considered in order to provide an overall understanding of the channel plan's quality. These metrics ensure that the improvement or

deterioration of each single radio is factored into any channel plan change. The objective is to prevent channel plan changes in which a single radio improves but at the expense of multiple other radios experiencing a considerable performance decline.

The RRM algorithms run at a specified updated interval, which is 600 seconds by default. Between update intervals, the RF group leader sends keep-alive messages to each of the RF group members and collects real-time RF data.

Note Several monitoring intervals are also available. See the "Configuring RRM" section on page 11-10 for details.

RF Group Name

A controller is configured with an RF group name, which is sent to all access points joined to the controller and used by the access points as the shared secret for generating the hashed MIC in the neighbor messages. To create an RF group, you simply configure all of the controllers to be included in the group with the same RF group name.

If there is any possibility that an access point joined to a controller may hear RF transmissions from an access point on a different controller, the controllers should be configured with the same RF group name. If RF transmissions between access points can be heard, then system-wide RRM is recommended to avoid 802.11 interference and contention as much as possible.

Configuring an RF Group

This section provides instructions for configuring RF groups through either the GUI or the CLI.

Note The RF group name is generally set at deployment time through the Startup Wizard. However, you can change it as necessary.

Note When the multiple-country feature is being used, all controllers intended to join the same RF group must be configured with the same set of countries, configured in the same order.

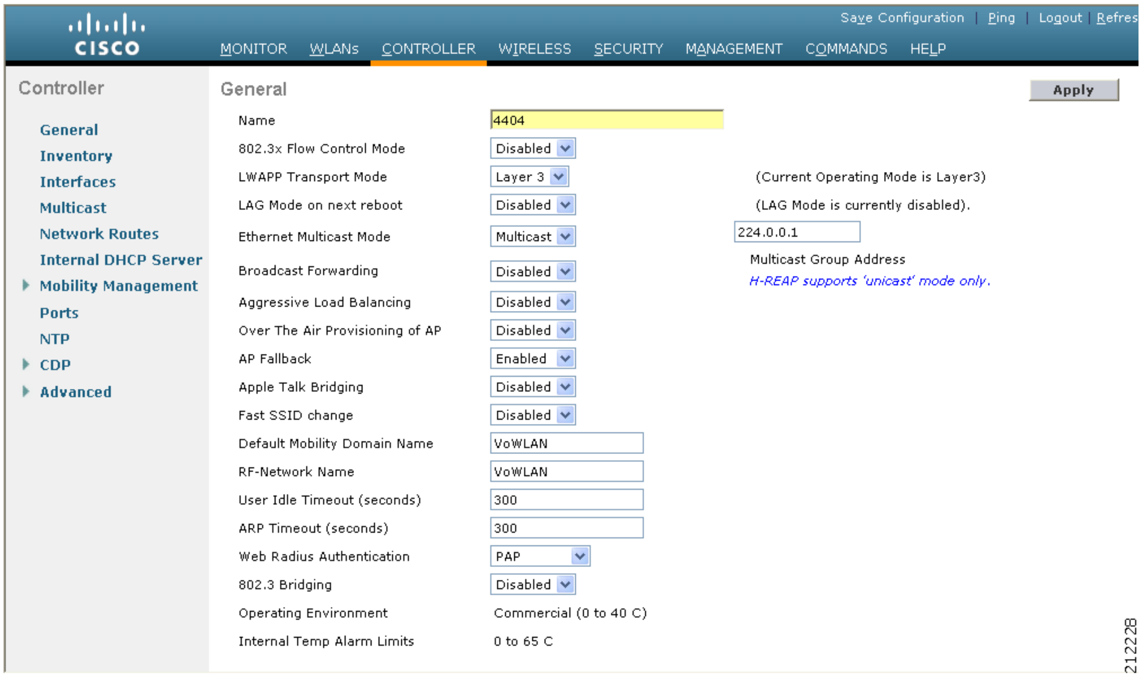
Note You can also configure RF groups using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to Configure an RF Group

Follow these steps to create an RF group using the GUI.

Step 1 Choose **Controller** > **General** to open the General page (see Figure 11-1).

Figure 11-1 General Page



Step 2 Enter a name for the RF group in the RF-Network Name field. The name can contain up to 19 ASCII characters.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 Repeat this procedure for each controller that you want to include in the RF group.

Using the CLI to Configure RF Groups

Follow these steps to configure an RF group using the CLI.

Step 1 Enter **config network rf-network-name** *name* to create an RF group.

Note Enter up to 19 ASCII characters for the group name.

Step 2 Enter **show network** to view the RF group.

Step 3 Enter **save config** to save your settings.

Step 4 Repeat this procedure for each controller that you want to include in the RF group.

Viewing RF Group Status

This section provides instructions for viewing the status of the RF group through either the GUI or the CLI.

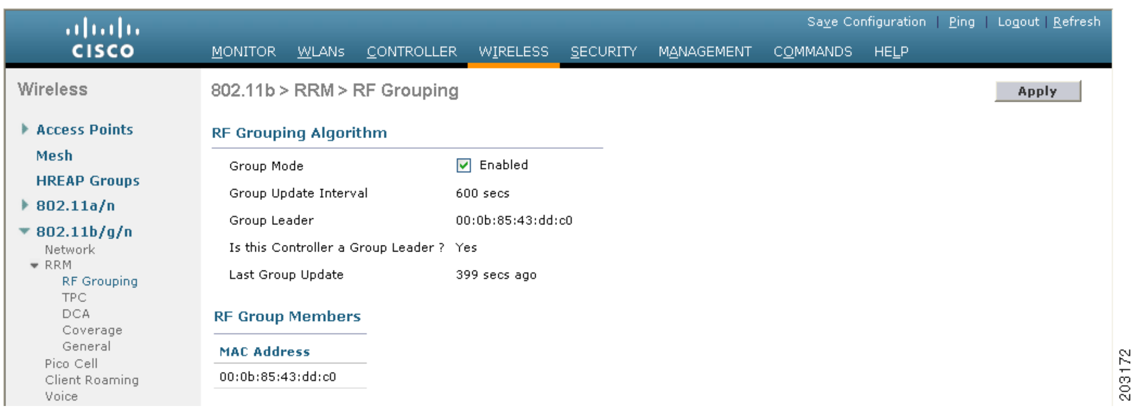
Note You can also view the status of RF groups using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to View RF Group Status

Follow these steps to view the status of the RF group using the GUI.

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **RF Grouping** to open the 802.11a (or 802.11b/g) RRM > RF Grouping page (see Figure 11-2).

Figure 11-2 802.11a > RRM > RF Grouping Page



This page shows the details of the RF group, specifically how often the group information is updated (600 seconds by default), the MAC address of the RF group leader, whether this particular controller is the group leader, the last time the group information was updated, and the MAC addresses of all group members.

Note Automatic RF grouping, which is set through the **Group Mode** check box, is enabled by default. See the "Using the GUI to Configure RF Group Mode" section on page 11-11 for more information on this parameter.

Step 2 If desired, repeat this procedure for the network type you did not select (802.11a or 802.11b/g).

Using the CLI to View RF Group Status

Follow these steps to view the status of the RF group using the CLI.

Step 1 Enter **show advanced 802.11a group** to see which controller is the RF group leader for the 802.11a RF network. Information similar to the following appears:

```
Radio RF Grouping
      802.11a Group Mode............................. AUTO
      802.11a Group Update Interval.................. 600 seconds
      802.11a Group Leader........................... 00:16:9d:ca:d9:60
        802.11a Group Member......................... 00:16:9d:ca:d9:60
      802.11a Last Run............................ 594 seconds ago
```

This text shows the details of the RF group, specifically whether automatic RF grouping is enabled for this controller, how often the group information is updated (600 seconds by default), the MAC address of the RF group leader, the MAC address of this particular controller, and the last time the group information was updated.

Note If the MAC addresses of the group leader and the group member are identical, this controller is currently the group leader.

Step 2 Enter **show advanced 802.11b group** to see which controller is the RF group leader for the 802.11b/g RF network.

Configuring RRM

The controller's preconfigured RRM settings are optimized for most deployments. However, you can modify the controller's RRM configuration parameters at any time through either the GUI or the CLI.

Note You can configure these parameters on controllers that are part of an RF group or on controllers that are not part of an RF group.

Note The RRM parameters should be set to the same values on every controller in an RF group. The RF group leader can change as a result of controller reboots or depending on which radios hear each other. If the RRM parameters are not identical for all RF group members, varying results can occur when the group leader changes.

Using the GUI to Configure RRM

Using the controller GUI, you can configure the following RRM parameters: RF group mode, transmit power control, dynamic channel assignment, coverage hole detection, profile thresholds, monitoring channels, and monitor intervals. To configure these parameters, follow the instructions in the subsections below.

Using the GUI to Configure RF Group Mode

Using the controller GUI, follow these steps to configure RF group mode.

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **RF Grouping** to open the 802.11a (or 802.11b/g) RRM > RF Grouping page (see Figure 11-2).

Step 2 Check the **Group Mode** check box to enable this controller to participate in an RF group, or uncheck it to disable this feature. If you enable this feature, the controller automatically forms an RF group with other controllers, and the group dynamically elects a leader to optimize RMM parameter settings for the the group. If you disable it, the controller does not participate in automatic RF grouping; instead it optimizes the access points connected directly to it. The default value is checked.

> **Note** Cisco recommends that controllers participate in automatic RF grouping. Note that you can override RRM settings without disabling automatic RF group participation. See the "Overriding RRM" section on page 11-27 for instructions.

Step 3 Click **Apply** to commit your changes.

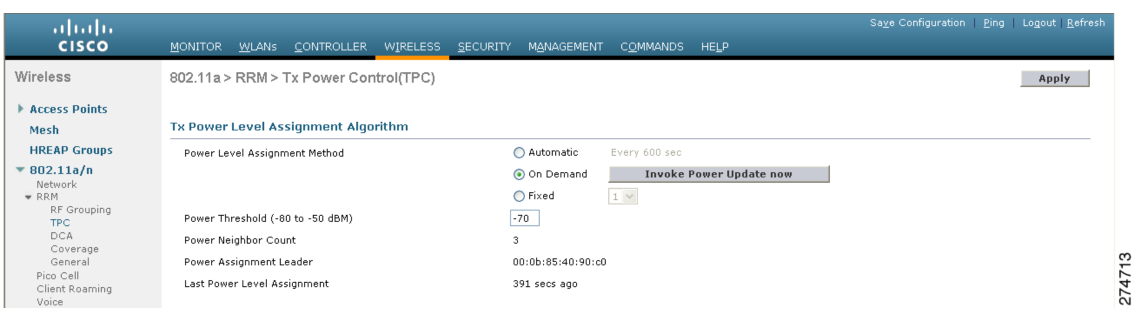
Step 4 Click **Save Configuration** to save your changes.

Using the GUI to Configure Transmit Power Control

Using the controller GUI, follow these steps to configure transmit power control settings.

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **TPC** to open the 802.11a (or 802.11b/g) > RRM > Tx Power Control (TPC) page (see Figure 11-3).

Figure 11-3 802.11a > RRM > Tx Power Control (TPC) Page



Step 2 Choose one of the following options from the Power Level Assignment Method drop-down box to specify the controller's dynamic power assignment mode:

- **Automatic**—Causes the controller to periodically evaluate and, if necessary, update the transmit power for all joined access points. This is the default value.
- **On Demand**—Causes the controller to periodically evaluate the transmit power for all joined access points. However, the controller updates the power, if necessary, only when you click **Invoke Power Update Now**.

  Note The controller does not evaluate and update the transmit power immediately after you click **Invoke Power Update Now**. It waits for the next 600-second interval. This value is not configurable.

- **Fixed**—Prevents the controller from evaluating and, if necessary, updating the transmit power for joined access points. The power level is set to the fixed value chosen from the drop-down box.

  Note The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. See Step 7 on page 11-31 for information on available transmit power levels.

Note For optimal performance, Cisco recommends that you use the Automatic setting. Refer to the "Disabling Dynamic Channel and Power Assignment Globally for a Controller" section on page 11-35 for instructions if you ever need to disable the controller's dynamic channel and power settings.

Step 3 In the Power Threshold field, enter the cutoff signal level used by RRM when determining whether to reduce an access point's power. The default value for this parameter is –70 dBm but can be changed when access points are transmitting at higher (or lower) than desired power levels.

The range for this parameter is –80 to –50 dBm. Increasing this value (between –65 and –50 dBm) causes the access points to operate at higher transmit power rates. Decreasing the value has the opposite effect.

In applications with a dense population of access points, it may be useful to decrease the threshold to –80 or –75 dBm in order to reduce the number of BSSIDs (access points) and beacons seen by the wireless clients. Some wireless clients might have difficulty processing a large number of BSSIDs or a high beacon rate and might exhibit problematic behavior with the default threshold.

This page also shows the following non-configurable transmit power level parameter settings:

- **Power Neighbor Count**—The minimum number of neighbors an access point must have for the transmit power control algorithm to run.
- **Power Assignment Leader**—The MAC address of the RF group leader, which is responsible for power level assignment.
- **Last Power Level Assignment**—The last time RRM evaluated the current transmit power level assignments.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Overriding the TPC Algorithm with Minimum and Maximum Transmit Power Settings

The TPC algorithm has undergone a major rework in this release and it should do an adequate job of balancing RF power in many diverse RF environments. However, it is possible that automatic power control will not be able to resolve some scenarios in which an adequate RF design was not possible to implement due to architectural restrictions or site restrictions—for example, when all access points must be mounted in a central hallway, placing the access points close together, but requiring coverage out to the edge of the building.

In these scenarios you can configure maximum and minimum transmit power limits to override TPC recommendations. The maximum and minimum TPC power settings only apply to access points attached to a controller from which they are configured; it is not a global RRM command. Note that the default settings essentially disable this feature, and you should use care when overriding TPC recommendations.

To set the Maximum Power Level Assignment and Minimum Power Level Assignment fields, enter the maximum and minimum transmit power used by RRM on the Tx Power Controle page. The range for these parameters is -10 to 30 dBM. The minimum value cannot be greater than the maximum value; the maximum value cannot be less than the minimum value.

If you configure a maximum transmit power, RRM does not allow any access point attached to the controller to exceed this transmit power level (whether the power is set by RRM TPC or by Coverage Hole Detection). For example, if you configure a maximum transmit power of 11 dBm, then no access point would transmit above 11 dBm, unless the access point is configured manually.

Using the GUI to Configure Dynamic Channel Assignment

Using the controller GUI, follow these steps to specify the channels that the dynamic channel assignment (DCA) algorithm considers when selecting the channels to be used for RRM scanning. This functionality is helpful when you know that the clients do not support certain channels because they are legacy devices or they have certain regulatory restrictions.

Note If a WLAN is configured to an 802.11g only radio policy and a LAP is configured to channel 14, then the WLAN clients try to associate with the LAP, which does not work as expected because of the 802.11g only policy. The workaround to the problem is one of the following:
- Disable channel 14 manually when 802.11g only policy is configured in WLANs.
- Do not select 802.11g only policy when channel 14 is configured to a LAP.

Step 1 To disable the 802.11a or 802.11b/g network, follow these steps:

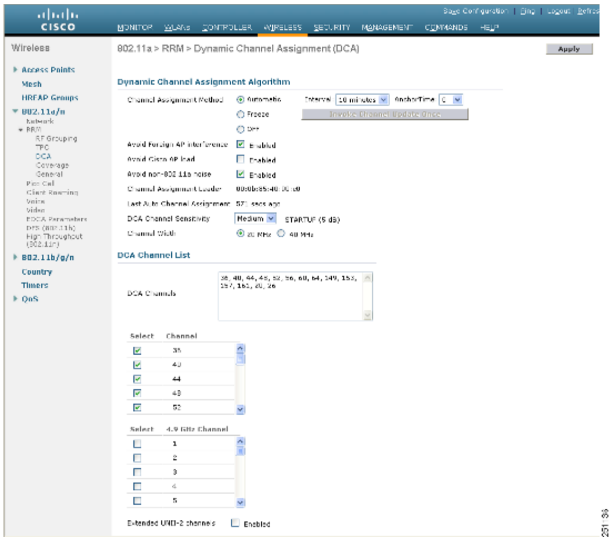
a. Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Uncheck the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 2 Choose **Wireless > 802.11a/n** or **802.11b/g/n > RRM > DCA** to open the 802.11a (or 802.11b/g) > RRM > Dynamic Channel Assignment (DCA) page (see Figure 11-4).

Figure 11-4 802.11a > RRM > Dynamic Channel Assignment (DCA) Page



Step 3 Choose one of the following options from the Channel Assignment Method drop-down box to specify the controller's DCA mode:

- **Automatic**—Causes the controller to periodically evaluate and, if necessary, update the channel assignment for all joined access points. This is the default value.
- **Freeze**—Causes the controller to evaluate and update the channel assignment for all joined access points, if necessary, but only when you click **Invoke Channel Update Once**.

  Note The controller does not evaluate and update the channel assignment immediately after you click **Invoke Channel Update Once**. It waits for the next interval to elapse.

- **OFF**—Turns off DCA and sets all access point radios to the first channel of the band, which is the default value. If you choose this option, you must manually assign channels on all radios.

Note For optimal performance, Cisco recommends that you use the Automatic setting. Refer to the "Disabling Dynamic Channel and Power Assignment Globally for a Controller" section on page 11-35 for instructions if you ever need to disable the controller's dynamic channel and power settings.

Step 4 From the Interval drop-down box, choose one of the following options to specify how often the DCA algorithm is allowed to run: 10 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 6 hours, 8 hours, 12 hours, or 24 hours. The default value is 10 minutes.

Note If your controller supports only OfficeExtend access points, Cisco recommends that you set the DCA interval to 6 hours for optimal performance. For deployments with a combination of OfficeExtend access points and local access points, the range of 10 minutes to 24 hours can be used.

Step 5 From the AnchorTime drop-down box, choose a number to specify the time of day when the DCA algorithm is to start. The options are numbers between 0 and 23 (inclusive) representing the hour of the day from 12:00 a.m. to 11:00 p.m.

Step 6 Check the **Avoid Foreign AP Interference** check box to cause the controller's RRM algorithms to consider 802.11 traffic from foreign access points (those not included in your wireless network) when assigning channels to lightweight access points, or uncheck it to disable this feature. For example, RRM may adjust the channel assignment to have access points avoid channels close to foreign access points. The default value is checked.

Step 7 Check the **Avoid Cisco AP Load** check box to cause the controller's RRM algorithms to consider 802.11 traffic from Cisco lightweight access points in your wireless network when assigning channels, or uncheck it to disable this feature. For example, RRM can assign better reuse patterns to access points that carry a heavier traffic load. The default value is unchecked.

Step 8 Check the **Avoid Non-802.11a (802.11b) Noise** check box to cause the controller's RRM algorithms to consider noise (non-802.11 traffic) in the channel when assigning channels to lightweight access points, or uncheck it to disable this feature. For example, RRM may have access points avoid channels with significant interference from non-access point sources, such as microwave ovens. The default value is checked.

Step 9 From the DCA Channel Sensitivity drop-down box, choose one of the following options to specify how sensitive the DCA algorithm is to environmental changes such as signal, load, noise, and interference when determining whether to change channels:

- **Low**—The DCA algorithm is not particularly sensitive to environmental changes.
- **Medium**—The DCA algorithm is moderately sensitive to environmental changes.
- **High**—The DCA algorithm is highly sensitive to environmental changes.

The default value is Medium. The DCA sensitivity thresholds vary by radio band, as noted in Table 11-1.

Table 11-1 DCA Sensitivity Thresholds

Option	2.4-GHz DCA Sensitivity Threshold	5-GHz DCA Sensitivity Threshold
High	5 dB	5 dB
Medium	10 dB	15 dB
Low	20 dB	20 dB

Step 10 For 802.11a/n networks only, choose one of the following Channel Width options to specify the channel bandwidth supported for all 802.11n radios in the 5-GHz band:

- **20 MHz**—The 20-MHz channel bandwidth (default)
- **40 MHz**—The 40-MHz channel bandwidth

Note If you choose 40 MHz, be sure to choose at least two adjacent channels from the DCA Channel List in Step 11 (for example, a primary channel of 36 and an extension channel of 40). If you choose only one channel, that channel is not used for 40-MHz channel width.

Note If you choose 40 MHz, you can also configure the primary and extension channels used by individual access points. Refer to the "Using the GUI to Statically Assign Channel and Transmit Power Settings" section on page 11-28 for configuration instructions.

Note To override the globally configured DCA channel width setting, you can statically configure an access point's radio for 20- or 40-MHz mode on the 802.11a/n Cisco APs > Configure page. If you ever then change the static RF channel assignment method to Global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using. It can take up to 30 minutes (depending on how often DCA is configured to run) for the change to take effect.

This page also shows the following non-configurable channel parameter settings:

- **Channel Assignment Leader**—The MAC address of the RF group leader, which is responsible for channel assignment.
- **Last Auto Channel Assignment**—The last time RRM evaluated the current channel assignments.

Step 11 In the DCA Channel List section, the DCA Channels field shows the channels that are currently selected. To choose a channel, check its check box in the Select column. To exclude a channel, uncheck its check box.

Range:
802.11a—36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140, 149, 153, 157, 161, 165, 190, 196
802.11b/g—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Default:
802.11a—36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140, 149, 153, 157, 161
802.11b/g—1, 6, 11

Note These extended UNII-2 channels in the 802.11a band do not appear in the channel list: 100, 104, 108, 112, 116, 132, 136, and 140. If you have Cisco Aironet 1520 series mesh access points in the -E regulatory domain, you must include these channels in the DCA channel list before you start operation. If you are upgrading from a previous release, verify that these channels are included in the DCA channel list. To include these channels in the channel list, check the **Extended UNII-2 Channels** check box.

Step 12 If you are using Cisco Aironet 1520 series mesh access points in your network, you need to set the 4.9-GHz channels in the 802.11a band on which they are to operate. The 4.9-GHz band is for public safety client access traffic only. To choose a 4.9-GHz channel, check its check box in the Select column. To exclude a channel, uncheck its check box.

Range:
802.11a—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26

Default:
802.11a—20, 26

Step 13 Click **Apply** to commit your changes.

Step 14 To re-enable the 802.11a or 802.11b/g network, follow these steps:

a. Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Check the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 15 Click **Save Configuration** to save your changes.

Note To see why the DCA algorithm changed channels, choose **Monitor** and then **View All** under Most Recent Traps. The trap provides the MAC address of the radio that changed channels, the previous channel and the new channel, the reason why the change occurred, the energy before and after the change, the noise before and after the change, and the interference before and after the change.

Using the GUI to Configure Coverage Hole Detection

Using the controller GUI, follow these steps to enable coverage hole detection.

Note In controller software release 5.2 or later, you can disable coverage hole detection on a per-WLAN basis. See the "Disabling Coverage Hole Detection per WLAN" section on page 6-65 for more information.

Step 1 To disable the 802.11a or 802.11b/g network, follow these steps:

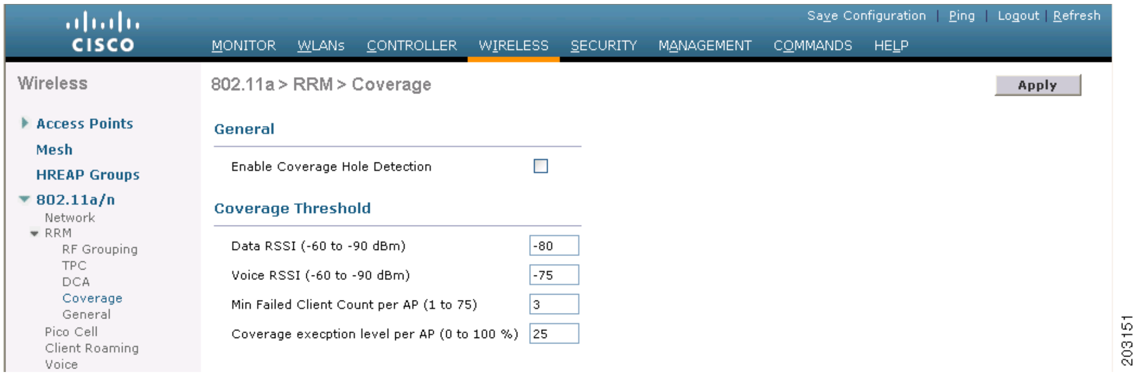
a. Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Uncheck the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 2 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **Coverage** to open the 802.11a (or 802.11b/g) > RRM > Coverage page (see Figure 11-5).

Figure 11-5 802.11a > RRM > Coverage Page



Step 3 Check the **Enable Coverage Hole Detection** check box to enable coverage hole detection, or uncheck it to disable this feature. If you enable coverage hole detection, the controller automatically determines, based on data received from the access points, if any access points have clients that are potentially located in areas with poor coverage. The default value is checked.

Step 4 In the Data RSSI field, enter the minimum receive signal strength indication (RSSI) value for data packets received by the access point. The value that you enter is used to identify coverage holes (or areas of poor coverage) within your network. If the access point receives a packet in the data queue with an RSSI value below the value that you enter here, a potential coverage hole has been detected. The valid range is –90 to –60 dBm, and the default value is –80 dBm. The access point takes data RSSI measurements every 5 seconds and reports them to the controller in 90-second intervals.

Step 5 In the Voice RSSI field, enter the minimum receive signal strength indication (RSSI) value for voice packets received by the access point. The value that you enter is used to identify coverage holes within your network. If the access point receives a packet in the voice queue with an RSSI value below the value that you enter here, a potential coverage hole has been detected. The valid range is –90 to –60 dBm, and the default value is –75 dBm. The access point takes voice RSSI measurements every 5 seconds and reports them to the controller in 90-second intervals.

Step 6 In the Min Failed Client Count per AP field, enter the minimum number of clients on an access point with an RSSI value at or below the data or voice RSSI threshold. The valid range is 1 to 75, and the default value is 3.

Step 7 In the Coverage Exception Level per AP field, enter the percentage of clients on an access point that are experiencing a low signal level but cannot roam to another access point. The valid range is 0 to 100%, and the default value is 25%.

Note If both the number and percentage of failed packets exceed the values configured for Failed Packet Count and Failed Packet Percentage (configurable through the controller CLI; see page 11-24) for a 5-second period, the client is considered to be in a pre-alarm condition. The controller uses this information to distinguish between real and false coverage holes. False positives are generally due to the poor roaming logic implemented on most clients. A coverage hole is detected if both the number and percentage of failed clients meet or exceed the values entered in the Min Failed Client Count per AP and Coverage Exception Level per AP fields over a 90-second period. The controller determines if the coverage hole can be corrected and, if appropriate, mitigates the coverage hole by increasing the transmit power level for that specific access point.

Step 8 Click **Apply** to commit your changes.

Step 9 To re-enable the 802.11a or 802.11b/g network, follow these steps:

a. Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Check the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

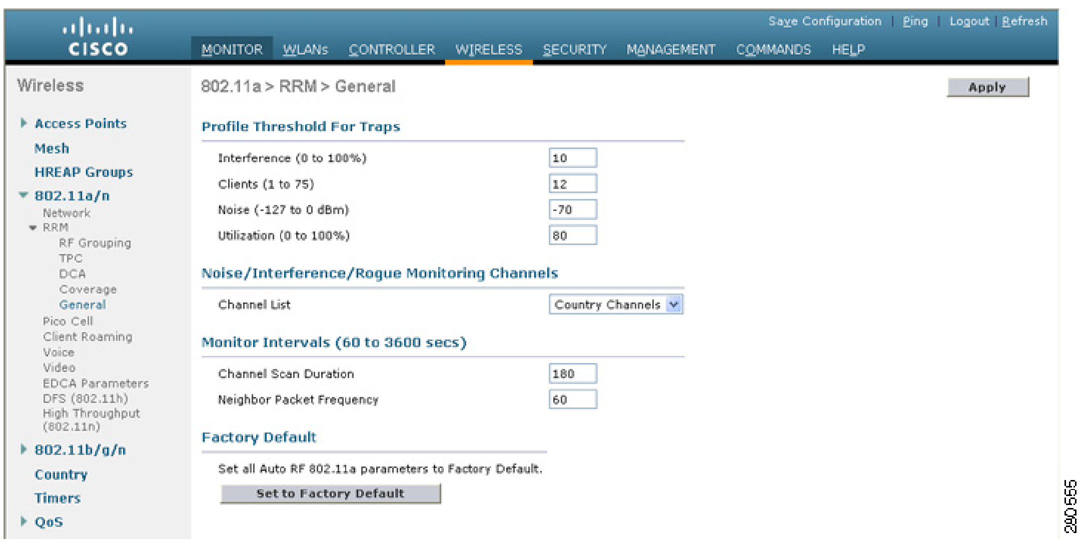
Step 10 Click **Save Configuration** to save your changes.

Using the GUI to Configure RRM Profile Thresholds, Monitoring Channels, and Monitor Intervals

Using the controller GUI, follow these steps to configure RRM profile thresholds, monitoring channels, and monitor intervals.

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **General** to open the 802.11a (or 802.11b/g) > RRM > General page (see Figure 11-6).

Figure 11-6 802.11a > RRM > General Page



Step 2 To configure profile thresholds used for alarming, follow these steps.

Note The profile thresholds have no bearing on the functionality of the RRM algorithms. Lightweight access points send an SNMP trap (or an alert) to the controller when the values set for these threshold parameters are exceeded.

a. In the Interference field, enter the percentage of interference (802.11 traffic from sources outside of your wireless network) on a single access point. The valid range is 0 to 100%, and the default value is 10%.

b. In the Clients field, enter the number of clients on a single access point. The valid range is 1 to 75, and the default value is 12.

c. In the Noise field, enter the level of noise (non-802.11 traffic) on a single access point. The valid range is –127 to 0 dBm, and the default value is –70 dBm.

d. In the Utilization field, enter the percentage of RF bandwidth being used by a single access point. The valid range is 0 to 100%, and the default value is 80%.

Step 3 From the Channel List drop-down box, choose one of the following options to specify the set of channels that the access point uses for RRM scanning:

- **All Channels**—RRM channel scanning occurs on all channels supported by the selected radio, which includes channels not allowed in the country of operation.
- **Country Channels**—RRM channel scanning occurs only on the data channels in the country of operation. This is the default value.
- **DCA Channels**—RRM channel scanning occurs only on the channel set used by the DCA algorithm, which by default includes all of the non-overlapping channels allowed in the country of operation. However, you can specify the channel set to be used by DCA if desired. To do so, follow the instructions in the "Using the GUI to Configure Dynamic Channel Assignment" section on page 11-13.

Step 4 To configure monitor intervals, follow these steps:

a. In the Channel Scan Duration field, enter (in seconds) the sum of the time between scans for each channel within a radio band. The entire scanning process takes 50 ms per channel, per radio and runs at the Channel Scan Duration interval. The time spent listening on each channel is determined by the non-configurable 50-ms scan time and the number of channels to be scanned. For example, in the U.S. all 11 802.11b/g channels are scanned for 50 ms each within the default 180-second interval. So every 16 seconds, 50 ms is spent listening on each scanned channel (180/11 = ~16 seconds). The Channel Scan Duration parameter determines the interval at which the scanning occurs.The valid range is 60 to 3600 seconds, and the default value is 180 seconds for the 802.11a radios and the 802.11b/g radios.

Note If your controller supports only OfficeExtend access points, Cisco recommends that you set the channel scan duration to 1800 seconds for optimal performance. For deployments with a combination of OfficeExtend access points and local access points, the range of 60 to 3600 seconds can be used.

b. In the Neighbor Packet Frequency field, enter (in seconds) how frequently neighbor packets (messages) are sent, which eventually builds the neighbor list. The valid range is 60 to 3600 seconds, and the default value is 60 seconds.

Note If your controller supports only OfficeExtend access points, Cisco recommends that you set the neighbor packet frequency to 600 seconds for optimal performance. For deployments with a combination of OfficeExtend access points and local access points, the range of 60 to 3600 seconds can be used.

Note In controller software release 4.1.185.0 or later, if the access point radio does not receive a neighbor packet from an existing neighbor within 60 minutes, the controller deletes that neighbor from the neighbor list. In controller software releases prior to 4.1.185.0, the controller waits only 20 minutes before deleting an unresponsive neighbor radio from the neighbor list.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Note Click **Set to Factory Default** if you ever want to return all of the controller's RRM parameters to their factory default values.

Using the CLI to Configure RRM

Using the controller CLI, follow these steps to configure RRM.

Step 1 Enter this command to disable the 802.11a or 802.11b/g network:

config {**802.11a** | **802.11b**} **disable network**

Step 2 Perform one of the following to configure transmit power control:

- To have RRM automatically set the transmit power for all 802.11a or 802.11b/g radios at periodic intervals, enter this command:

  config {**802.11a** | **802.11b**} **txPower global auto**

- To have RRM automatically reset the transmit power for all 802.11a or 802.11b/g radios one time, enter this command:

  config {**802.11a** | **802.11b**} **txPower global once**

- To configure the transmit power range that overrides the Transmit Power Control algorithm, use this command to enter the maximum and minimum trnasmit power used by RRM:

  config {**802.11a** | **802.11b**} **txPower global** {**max** | **min**} *txpower*

  where *txpower* is a value from -10 to 30 dBM. The minimum value cannot be greater than the maximum value; the maximum value cannot be less than the minimum value.

  If you configure a maximum transmit power, RRM does not allow any access point to exceed this transmit power (whether the maximum is set at RRM startup, or by Coverage Hole Detection). For example, if you configure a maximum transmit power of 11 dBm, then no access opint would transmit above 11 dBm, unless the access point is configured manually.

- To manually change the default transmit power setting of –70 dBm, enter this command:

  config advanced {**802.11a** | **802.11b**} **tx-power-control-thresh** *threshold*

  where *threshold* is a value from –80 to –50 dBm. Increasing this value (between –65 and –50 dBm) causes the access points to operate at higher transmit power rates. Decreasing the value has the opposite effect.

  In applications with a dense population of access points, it may be useful to decrease the threshold to –80 or –75 dBm in order to reduce the number of BSSIDs (access points) and beacons seen by the wireless clients. Some wireless clients may have difficulty processing a large number of BSSIDs or a high beacon rate and may exhibit problematic behavior with the default threshold.

Step 3 Perform one of the following to configure dynamic channel assignment (DCA):

- To have RRM automatically configure all 802.11a or 802.11b/g channels based on availability and interference, enter this command:

  config {**802.11a** | **802.11b**} **channel global auto**

- To have RRM automatically reconfigure all 802.11a or 802.11b/g channels one time based on availability and interference, enter this command:

  config {**802.11a** | **802.11b**} **channel global once**

- To disable RRM and set all channels to their default values, enter this command:

  config {**802.11a** | **802.11b**} **channel global off**

- To specify the channel set used for DCA, enter this command:

  config advanced {**802.11a** | **802.11b**} **channel** {**add** | **delete**} *channel_number*

  You can enter only one channel number per command. This command is helpful when you know that the clients do not support certain channels because they are legacy devices or they have certain regulatory restrictions.

Step 4 Use these commands to configure additional DCA parameters:

- **config advanced** {**802.11a** | **802.11b**} **channel dca anchor-time** *value*—Specifies the time of day when the DCA algorithm is to start. *Valu*e is a number between 0 and 23 (inclusive) representing the hour of the day from 12:00 a.m. to 11:00 p.m.
- **config advanced** {**802.11a** | **802.11b**} **channel dca interval** *value*—Specifies how often the DCA algorithm is allowed to run. *Valu*e is one of the following: 1, 2, 3, 4, 6, 8, 12, or 24 hours or 0, which is the default value of 10 minutes (or 600 seconds).

  Note If your controller supports only OfficeExtend access points, Cisco recommends that you set the DCA interval to 6 hours for optimal performance. For deployments with a combination of OfficeExtend access points and local access points, the range of 10 minutes to 24 hours can be used.

- **config advanced** {**802.11a** | **802.11b**} **channel dca sensitivity** {**low** | **medium** | **high**}—Specifies how sensitive the DCA algorithm is to environmental changes such as signal, load, noise, and interference when determining whether to change channel.
  - **low** means that the DCA algorithm is not particularly sensitive to environmental changes.
  - **medium** means that the DCA algorithm is moderately sensitive to environmental changes.
  - **high** means that the DCA algorithm is highly sensitive to environmental changes.

  The DCA sensitivity thresholds vary by radio band, as noted in Table 11-2.

Table 11-2 DCA Sensitivity Thresholds

Option	2.4-GHz DCA Sensitivity Threshold	5-GHz DCA Sensitivity Threshold
High	5 dB	5 dB
Medium	15 dB	20 dB
Low	30 dB	35 dB

- **config advanced 802.11a channel dca chan-width-11n** {**20** | **40**}—Configures the DCA channel width for all 802.11n radios in the 5-GHz band, where
  - **20** sets the channel width for 802.11n radios to 20 MHz. This is the default value.
  - **40** sets the channel width for 802.11n radios to 40 MHz.

  > **Note** If you choose 40, be sure to set at least two adjacent channels in the **config advanced 802.11a channel** {**add** | **delete**} *channel_number* command in Step 3 (for example, a primary channel of 36 and an extension channel of 40). If you set only one channel, that channel is not used for 40-MHz channel width.

  > **Note** If you choose 40, you can also configure the primary and extension channels used by individual access points. Refer to the "Using the CLI to Statically Assign Channel and Transmit Power Settings" section on page 11-32 for configuration instructions.

> **Note** To override the globally configured DCA channel width setting, you can statically configure an access point's radio for 20- or 40-MHz mode using the **config 802.11a chan_width** *Cisco_AP* {**20** | **40**} command. If you ever then change the static configuration to global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using. It can take up to 30 minutes (depending on how often DCA is configured to run) for the change to take effect.

- **config advanced** {**802.11a** | **802.11b**} **channel foreign** {**enable** | **disable**}—Enables or disables foreign access point interference avoidance in the channel assignment.
- **config advanced** {**802.11a** | **802.11b**} **channel load** {**enable** | **disable**}—Enables or disables load avoidance in the channel assignment.
- **config advanced** {**802.11a** | **802.11b**} **channel noise** {**enable** | **disable**}—Enables or disables noise avoidance in the channel assignment.
- **config advanced** {**802.11a** | **802.11b**} **channel update**—Initiates an update of the channel selection for every Cisco access point.

Step 5 Use these commands to configure coverage hole detection:

> **Note** In controller software release 5.2 or later, you can disable coverage hole detection on a per-WLAN basis. See the "Disabling Coverage Hole Detection per WLAN" section on page 6-65 for more information.

- **config advanced** {**802.11a** | **802.11b**} **coverage** {**enable** | **disable**}—Enables or disables coverage hole detection. If you enable coverage hole detection, the controller automatically determines, based on data received from the access points, if any access points have clients that are potentially located in areas with poor coverage. The default value is enabled.
- **config advanced** {**802.11a** | **802.11b**} **coverage** {**data** | **voice**} **rssi-threshold** *rssi*—Specifies the minimum receive signal strength indication (RSSI) value for packets received by the access point. The value that you enter is used to identify coverage holes (or areas of poor coverage) within your network. If the access point receives a packet in the data or voice queue with an RSSI value below the value you enter here, a potential coverage hole has been detected. The valid range is –90 to –60

dBm, and the default value is –80 dBm for data packets and –75 dBm for voice packets. The access point takes RSSI measurements every 5 seconds and reports them to the controller in 90-second intervals.

- **config advanced** {**802.11a** | **802.11b**} **coverage level global** *clients*—Specifies the minimum number of clients on an access point with an RSSI value at or below the data or voice RSSI threshold. The valid range is 1 to 75, and the default value is 3.
- **config advanced** {**802.11a** | **802.11b**} **coverage exception global** *percent*—Specifies the percentage of clients on an access point that are experiencing a low signal level but cannot roam to another access point. The valid range is 0 to 100%, and the default value is 25%.
- **config advanced** {**802.11a** | **802.11b**} **coverage** {**data** | **voice**} **packet-count** *packets*—Specifies the minimum failure count threshold for uplink data or voice packets. The valid range is 1 to 255 packets, and the default value is 10 packets.
- **config advanced** {**802.11a** | **802.11b**} **coverage** {**data** | **voice**} **fail-rate** *percent*—Specifies the failure rate threshold for uplink data or voice packets. The valid range is 1 to 100%, and the default value is 20%.

Note If both the number and percentage of failed packets exceed the values entered in the **packet-count** and **fail-rate** commands for a 5-second period, the client is considered to be in a pre-alarm condition. The controller uses this information to distinguish between real and false coverage holes. False positives are generally due to the poor roaming logic implemented on most clients. A coverage hole is detected if both the number and percentage of failed clients meet or exceed the values entered in the **coverage level global** and **coverage exception global** commands over a 90-second period. The controller determines if the coverage hole can be corrected and, if appropriate, mitigates the coverage hole by increasing the transmit power level for that specific access point.

Step 6 Enter this command to enable the 802.11a or 802.11b/g network:

config {**802.11a** | **802.11b**} **enable network**

Note To enable the 802.11g network, enter **config 802.11b 11gSupport enable** after the **config 802.11b enable network** command.

Step 7 Enter this command to save your settings:

save config

Using the CLI to View RRM Settings

Use these commands to view 802.11a and 802.11b/g RRM settings:

show advanced {**802.11a** | **802.11b**} *?*

where *?* is one of the following:

- **ccx** {**global** | *Cisco_AP*}—Shows the CCX RRM configuration.

```
802.11a Client Beacon Measurements:
    disabled
```

- **channel**—Shows the channel assignment configuration and statistics.

```
Automatic Channel Assignment
  Channel Assignment Mode........................ ONCE
  Channel Update Interval........................ 600 seconds
  Anchor time (Hour of the day).................. 20
  Channel Update Count........................... 0
  Channel Update Contribution.................... S.IU
  Channel Assignment Leader...................... 00:0b:85:40:90:c0
  Last Run....................................... 532 seconds ago
  DCA Sensitivity Level.......................... MEDIUM (20 dB)
  DCA 802.11n Channel Width...................... 40 MHz
  Channel Energy Levels
    Minimum...................................... unknown
    Average...................................... unknown
    Maximum...................................... unknown
  Channel Dwell Times
    Minimum...................................... unknown
    Average...................................... unknown
    Maximum...................................... unknown
  Auto-RF Allowed Channel List................... 36,40
  Auto-RF Unused Channel List.................... 44,48,52,56,60,64,100,104,
    ......................................... 108,112,116,132,136,140,149,
    ............................................ 153,157,161,165,190,196
  DCA Outdoor AP option...................... Disabled
```

- **coverage**—Shows the coverage hole detection configuration and statistics.

```
Coverage Hole Detection
  802.11a Coverage Hole Detection Mode........... Enabled
  802.11a Coverage Voice Packet Count............ 10 packets
  802.11a Coverage Voice Packet Percentage....... 20%
  802.11a Coverage Voice RSSI Threshold.......... -75 dBm
  802.11a Coverage Data Packet Count............. 10 packets
  802.11a Coverage Data Packet Percentage........ 20%
  802.11a Coverage Data RSSI Threshold........... -80 dBm
  802.11a Global coverage exception level........ 25%
  802.11a Global client minimum exception lev. 3 clients
```

- **logging**—Shows the RF event and performance logging.

```
RF Event and Performance Logging
  Channel Update Logging......................... Off
  Coverage Profile Logging....................... Off
  Foreign Profile Logging........................ Off
  Load Profile Logging........................... Off
  Noise Profile Logging.......................... Off
  Performance Profile Logging.................... Off
  TxPower Update Logging...................... Off
```

- **monitor**—Shows the Cisco radio monitoring.

```
Default 802.11a AP monitoring
  802.11a Monitor Mode........................... enable
  802.11a Monitor Channels....................... Country channels
  802.11a AP Coverage Interval................... 180 seconds
  802.11a AP Load Interval....................... 60 seconds
  802.11a AP Noise Interval...................... 180 seconds
  802.11a AP Signal Strength Interval......... 60 seconds
```

- **profile** {**global** | *Cisco_AP*}—Shows the access point performance profiles.

```
Default 802.11a AP performance profiles
  802.11a Global Interference threshold.......... 10%
  802.11a Global noise threshold................. -70 dBm
```

```
  802.11a Global RF utilization threshold........ 80%
  802.11a Global throughput threshold........... 1000000 bps
  802.11a Global clients threshold........... 12 clients
```

- **receiver**—Shows the 802.11a or 802.11b/g receiver configuration and statistics.

```
802.11a Advanced Receiver Settings
 RxStart  : Signal Threshold..................... 15
 RxStart  : Signal Jump Threshold................ 5
 RxStart  : Preamble Power Threshold............. 2
 RxRestart: Signal Jump Status................... Enabled
 RxRestart: Signal Jump Threshold................ 10
 TxStomp  : Low RSSI Status...................... Enabled
 TxStomp  : Low RSSI Threshold................... 30
 TxStomp  : Wrong BSSID Status................... Enabled
 TxStomp  : Wrong BSSID Data Only Status......... Enabled
 RxAbort  : Raw Power Drop Status................ Disabled
 RxAbort  : Raw Power Drop Threshold............. 10
 RxAbort  : Low RSSI Status...................... Disabled
 RxAbort  : Low RSSI Threshold................... 0
 RxAbort  : Wrong BSSID Status................... Disabled
 RxAbort  : Wrong BSSID Data Only Status......... Disabled
 -------------------------------------------....
 pico-cell-V2 parameters in dbm units:...........

 RxSensitivity: Min,Max,Current RxSense Thres.... 0,0,0
 CCA Threshold: Min,Max,Current Clear Channel.... 0,0,0
Tx Pwr: Min,Max,Current Transmit Power for A.... 0,0,0
 -------------------------------------------....
```

- **summary**—Shows the configuration and statistics of the 802.11a or 802.11b/g access points.

```
AP Name   MAC Address        Admin State  Operation State Channel TxPower
-------- ------------------ ------------- --------------- -------- -------
AP1140   00:22:90:96:5b:d0    ENABLED         DOWN        64*     1(*)
AP1240   00:21:1b:ea:36:60    ENABLED         DOWN       161*     1(*)
AP1130   00:1f:ca:cf:b6:60    ENABLED      REGISTERED    48*      1(*)
```

- **txpower**—Shows the transmit power assignment configuration and statistics.

```
Automatic Transmit Power Assignment
  Transmit Power Assignment Mode................. AUTO
  Transmit Power Update Interval................. 600 seconds
  Transmit Power Update Count.................... 0
  Transmit Power Threshold....................... -70 dBm
  Transmit Power Neighbor Count.................. 3 APs
  Min Transmit Power............................. -100 dBm
  Max Transmit Power............................. 100 dBm
  Transmit Power Update Contribution............. SNI.
  Transmit Power Assignment Leader............... 00:0b:85:40:90:c0
  Last Run....................................... 354 seconds ago
```

Using the CLI to Debug RRM Issues

Use these commands to troubleshoot and verify RRM behavior:

debug airewave-director *?*

where *?* is one of the following:

- **all**—Enables debugging for all RRM logs.
- **channel**—Enables debugging for the RRM channel assignment protocol.

- **detail**—Enables debugging for RRM detail logs.
- **error**—Enables debugging for RRM error logs.
- **group**—Enables debugging for the RRM grouping protocol.
- **manager**—Enables debugging for the RRM manager.
- **message**—Enables debugging for RRM messages.
- **packet**—Enables debugging for RRM packets.
- **power**—Enables debugging for the RRM power assignment protocol as well as coverage hole detection.
- **profile**—Enables debugging for RRM profile events.
- **radar**—Enables debugging for the RRM radar detection/avoidance protocol.
- **rf-change**—Enables debugging for RRM RF changes.

Overriding RRM

In some deployments, it is desirable to statically assign channel and transmit power settings to the access points instead of relying on the RRM algorithms provided by Cisco. Typically, this is true in challenging RF environments and non-standard deployments but not the more typical carpeted offices.

Note If you choose to statically assign channels and power levels to your access points and/or to disable dynamic channel and power assignment, you should still use automatic RF grouping to avoid spurious rogue device events.

You can disable dynamic channel and power assignment globally for a controller, or you can leave dynamic channel and power assignment enabled and statically configure specific access point radios with a channel and power setting. Follow the instructions in one of the following sections:

- Statically Assigning Channel and Transmit Power Settings to Access Point Radios, page 11-28
- Disabling Dynamic Channel and Power Assignment Globally for a Controller, page 11-35

Note While you can specify a global default transmit power parameter for each network type that applies to all the access point radios on a controller, you must set the channel for each access point radio when you disable dynamic channel assignment. You may also want to set the transmit power for each access point instead of leaving the global transmit power in effect.

Statically Assigning Channel and Transmit Power Settings to Access Point Radios

This section provides instructions for statically assigning channel and power settings using the GUI or CLI.

Note Cisco recommends that you assign different nonoverlapping channels to access points that are within close proximity to each other. The nonoverlapping channels in the U.S. are 36, 40, 44, 48, 52, 56, 60, 64, 149, 153, 157, and 161 in an 802.11a network and 1, 6, and 11 in an 802.11b/g network.

Note Cisco recommends that you do not assign all access points that are within close proximity to each other to the maximum power level.

Using the GUI to Statically Assign Channel and Transmit Power Settings

Follow these steps to statically assign channel and/or power settings on a per access point radio basis using the GUI.

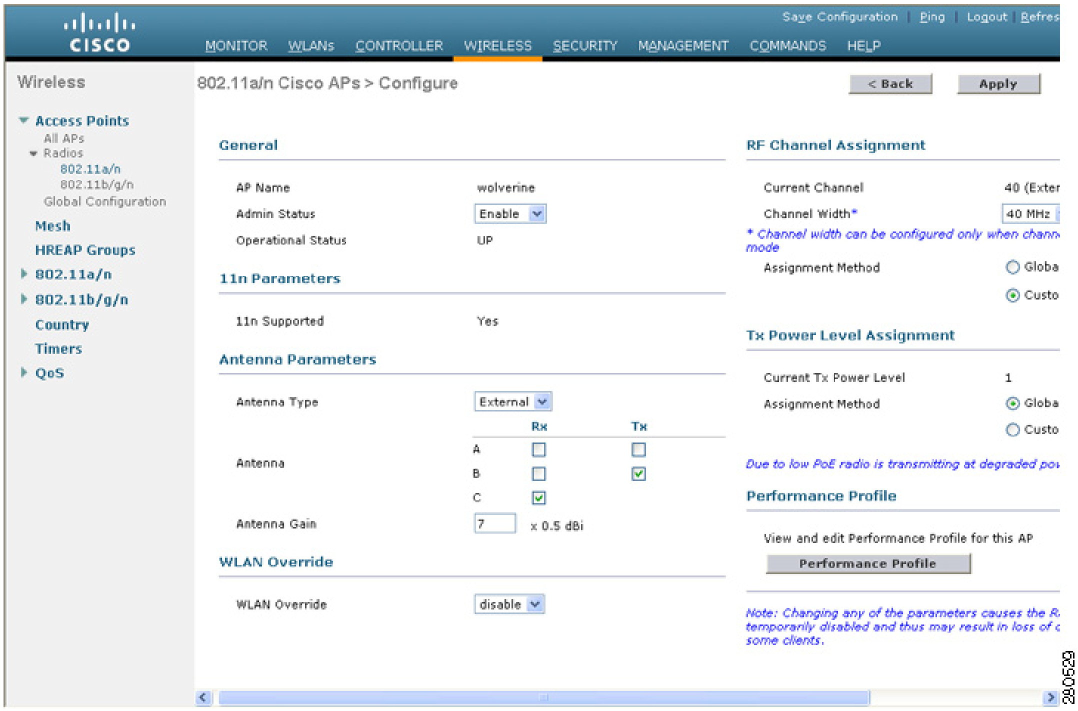
Step 1 Choose **Wireless** > **Access Points** > **Radios** > **802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page (see Figure 11-7).

Figure 11-7 802.11a/n Radios Page

This page shows all the 802.11a/n or 802.11b/g/n access point radios that are joined to the controller and their current settings. The Channel field shows both the primary and extension channels and uses an asterisk to indicate if they are globally assigned.

Step 2 Hover your cursor over the blue drop-down arrow for the access point for which you want to modify the radio configuration and choose **Configure**. The 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page appears (see Figure 11-8).

Figure 11-8 802.11a/n Cisco APs > Configure Page



Step 3 To be able to assign primary and extension channels to the access point radio, choose **Custom** for the Assignment Method under RF Channel Assignment.

Step 4 Choose one of the following options from the Channel Width drop-down box:

- **20 MHz**—Allows the radio to communicate using only 20-MHz channels. Choose this option for legacy 802.11a radios, 20-MHz 802.11n radios, or 40-MHz 802.11n radios that you want to operate using only 20-MHz channels. This is the default value.
- **40 MHz**—Allows 40-MHz 802.11n radios to communicate using two adjacent 20-MHz channels bonded together. The radio uses the primary channel that you choose in Step 6 as well as its extension channel for faster throughput. Each channel has only one extension channel (36 and 40 are a pair, 44 and 48 are a pair, and so on). For example, if you choose a primary channel of 44, the controller would use channel 48 as the extension channel. Conversely, if you choose a primary channel of 48, the controller would use channel 44 as the extension channel.

  Note Cisco recommends that you do not configure 40-MHz channels in the 2.4-GHz radio band because severe co-channel interference can occur.

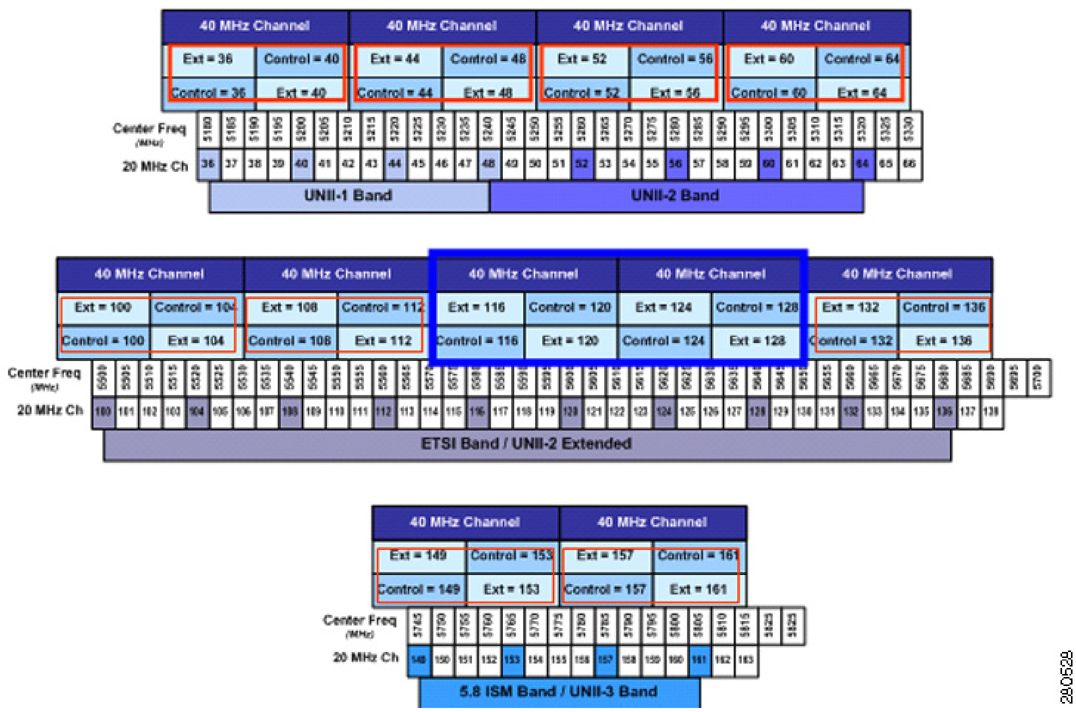
Note The Channel Width parameter can be configured for 802.11a/n radios only if the RF channel assignment method is in custom mode and for 802.11b/g/n radios only if both the RF channel assignment method and the Tx power level assignment method are in custom mode.

> **Note** Statically configuring an access point's radio for 20- or 40-MHz mode overrides the globally configured DCA channel width setting on the 802.11a > RRM > Dynamic Channel Assignment (DCA) page. If you ever change the static RF channel assignment method back to Global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using. It can take up to 30 minutes (depending on how often DCA is configured to run) for the change to take effect.

Figure 11-9 illustrates channel bonding in the 5-GHz band. Low channels are preferred.

> **Note** Channels 116, 120, 124, and 128 are not available in the U.S. and Canada for 40-MHz channel bonding.

Figure 11-9 Channel Bonding in the 5-GHz Band



Step 5 Follow these steps to configure the antenna parameters for this radio:

a. From the Antenna Type drop-down box, choose **Internal** or **External** to specify the type of antennas used with the access point radio.

b. Check and uncheck the check boxes in the Antenna field to enable and disable the use of specific antennas for this access point, where A, B, and C are specific antenna ports. A is the right antenna port, B is the left antenna port, and C is the center antenna port. For example, to enable transmissions from antenna ports A and B and receptions from antenna port C, you would check the following check boxes: Tx: A and B and Rx: C.

c. In the Antenna Gain field, enter a number to specify an external antenna's ability to direct or focus radio energy over a region of space. High-gain antennas have a more focused radiation pattern in a specific direction. The antenna gain is measured in 0.5 dBi units, and the default value is 7 times 0.5 dBi, or 3.5 dBi.

   If you have a high-gain antenna, enter a value that is twice the actual dBi value (refer to the *Cisco Aironet Antenna Reference Guide* for antenna dBi values). Otherwise, enter 0. For example, if your antenna has a 4.4-dBi gain, multiply the 4.4 dBi by 2 to get 8.8 and then round down to enter only the whole number (8). The controller reduces the actual equivalent isotropic radiated power (EIRP) to make sure that the antenna does not violate your country's regulations.

d. Choose one of the following options from the Diversity drop-down box:
   - **Enabled**—Enables the antenna connectors on both sides of the access point. This is the default value.
   - **Side A** or **Right**—Enables the antenna connector on the right side of the access point.
   - **Side B** or **Left**—Enables the antenna connector on the left side of the access point.

Step 6 To assign an RF channel to the access point radio, choose **Custom** for the Assignment Method under RF Channel Assignment and choose a channel from the drop-down box.

The channel you choose is the primary channel (for example, channel 36), which is used for communication by legacy 802.11a radios and 802.11n 20-MHz radios. 802.11n 40-MHz radios use this channel as the primary channel but also use an additional bonded extension channel for faster throughput, if you chose 40 MHz for the channel width in Step 4.

Note The Current Channel field shows the current primary channel. If you chose 40 MHz for the channel width in Step 4, the extension channel appears in parentheses after the primary channel.

Note Changing the operating channel causes the access point radio to reset.

Step 7 To assign a transmit power level to the access point radio, choose **Custom** for the Assignment Method under Tx Power Level Assignment and choose a transmit power level from the drop-down box.

The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. The number of available power levels varies based on the access point model. However, power level 1 is always the maximum power level allowed per country code setting, with each successive power level representing 50% of the previous power level. For example, 1 = maximum power level in a particular regulatory domain, 2 = 50% power, 3 = 25% power, 4 = 12.5% power, and so on.

Note Refer to the hardware installation guide for your access point for the maximum transmit power levels supported per regulatory domain. Also, refer to the data sheet for your access point for the number of power levels supported.

Note If the access point is not operating at full power, the "Due to low PoE, radio is transmitting at degraded power" message appears under the Tx Power Level Assignment section. Refer to the "Configuring Power over Ethernet" section on page 7-98 for more information on PoE power levels.

Step 8 To enable this configuration for the access point, choose **Enable** from the Admin Status drop-down box.

Step 9 Click **Apply** to commit your changes.

Step 10 To have the controller send the access point radio admin state immediately to WCS, follow these steps:

a. Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Check the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Step 12 Repeat this procedure for each access point radio for which you want to assign a static channel and power level.

Using the CLI to Statically Assign Channel and Transmit Power Settings

Follow these steps to statically assign channel and/or power settings on a per access point radio basis using the CLI.

Step 1 To disable the radio of a particular access point on the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **disable** *Cisco_AP*

Step 2 To configure the channel width for a particular access point, enter this command:

config {**802.11a** | **802.11b**} **chan_width** *Cisco_AP* {**20** | **40**}

where

- **20** allows the radio to communicate using only 20-MHz channels. Choose this option for legacy 802.11a radios, 20-MHz 802.11n radios, or 40-MHz 802.11n radios that you want to operate using only 20-MHz channels. This is the default value.
- **40** allows 40-MHz 802.11n radios to communicate using two adjacent 20-MHz channels bonded together. The radio uses the primary channel that you choose in Step 5 as well as its extension channel for faster throughput. Each channel has only one extension channel (36 and 40 are a pair, 44 and 48 are a pair, and so on). For example, if you choose a primary channel of 44, the controller would use channel 48 as the extension channel. Conversely, if you choose a primary channel of 48, the controller would use channel 44 as the extension channel.

Note This parameter can be configured only if the primary channel is statically assigned.

Note Cisco recommends that you do not configure 40-MHz channels in the 2.4-GHz radio band because severe co-channel interference can occur.

> **Note** Statically configuring an access point's radio for 20- or 40-MHz mode overrides the globally configured DCA channel width setting (configured using the **config advanced 802.11a channel dca chan-width-11n** {**20** | **40**} command). If you ever change the static configuration back to global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using. It can take up to 30 minutes (depending on how often DCA is configured to run) for the change to take effect.

Figure 11-9 on page 11-30 shows channel bonding in the 5-GHz band. Low channels are preferred.

> **Note** Channels 116, 120, 124, and 128 are not available in the U.S. and Canada for 40-MHz channel bonding.

Step 3 To enable or disable the use of specific antennas for a particular access point, enter this command:

config {**802.11a** | **802.11b**} **11nsupport antenna** {**tx** | **rx**} *Cisco_AP* {**A** | **B** | **C**} {**enable** | **disable**}

where A, B, and C are antenna ports. A is the right antenna port, B is the left antenna port, and C is the center antenna port. For example, to enable transmissions from the antenna in access point AP1's antenna port C on the 802.11a network, you would enter the following command:

config 802.11a 11nsupport antenna tx AP1 C enable

Step 4 To specify the external antenna gain, which is a measure of an external antenna's ability to direct or focus radio energy over a region of space, enter this command:

config {**802.11a** | **802.11b**} **antenna extAntGain** *antenna_gain Cisco_AP*

High-gain antennas have a more focused radiation pattern in a specific direction. The antenna gain is measured in 0.5 dBi units, and the default value is 7 times 0.5 dBi, or 3.5 dBi.

If you have a high-gain antenna, enter a value that is twice the actual dBi value (refer to the *Cisco Aironet Antenna Reference Guide* for antenna dBi values). Otherwise, enter 0. For example, if your antenna has a 4.4-dBi gain, multiply the 4.4 dBi by 2 to get 8.8 and then round down to enter only the whole number (8). The controller reduces the actual equivalent isotropic radiated power (EIRP) to make sure that the antenna does not violate your country's regulations.

Step 5 To specify the channel that a particular access point is to use, enter this command:

config {**802.11a** | **802.11b**} **channel ap** *Cisco_AP channel*

Example: To configure 802.11a channel 36 as the default channel on AP1, enter this command: **config 802.11a channel ap AP1 36**.

The channel you choose is the primary channel (for example, channel 36), which is used for communication by legacy 802.11a radios and 802.11n 20-MHz radios. 802.11n 40-MHz radios use this channel as the primary channel but also use an additional bonded extension channel for faster throughput, if you chose 40 for the channel width in Step 2.

> **Note** Changing the operating channel causes the access point radio to reset.

Step 6 To specify the transmit power level that a particular access point is to use, enter this command:

config {**802.11a** | **802.11b**} **txPower ap** *Cisco_AP power_level*

Example: To set the transmit power for 802.11a AP1 to power level 2, enter this command: **config 802.11a txPower ap AP1 2**.

The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. The number of available power levels varies based on the access point model. However, power level 1 is always the maximum power level allowed per country code setting, with each successive power level representing 50% of the previous power level. For example, 1 = maximum power level in a particular regulatory domain, 2 = 50% power, 3 = 25% power, 4 = 12.5% power, and so on.

Note Refer to the hardware installation guide for your access point for the maximum transmit power levels supported per regulatory domain. Also, refer to the data sheet for your access point for the number of power levels supported.

Step 7 To save your settings, enter this command:

save config

Step 8 Repeat Step 2 through Step 7 for each access point radio for which you want to assign a static channel and power level.

Step 9 To re-enable the access point radio, enter this command:

config {**802.11a** | **802.11b**} **enable** *Cisco_AP*

Step 10 To have the controller send the access point radio admin state immediately to WCS, enter this command:

config {**802.11a** | **802.11b**} **enable network**

Step 11 To save your settings, enter this command:

save config

Step 12 To see the configuration of a particular access point, enter this command:

show ap config {**802.11a** | **802.11b**} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 7
Cisco AP Name.................................... AP1
...
Tx Power
Num Of Supported Power Levels ............ 8
      Tx Power Level 1 ......................... 20 dBm
      Tx Power Level 2 ......................... 17 dBm
      Tx Power Level 3 ......................... 14 dBm
      Tx Power Level 4 ......................... 11 dBm
      Tx Power Level 5 ......................... 8 dBm
      Tx Power Level 6 ......................... 5 dBm
      Tx Power Level 7 ......................... 2 dBm
      Tx Power Level 8 ......................... -1 dBm
      Tx Power Configuration ................... CUSTOMIZED
      Current Tx Power Level ................... 1

Phy OFDM parameters
      Configuration ............................ CUSTOMIZED
      Current Channel .......................... 36
      Extension Channel ........................ 40
      Channel Width............................. 40 Mhz
      Allowed Channel List...................... 36,44,52,60,100,108,116,132,
        ........................................ 149,157
      TI Threshold ............................. -50
      Antenna Type.............................. EXTERNAL_ANTENNA
      External Antenna Gain (in .5 dBi units).... 7
      Diversity................................. DIVERSITY_ENABLED
```

```
802.11n Antennas
        Tx
         A..................................... ENABLED
         B..................................... ENABLED
        Rx
         A..................................... DISABLED
         B..................................... DISABLED
         C.................................. ENABLED
```

Disabling Dynamic Channel and Power Assignment Globally for a Controller

This section provides instructions for disabling dynamic channel and power assignment using the GUI or CLI.

Using the GUI to Disable Dynamic Channel and Power Assignment

Follow these steps to configure disable dynamic channel and power assignment using the GUI.

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **Auto RF** to open the 802.11a (or 802.11b/g) Global Parameters > Auto RF page (see Figure 11-2).

Step 2 To disable dynamic channel assignment, choose **OFF** under RF Channel Assignment.

Step 3 To disable dynamic power assignment, choose **Fixed** under Tx Power Level Assignment and choose a default transmit power level from the drop-down box.

Note See Step 7 on page 11-31 for information on transmit power levels.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Step 6 If you are overriding the default channel and power settings on a per radio basis, assign static channel and power settings to each of the access point radios that are joined to the controller.

Step 7 If desired, repeat this procedure for the network type you did not select (802.11a or 802.11b/g).

Using the CLI to Disable Dynamic Channel and Power Assignment

Follow these steps to disable RRM for all 802.11a or 802.11b/g radios.

Step 1 Enter this command to disable the 802.11a or 802.11b/g network:

config {**802.11a** | **802.11b**} **disable network**

Step 2 Enter this command to disable RRM for all 802.11a or 802.11b/g radios and set all channels to the default value:

config {**802.11a** | **802.11b**} **channel global off**

Step 3 Enter this command to enable the 802.11a or 802.11b/g network:

config {**802.11a** | **802.11b**} **enable network**

> **Note** To enable the 802.11g network, enter **config 802.11b 11gSupport enable** after the **config 802.11b enable network** command.

Step 4 Enter this command to save your settings:

save config

Enabling Rogue Access Point Detection in RF Groups

After you have created an RF group of controllers, you need to configure the access points connected to the controllers to detect rogue access points. The access points will then check the beacon/probe-response frames in neighboring access point messages to see if they contain an authentication information element (IE) that matches that of the RF group. If the check is successful, the frames are authenticated. Otherwise, the authorized access point reports the neighboring access point as a rogue, records its BSSID in a rogue table, and sends the table to the controller.

Using the GUI to Enable Rogue Access Point Detection in RF Groups

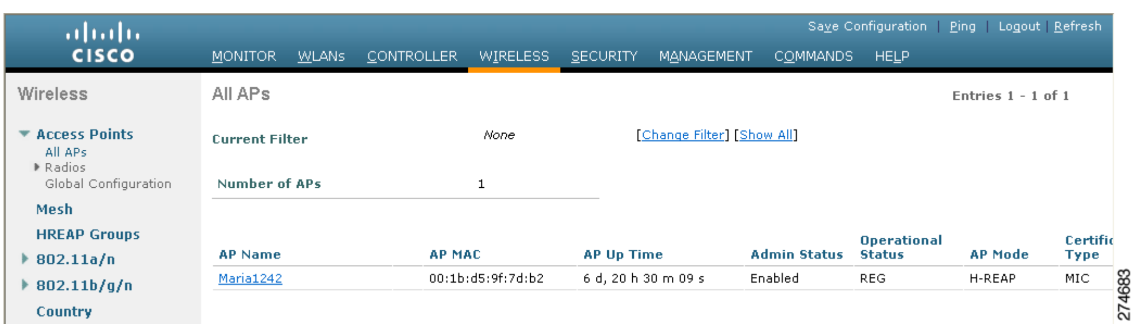
Using the controller GUI, follow these steps to enable rogue access point detection in RF groups.

Step 1 Make sure that each controller in the RF group has been configured with the same RF group name.

> **Note** The name is used to verify the authentication IE in all beacon frames. If the controllers have different names, false alarms will occur.

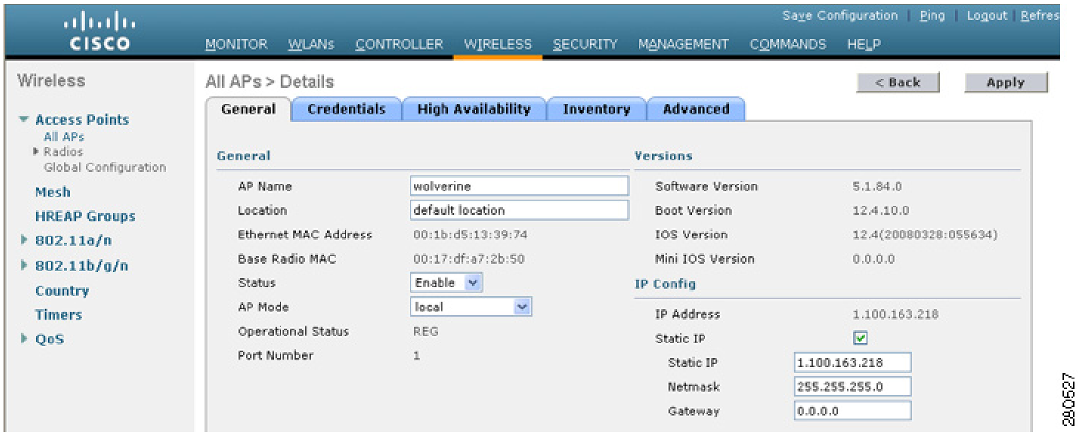
Step 2 Choose **Wireless** to open the All APs page (see Figure 11-10).

Figure 11-10 All APs Page



Step 3 Click the name of an access point to open the All APs > Details page (see Figure 11-11).

Figure 11-11 All APs > Details Page



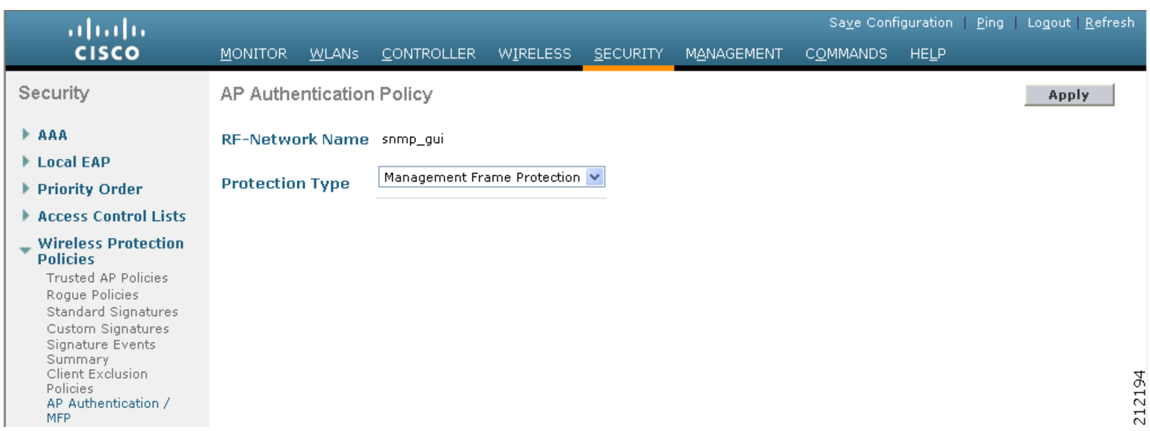
Step 4 Choose either **local** or **monitor** from the AP Mode drop-down box and click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Step 6 Repeat Step 2 through Step 5 for every access point connected to the controller.

Step 7 Choose **Security** > **Wireless Protection Policies** > **AP Authentication/MFP** to open the AP Authentication Policy page (see Figure 11-12).

Figure 11-12 AP Authentication Policy Page



The name of the RF group to which this controller belongs appears at the top of the page.

Step 8 Choose **AP Authentication** from the Protection Type drop-down box to enable rogue access point detection.

Step 9 Enter a number in the Alarm Trigger Threshold edit box to specify when a rogue access point alarm is generated. An alarm occurs when the threshold value (which specifies the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.

Note The valid threshold range is from1 to 255, and the default threshold value is 1. To avoid false alarms, you may want to set the threshold to a higher value.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Step 12 Repeat this procedure on every controller in the RF group.

> **Note** If rogue access point detection is not enabled on every controller in the RF group, the access points on the controllers with this feature disabled are reported as rogues.

Using the CLI to Enable Rogue Access Point Detection in RF Groups

Using the controller CLI, follow these steps to enable rogue access point detection in RF groups.

Step 1 Make sure that each controller in the RF group has been configured with the same RF group name.

> **Note** The name is used to verify the authentication IE in all beacon frames. If the controllers have different names, false alarms will occur.

Step 2 Enter **config ap mode local** *Cisco_AP* or **config ap mode monitor** *Cisco_AP* to configure this particular access point for local (normal) mode or monitor (listen-only) mode.

Step 3 Enter **save config** to save your settings.

Step 4 Repeat Step 2 and Step 3 for every access point connected to the controller.

Step 5 Enter **config wps ap-authentication** to enable rogue access point detection.

Step 6 Enter **config wps ap-authentication** *threshold* to specify when a rogue access point alarm is generated. An alarm occurs when the threshold value (which specifies the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.

> **Note** The valid threshold range is from1 to 255, and the default threshold value is 1. To avoid false alarms, you may want to set the threshold to a higher value.

Step 7 Enter **save config** to save your settings.

Step 8 Repeat Step 5 through Step 7 on every controller in the RF group.

> **Note** If rogue access point detection is not enabled on every controller in the RF group, the access points on the controllers with this feature disabled are reported as rogues.

Configuring Beamforming

Beamforming (also called *ClientLink*) is a spatial-filtering mechanism used at a transmitter to improve the received signal power or signal-to-noise (SNR) ratio at an intended receiver (client).

Cisco Aironet 1140 and 1250 series access points support beamforming. Beamforming uses multiple transmit antennas to focus transmissions in the direction of an 802.11a or 802.11g client, which increases the downlink SNR and the data rate to the client, reduces coverage holes, and enhances overall system performance. Beamforming works with all existing 802.11a and 802.11g clients.

Beamforming starts only when the signal from the client falls below these thresholds:

- **802.11a clients—**RSSI of –60 dBm or weaker
- **802.11g clients—**RSSI of –50 dBm or weaker

Note 802.11b clients do not support beamforming.

The access point actively maintains beamforming data for up to 15 clients per radio. These are the clients to which the access point is currently beamforming.

In the receive data path, the access point updates the beamforming data (the transmit steering matrix) for the active entries when packets are received from an address matching an active entry. If a packet is received from a beamforming client that is not an active entry, the access point automatically replaces the oldest active entry.

In the transmit data path, if the packet is destined for an active entry, the access point links the packets based on the recorded beamforming data.

Guidelines for Using Beamforming

Follow these guidelines for using beamforming:

- Beamforming is supported only for legacy orthogonal frequency-division multiplexing (OFDM) data rates (6, 9, 12, 18, 24, 36, 48, and 54 Mbps).

  Note Beamforming is not supported for complementary code keying (CCK) data rates (1, 2, 5.5, and 11 Mbps).

- Only access points that support 802.11n (currently the 1140 and 1250 series access points) can use beamforming.
- Two or more antennas must be enabled for transmission.
- All three antennas must be enabled for reception.
- OFDM data rates must be enabled.
- Beamforming must be enabled.

Note If the antenna configuration restricts operation to a single transmit antenna or if OFDM data rates are disabled, beamforming is not used.

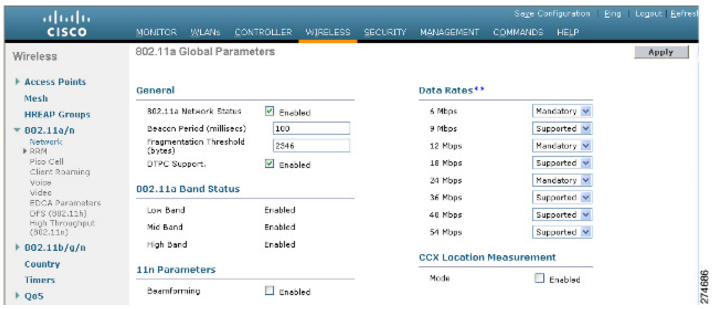
Using the GUI to Configure Beamforming

Using the controller GUI, follow these steps to configure beamforming.

Step 1 To disable the 802.11a or 802.11b/g network, follow these steps:

a. Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page (see Figure 11-13).

Figure 11-13 802.11a Global Parameters Page



b. Uncheck the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 2 Check the **Beamforming** check box to globally enable beamforming on your 802.11a or 802.11g network, or leave it unchecked to disable this feature. The default value is disabled.

Step 3 To re-enable the network, check the **802.11a** (or **802.11b/g**) **Network Status** check box.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

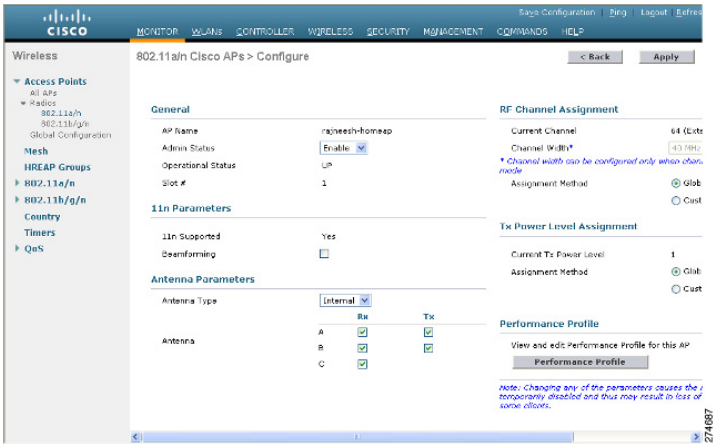
Note After you enable beamforming on the network, it is automatically enabled for all the radios applicable to that network type.

Step 6 If you want to override the global configuration and enable or disable beamforming for a specific access point, follow these steps:

a. Choose **Wireless** > **Access Points** > **Radios** > **802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

b. Hover your cursor over the blue drop-down arrow for the access point for which you want to modify the radio configuration and choose **Configure**. The 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page appears (see Figure 11-14).

Figure 11-14 802.11a/n Cisco APs > Configure Page



Step 7 In the 11n Parameters section, check the **Beamforming** check box to enable beamforming for this access point or leave it unchecked to disable this feature. The default value is unchecked if beamforming is disabled on the network and checked if beamforming is enabled on the network.

Note If the access point does not support 802.11n, the Beamforming option is not available.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure Beamforming

Using the controller CLI, follow these steps to configure beamforming.

Step 1 To disable the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **disable network**

Step 2 To globally enable or disable beamforming on your 802.11a or 802.11g network, enter this command:

config {**802.11a** | **802.11b**} **beamforming global {enable | disable}**

The default value is disabled.

Note After you enable beamforming on the network, it is automatically enabled for all the radios applicable to that network type.

Step 3 To override the global configuration and enable or disable beamforming for a specific access point, enter this command:

config {**802.11a** | **802.11b**} **beamforming ap** *Cisco_AP* **{enable | disable}**

The default value is disabled if beamforming is disabled on the network and enabled if beamforming is enabled on the network.

Step 4 To re-enable the network, enter this command:

config {**802.11a** | **802.11b**} **enable network**

Step 5 To save your changes, enter this command:

save config

Step 6 To see the beamforming status for your network, enter this command:

show {**802.11a** | **802.11b**}

Information similar to the following appears:

```
802.11a Network................................. Enabled
11nSupport...................................... Enabled
      802.11a Low Band.......................... Enabled
      802.11a Mid Band.......................... Enabled
      802.11a High Band......................... Enabled
...
Pico-Cell-V2 Status............................. Disabled
TI Threshold.................................... -50
Legacy Tx Beamforming setting................. Enabled
```

Step 7 To see the beamforming status for a specific access point, enter this command:

show ap config {**802.11a** | **802.11b**} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier............................. 14
Cisco AP Name................................... 1250-1
Country code.................................... US  - United States
Regulatory Domain allowed by Country............ 802.11bg:-A     802.11a:-A
...
Phy OFDM parameters
      Configuration ............................ AUTOMATIC
      Current Channel .......................... 149
      Extension Channel ........................ NONE
      Channel Width............................. 20 Mhz
      Allowed Channel List...................... 36,40,44,48,52,56,60,64,100,
        ........................................ 104,108,112,116,132,136,140,
        ........................................ 149,153,157,161,165
      TI Threshold ............................. -50
      Legacy Tx Beamforming Configuration ....... CUSTOMIZED
      Legacy Tx Beamforming ..................... ENABLED
```

Configuring CCX Radio Management Features

You can configure two parameters that affect client location calculations:

- Radio measurement requests
- Location calibration

These parameters are supported in Cisco Client Extensions (CCX) v2 and higher and are designed to enhance location accuracy and timeliness for participating CCX clients. See the "Configuring Cisco Client Extensions" section on page 6-49 for more information on CCX.

For the location features to operate properly, the access points must be configured for normal, monitor, or hybrid-REAP mode. However, for hybrid-REAP mode, the access point must be connected to the controller.

Note CCX is not supported on the AP1030.

Radio Measurement Requests

When this feature is enabled, lightweight access points issue broadcast radio measurement request messages to clients running CCXv2 or higher. The access points transmit these messages for every SSID over each enabled radio interface at a configured interval. In the process of performing 802.11 radio measurements, CCX clients send 802.11 broadcast probe requests on all the channels specified in the measurement request. The Cisco Location Appliance uses the uplink measurements based on these requests received at the access points to quickly and accurately calculate the client location. You do not need to specify on which channels the clients are to measure. The controller, access point, and client automatically determine which channels to use.

In controller software release 4.1 or later, the radio measurement feature has been expanded to enable the controller to also obtain information on the radio environment from the client's perspective (rather than from just that of the access point). In this case, the access points issue unicast radio measurement requests to a particular CCXv4 or v5 client. The client then sends various measurement reports back to the access point and onto the controller. These reports include information on the radio environment and data used to interpret the location of the clients. To prevent the access points and controller from being overwhelmed by radio measurement requests and reports, only two clients per access point and up to twenty clients per controller are supported. You can view the status of radio measurement requests for a particular access point or client as well as radio measurement reports for a particular client from the controller CLI.

Controller software release 4.1 or later also improves the ability of the Location Appliance to accurately interpret the location of a device through a new CCXv4 feature called location-based services. The controller issues a path-loss request to a particular CCXv4 or v5 client. If the client chooses to respond, it sends a path-loss measurement report to the controller. These reports contain the channel and transmit power of the client.

Note Non-CCX and CCXv1 clients simply ignore the CCX measurement requests and therefore do not participate in the radio measurement activity.

Location Calibration

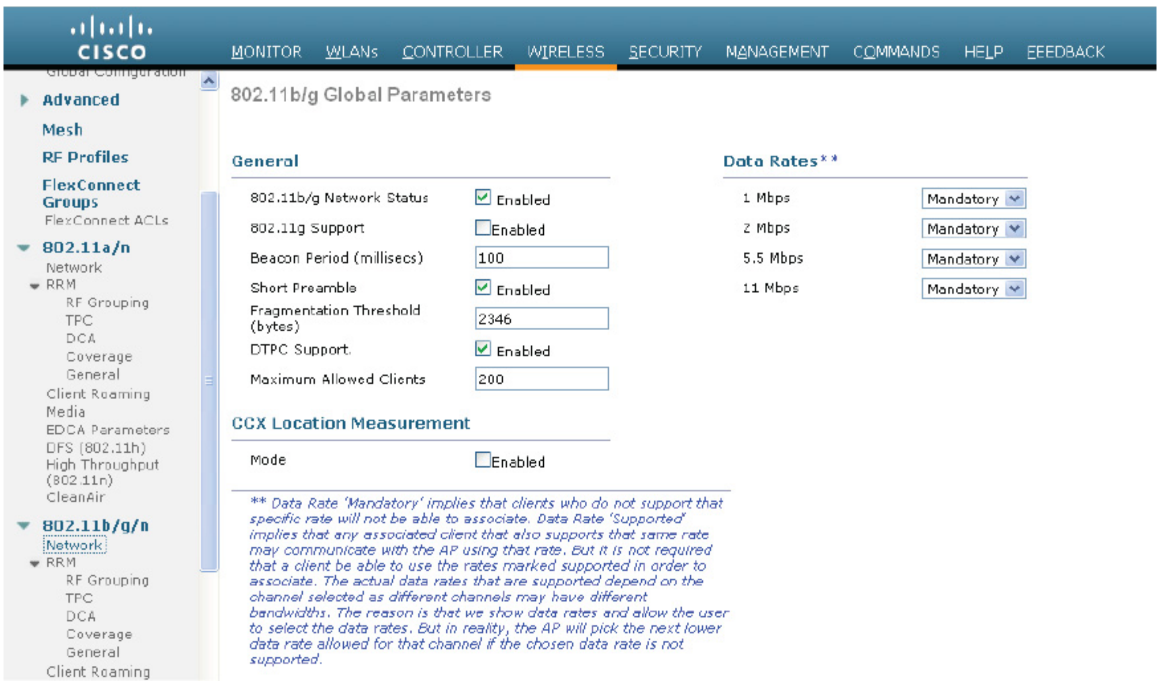
For CCX clients that need to be tracked more closely (for example, when a client calibration is performed), the controller can be configured to command the access point to send unicast measurement requests to these clients at a configured interval and whenever a CCX client roams to a new access point. These unicast requests can be sent out more often to these specific CCX clients than the broadcast measurement requests, which are sent to all clients. When location calibration is configured for non-CCX and CCXv1 clients, the clients are forced to disassociate at a specified interval to generate location measurements.

Using the GUI to Configure CCX Radio Management

Follow these steps to configure CCX radio management using the controller GUI.

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network**. The 802.11a (or 802.11b/g) Global Parameters page appears (see Figure 11-15).

Figure 11-15 802.11a Global Parameters Page



Step 2 Under CCX Location Measurement, check the **Mode** check box to globally enable CCX radio management. This parameter causes the access points connected to this controller to issue broadcast radio measurement requests to clients running CCX v2 or higher. The default value is disabled (or unchecked).

Step 3 If you checked the Mode check box in the previous step, enter a value in the Interval field to specify how often the access points are to issue the broadcast radio measurement requests.

Range: 60 to 32400 seconds

Default: 60 seconds

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your settings.

Step 6 Follow the instructions in Step 2 of the "Using the CLI to Configure CCX Radio Management" section below to enable access point customization.

> **Note** To enable CCX radio management for a particular access point, you must enable access point customization, which can be done only through the controller CLI.

Step 7 If desired, repeat this procedure for the other radio band (802.11a or 802.11b/g).

Using the CLI to Configure CCX Radio Management

Follow these steps to enable CCX radio management using the controller CLI.

Step 1 To globally enable CCX radio management, enter this command:

config advanced {**802.11a** | **802.11b**} **ccx location-meas global enable** *interval_seconds*

The range for the *interval_seconds* parameter is 60 to 32400 seconds, and the default value is 60 seconds. This command causes all access points connected to this controller in the 802.11a or 802.11b/g network to issue broadcast radio measurement requests to clients running CCXv2 or higher.

Step 2 To enable access point customization, enter these commands:

- **config advanced** {**802.11a** | **802.11b**} **ccx customize** *Cisco_AP* {**on** | **off**}

  This command enables or disables CCX radio management features for a particular access point in the 802.11a or 802.11b/g network.

- **config advanced** {**802.11a** | **802.11b**} **ccx location-meas ap** *Cisco_AP* **enable** *interval_seconds*

  The range for the *interval_seconds* parameter is 60 to 32400 seconds, and the default value is 60 seconds. This command causes a particular access point in the 802.11a or 802.11b/g network to issue broadcast radio measurement requests to clients running CCXv2 or higher.

Step 3 To enable or disable location calibration for a particular client, enter this command:

config client location-calibration {**enable** | **disable**} *client _mac interval_seconds*

> **Note** You can configure up to five clients per controller for location calibration.

Step 4 To save your settings, enter this command:

save config

Using the CLI to Obtain CCX Radio Management Information

Use these commands to obtain information about CCX radio management on the controller.

1. To see the CCX broadcast location measurement request configuration for all access points connected to this controller in the 802.11a or 802.11b/g network, enter this command:

   show advanced {**802.11a** | **802.11b**} **ccx global**

2. To see the CCX broadcast location measurement request configuration for a particular access point in the 802.11a or 802.11b/g network, enter this command:

   show advanced {**802.11a** | **802.11b**} **ccx ap** *Cisco_AP*

3. To see the status of radio measurement requests for a particular access point, enter this command:

   show ap ccx rm *Cisco_AP* **status**

   Information similar to the following appears:

```
A Radio

  Beacon Request................................ Enabled
  Channel Load Request.......................... Enabled
  Frame Request................................. Disabled
  Noise Histogram Request....................... Disabled
  Path Loss Request............................. Disabled
  Interval...................................... 60
  Iteration..................................... 5

B Radio

  Beacon Request................................ Disabled
  Channel Load Request.......................... Enabled
  Frame Request................................. Disabled
  Noise Histogram Request....................... Enabled
  Path Loss Request............................. Disabled
  Interval...................................... 60
  Iteration.................................. 5
```

4. To see the status of radio measurement requests for a particular client, enter this command:

   show client ccx rm *client_mac* **status**

   Information similar to the following appears:

```
Client Mac Address............................ 00:40:96:ae:53:b4
Beacon Request................................ Enabled
Channel Load Request.......................... Disabled
Frame Request................................. Disabled
Noise Histogram Request....................... Disabled
Path Loss Request............................. Disabled
Interval...................................... 5
Iteration..................................... 3
```

5. To see radio measurement reports for a particular client, enter these commands:
   - **show client ccx rm** *client_mac* **report beacon—**Shows the beacon report for the specified client.
   - **show client ccx rm** *client_mac* **report chan-load**—Shows the channel-load report for the specified client.

- **show client ccx rm** *client_mac* **report noise-hist**—Shows the noise-histogram report for the specified client.
- **show client ccx rm** *client_mac* **report frame**—Shows the frame report for the specified client.

6. To see the clients configured for location calibration, enter this command:

   show client location-calibration summary

7. To see the RSSI reported for both antennas on each access point that heard the client, enter this command:

   show client detail *client_mac*

Using the CLI to Debug CCX Radio Management Issues

Use these commands if you experience any CCX radio management problems.

1. To debug CCX broadcast measurement request activity, enter this command:

   debug airewave-director message {**enable** | **disable**}

2. To debug client location calibration activity, enter this command:

   debug ccxrm [**all** | **error** | **warning** | **message** | **packet** | **detail** {**enable** | **disable**}]

3. The CCX radio measurement report packets are encapsulated in Internet Access Point Protocol (IAPP) packets. Therefore, if the previous **debug ccxrm** command does not provide any debugs, enter this command to provide debugs at the IAPP level:

   debug iapp error {enable | disable}

4. To debug the output for forwarded probes and their included RSSI for both antennas, enter this command:

   debug dot11 load-balancing

Configuring Pico Cell Mode

In large multi-cell high-density wireless networks, it can be challenging to populate a site with a large number of access points to handle the desired cumulative bandwidth load while diminishing the contention between access points and maintaining quality of service. To optimize RF channel capacity and improve overall network performance, you can use the controller GUI or CLI to set high-density (or pico cell) mode parameters.

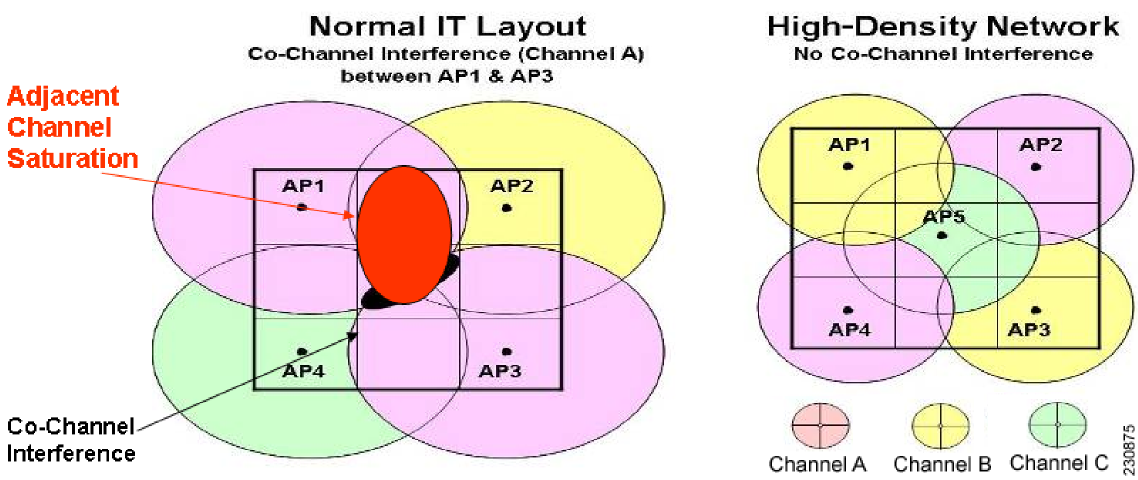
These parameters enable you to apply the same receiver sensitivity threshold, clear channel assessment (CCA) sensitivity threshold, and transmit power values across all access points registered to a given controller. When a client that supports high density associates to an access point with high density enabled, they exchange specific 802.11 information elements (IEs) that instruct the client to adhere to the access point's advertised receive sensitivity threshold, CCA sensitivity threshold, and transmit power values. These three parameters reduce the effective cell size by adjusting the received signal strength before an access point and client consider the channel accessible for the transfer of packets. When all access points and clients raise the signal standard in this way throughout a high-density area, access points can be deployed closer together without interfering with each other or being overwhelmed by environmental and distant-rogue signals.

The benefits of a high-density-enabled wireless network include the following:

- Most efficient use of the available spectrum
- Significant increase in aggregate client throughput or throughput per square feet
- Significant increase in wireless LAN capacity
- Linear capacity growth
- Higher interference tolerance by allowing WiFi to transmit over top of the interference

Figure 11-16 shows an example of a high-density network.

Figure 11-16 High-Density Network Example



Guidelines for Using Pico Cell Mode

Follow these guidelines for using pico cell mode:

- High-density networking is supported on Cisco lightweight access points and on notebooks using the Intel PRO/Wireless 3945ABG and Intel Wireless WiFi Link 4965AG clients.
- In order to use pico cell mode version 2, the WMM policy for the Intel clients must be set to Allowed.
- To support high-density, both the client s and access points must be configured for high density. Do not mix high-density and non-high-density devices in the same network.
- High-density access points must be joined to a dedicated controller.
- When you adjust the pico cell mode parameters, the following RRM values automatically change:
  - The default value of the Fixed option for the Power Level Assignment Method parameter [on the 802.11a (or 802.11b) > RRM > Tx Power Control (TPC) page] reflects the power setting that you specify for the pico cell Transmit Power parameter.
  - The default value of the Power Threshold parameter [on the 802.11a (or 802.11b) > RRM > Tx Power Control (TPC) page] reflects the value that you specify for the pico cell CCA Sensitivity Threshold parameter.

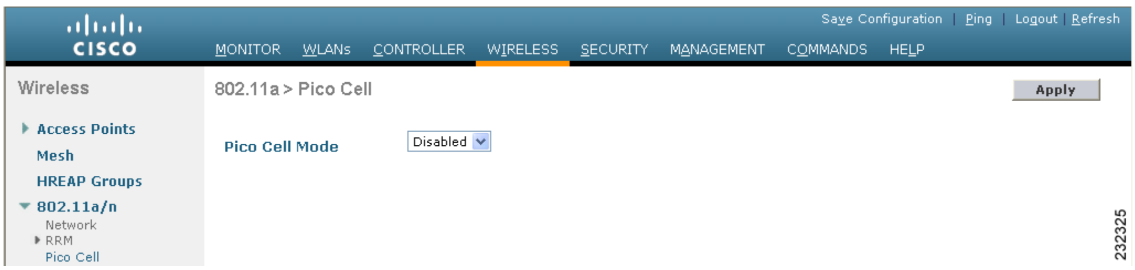
Using the GUI to Configure Pico Cell Mode

Follow these steps to configure pico cell mode using the controller GUI.

Step 1 Disable the 802.11a or 802.11b/g network before changing pico cell mode parameters. To do so, choose **Wireless** > **802.11a/n** (or **802.11b/g/n**) > **Network** and uncheck the **802.11a Network Status** (or **802.11b/g Network Status**) check box.

Step 2 Choose **Wireless** > **802.11a/n** (or **802.11b/g/n**) > **Pico Cell** to open the 802.11a (or 802.11b/g) > Pico Cell page (see Figure 11-17).

Figure 11-17 802.11a > Pico Cell Page



Step 3 Choose one of these options from the Pico Cell Mode drop-down box:

- **Disable**—Disables pico cell mode. This is the default value.
- **V1**—Enables pico cell mode version 1. This option is designed for use with legacy Airespace products (those released prior to Cisco's acquisition of Airespace). Cisco recommends that you choose V2 if you want to enable pico cell mode.
- **V2**—Enables pico cell mode version 2. Choose this option if you want to adjust the pico cell mode parameters to optimize network performance in high-density areas, where all the clients support high density.

Step 4 If you chose V2 in Step 3, the 802.11a (or 802.11b/g) > Pico Cell page displays three configurable fields: Rx Sensitivity Threshold, CCA Sensitivity Threshold, and Transmit Power (see Figure 11-18).

Figure 11-18 802.11a > Pico Cell Page with Pico Cell Mode V2 Parameters

Use the information in Table 11-3 to adjust the values of these parameters as necessary.

Note The default values for these parameters should be appropriate for most applications. Therefore, Cisco recommends that you use the default values.

Table 11-3 Pico Cell Mode V2 Parameters

Parameter	Description
Rx Sensitivity Threshold	Specifies the current, minimum, and maximum values (in dBm) for the receiver sensitivity of the 802.11a or 802.11b/g radio. The current value sets the receiver sensitivity on the local radio. The min and max values are used only for inclusion in the Inter-Access Point Protocol (IAPP) high-density reports. **Default:** –65 dBm (Current), –127 dBm (Min), and 127 dBm (Max)
CCA Sensitivity Threshold	Specifies the clear channel assessment (CCA) sensitivity threshold on all radios in the high-density cell. The current value programs the 802.11a or 802.11b/g receiver. The min and max values are for advertisement in IAPP reports. **Default:** –65 dBm (Current), –127 dBm (Min), and 127 dBm (Max)
Transmit Power	Specifies the high-density transmit power used by both the access point and client 802.11a or 802.11b/g radios. **Default:** 10 dBm (Current), –127 dBm (Min), and 127 dBm (Max)

Note The min and max values in Figure 11-18 and Table 11-3 are used only to indicate the range to the client. They are not used on the access point.

Step 5 Click **Apply** to commit your changes.

Step 6 Re-enable the 802.11a or 802.11b/g network. To do so, choose **Wireless** > **802.11a/n** (or **802.11b/g/n**) > **Network** and check the **802.11a Network Status** (or **802.11b/g Network Status**) check box.

Step 7 Click **Save Configuration** to save your changes.

Note If you change the values of the pico cell mode parameters and later want to reset them to their default values, click **Reset to Defaults** and then click **Apply**.

Using the CLI to Configure Pico Cell Mode

Note Refer to the "Using the GUI to Configure Pico Cell Mode" section on page 11-49 for descriptions and default values of the parameters used in the CLI commands.

Step 1 To disable the 802.11a or 802.11b/g network before changing pico cell mode parameters, enter this command:

config {**802.11a** | **802.11b**} **disable**

Step 2 To enable pico cell mode, enter one of these commands:

- **config** {**802.11a** | **802.11b**} **picocell enable**—Enables pico cell mode version 1. This command is designed for use with a specific application. Cisco recommends that you use the **config** {**802.11a** | **802.11b**} **picocell-V2 enable** command if you want to enable pico cell mode.
- **config** {**802.11a** | **802.11b**} **picocell-V2 enable**—Enables pico cell mode version 2. Use this command if you want to adjust the pico cell mode parameters to optimize network performance in high-density areas.

Step 3 If you enabled pico cell mode version 2 in Step 2, follow these steps to configure the receive sensitivity threshold, CCA sensitivity threshold, and transmit power parameters:

a. To configure the receive sensitivity threshold, enter this command:

   config advanced {**802.11a** | **802.11b**} **receiver pico-cell-V2 rx_sense_threshold** *min max current*

b. To configure the CCA sensitivity threshold, enter this command:

   config advanced {**802.11a** | **802.11b**} **receiver pico-cell-V2 cca_sense_threshold** *min max current*

c. To configure the transmit power, enter this command:

   config advanced {**802.11a** | **802.11b**} **receiver pico-cell-V2 sta_tx_pwr** *min max current*

Step 4 If you enabled pico cell mode version 2 in Step 2 and you want to transmit a unicast IAPP high-density frame request to a specific client, enter this command:

config advanced {**802.11a** | **802.11b**} **receiver pico-cell-V2 send_iapp_req** *client_mac*

Step 5 To re-enable the 802.11a or 802.11b/g network, enter this command:

config {**802.11a** | **802.11b**} **enable**

Step 6 To save your settings, enter this command:

save config

Using the CLI to Debug Pico Cell Mode Issues

Use these commands if you experience any pico cell mode problems.

1. To see the current status of pico cell mode, enter this command:

   show {**802.11a** | **802.11b**}

   Information similar to the following appears:

```
802.11a Network.................................. Disabled
11nSupport....................................... Disabled
      802.11a Low Band........................... Enabled
      802.11a Mid Band........................... Enabled
      802.11a High Band.......................... Enabled
...
Pico-Cell Status................................. Disabled
Pico-Cell-V2 Status........................... Enabled
```

2. To see the receiver parameters that are set by the pico cell mode commands, enter this command:

   show advanced {**802.11a** | **802.11b**} **receiver**

   Information similar to the following appears:

```
802.11a Advanced Receiver Settings
 RxStart  : Signal Threshold.................... 30
 RxStart  : Signal Jump Threshold............... 5
 RxStart  : Preamble Power Threshold............ 30
 RxRestart: Signal Jump Status.................. Enabled
 RxRestart: Signal Jump Threshold............... 10
 TxStomp  : Low RSSI Status..................... Disabled
 TxStomp  : Low RSSI Threshold.................. 30
 TxStomp  : Wrong BSSID Status.................. Disabled
 TxStomp  : Wrong BSSID Data Only Status........ Disabled
 RxAbort  : Raw Power Drop Status............... Disabled
 RxAbort  : Raw Power Drop Threshold............ 10
 RxAbort  : Low RSSI Status..................... Disabled
 RxAbort  : Low RSSI Threshold.................. 30
 RxAbort  : Wrong BSSID Status.................. Disabled
 RxAbort  : Wrong BSSID Data Only Status........ Disabled
 ............................................
 pico-cell-V2 parameters in dbm units:
 RxSensitivity: Min,Max,Current RxSense Thres.... -127,127,-65
 CCA Threshold: Min,Max,Current Clear Channel.... -127,127,-65
Tx Pwr: Min,Max,Current Transmit Power for A..... -127,127,10
 ............................................
```

3. To see the noise and interference information, coverage information, client signal strengths and signal-to-noise ratios, and nearby access points, enter this command:

   show ap auto-rf {**802.11a** | **802.11b**} *Cisco_AP*

   Information similar to the following appears:

```
Number Of Slots.................................. 2
AP Name.......................................... AP1242.47b2.31f6
MAC Address...................................... 00:16:47:b2:31:f6
  Radio Type..................................... RADIO_TYPE_80211a
  Noise Information
    Noise Profile................................ PASSED
  Interference Information
    Interference Profile......................... PASSED
  Load Information
    Load Profile................................. PASSED
    Receive Utilization.......................... 0 %
    Transmit Utilization......................... 0 %
    Channel Utilization.......................... 0 %
    Attached Clients............................. 0 clients
  Coverage Information
    Coverage Profile............................. PASSED
    Failed Clients............................... 0 clients
  Client Signal Strengths
    RSSI -100 dbm................................ 0 clients
    RSSI  -92 dbm................................ 0 clients
    RSSI  -84 dbm................................ 0 clients
    RSSI  -76 dbm................................ 0 clients
    RSSI  -68 dbm................................ 0 clients
    RSSI  -60 dbm................................ 0 clients
    RSSI  -52 dbm................................ 0 clients
```

```
Client Signal To Noise Ratios
  SNR    0 dB................................. 0 clients
  SNR    5 dB................................. 0 clients
  SNR   10 dB................................. 0 clients
  SNR   15 dB................................. 0 clients
  SNR   20 dB................................. 0 clients
  SNR   25 dB................................. 0 clients
  SNR   30 dB................................. 0 clients
  SNR   35 dB................................. 0 clients
  SNR   40 dB................................. 0 clients
  SNR   45 dB................................. 0 clients
Nearby APs
Radar Information
RF Parameter Recommendations
  Power Level................................. 0
  RTS/CTS Threshold........................... 0
  Fragmentation Threshold..................... 0
  Antenna Pattern............................. 0
```

Configuring Mobility Groups

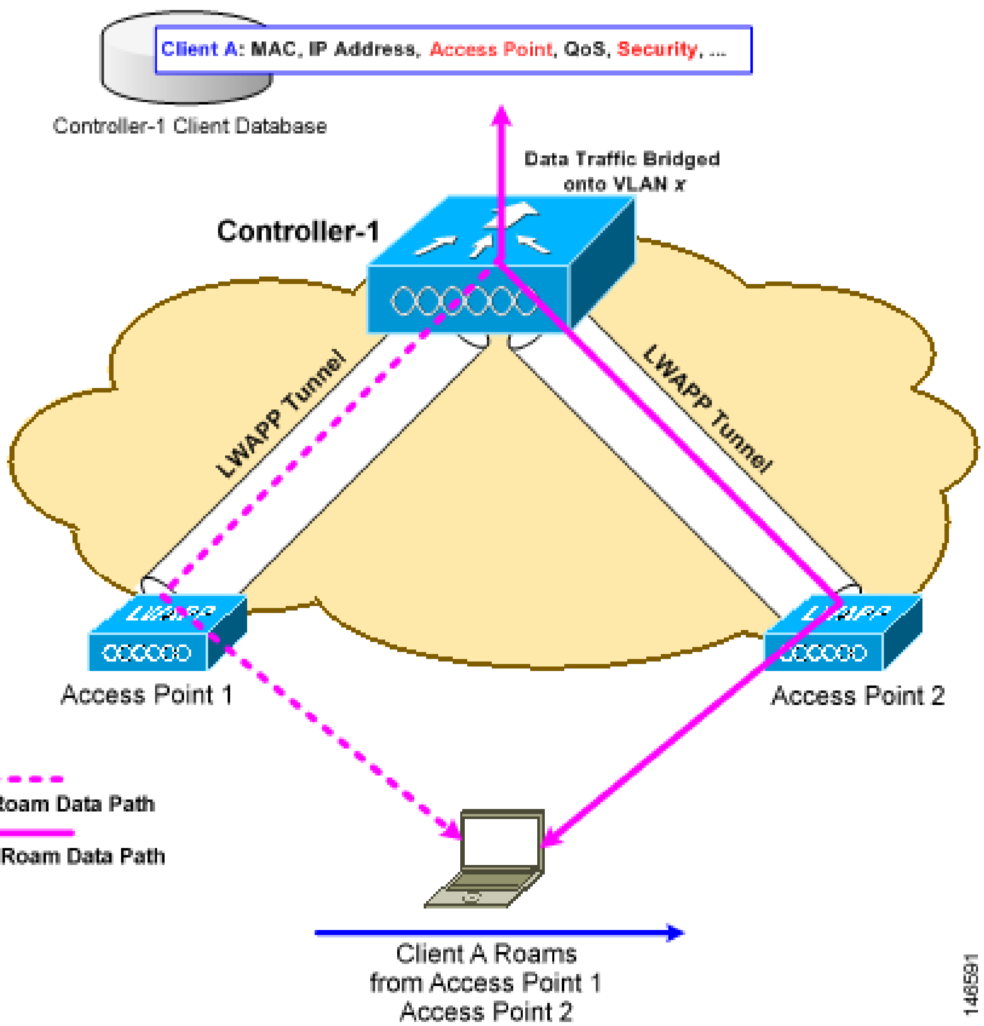
This chapter describes mobility groups and explains how to configure them on the controllers. It contains these sections:

Overview of Mobility

Mobility, or roaming, is a wireless LAN client's ability to maintain its association seamlessly from one access point to another securely and with as little latency as possible. This section explains how mobility works when controllers are included in a wireless network.

When a wireless client associates and authenticates to an access point, the access point's controller places an entry for that client in its client database. This entry includes the client's MAC and IP addresses, security context and associations, quality of service (QoS) contexts, the WLAN, and the associated access point. The controller uses this information to forward frames and manage traffic to and from the wireless client. Figure 12-1 illustrates a wireless client roaming from one access point to another when both access points are joined to the same controller.

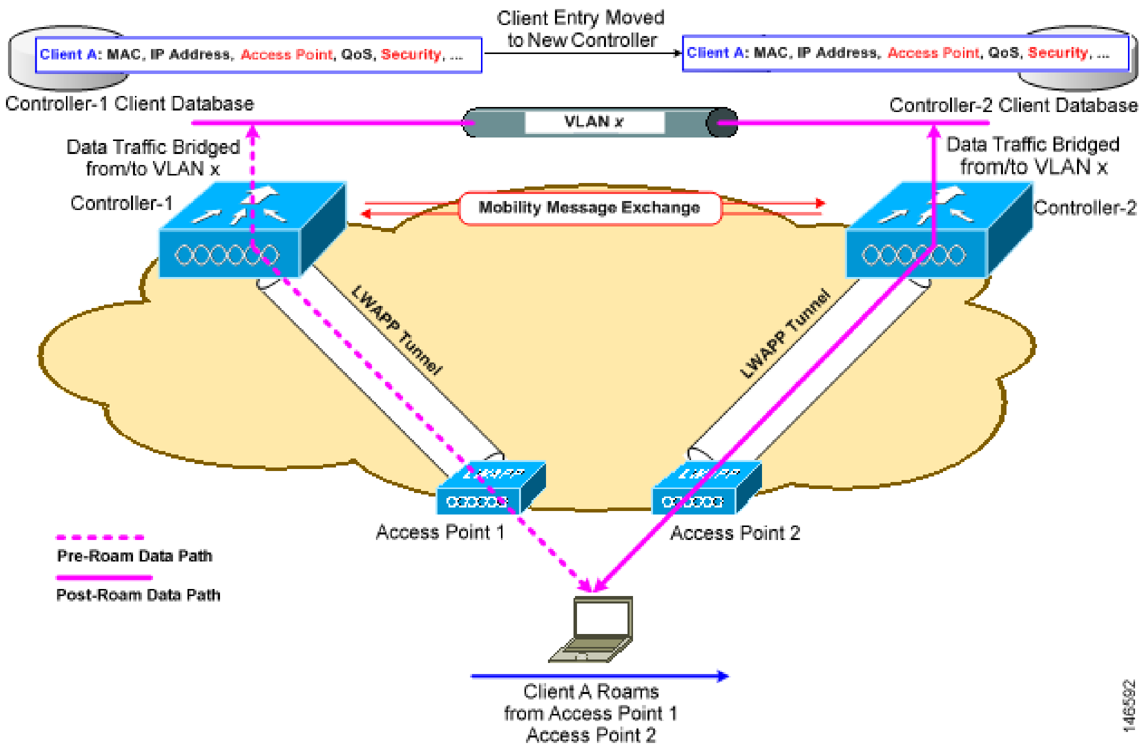
Figure 12-1 Intra-Controller Roaming



When the wireless client moves its association from one access point to another, the controller simply updates the client database with the newly associated access point. If necessary, new security context and associations are established as well.

The process becomes more complicated, however, when a client roams from an access point joined to one controller to an access point joined to a different controller. It also varies based on whether the controllers are operating on the same subnet. Figure 12-2 illustrates inter-controller roaming, which occurs when the controllers' wireless LAN interfaces are on the same IP subnet.

Figure 12-2 Inter-Controller Roaming

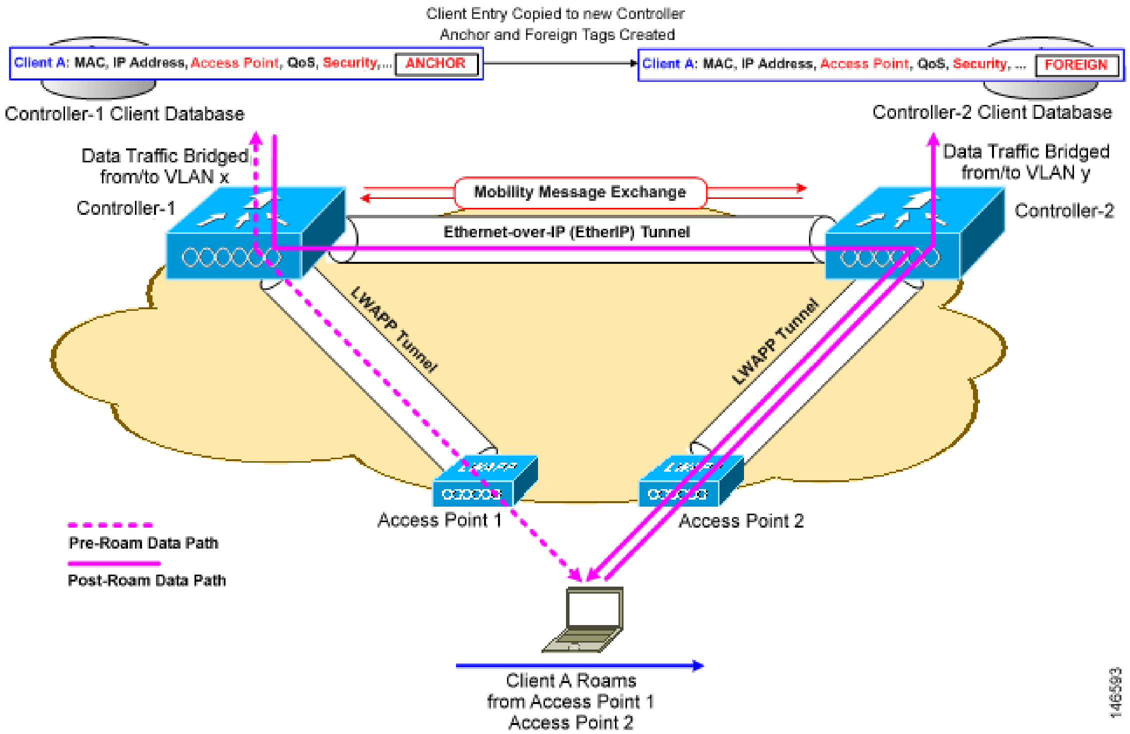


When the client associates to an access point joined to a new controller, the new controller exchanges mobility messages with the original controller, and the client database entry is moved to the new controller. New security context and associations are established if necessary, and the client database entry is updated for the new access point. This process remains transparent to the user.

Note All clients configured with 802.1X/Wi-Fi Protected Access (WPA) security complete a full authentication in order to comply with the IEEE standard.

Figure 12-3 illustrates inter-subnet roaming, which occurs when the controllers' wireless LAN interfaces are on different IP subnets.

Figure 12-3 Inter-Subnet Roaming



Inter-subnet roaming is similar to inter-controller roaming in that the controllers exchange mobility messages on the client roam. However, instead of moving the client database entry to the new controller, the original controller marks the client with an “Anchor” entry in its own client database. The database entry is copied to the new controller client database and marked with a “Foreign” entry in the new controller. The roam remains transparent to the wireless client, and the client maintains its original IP address.

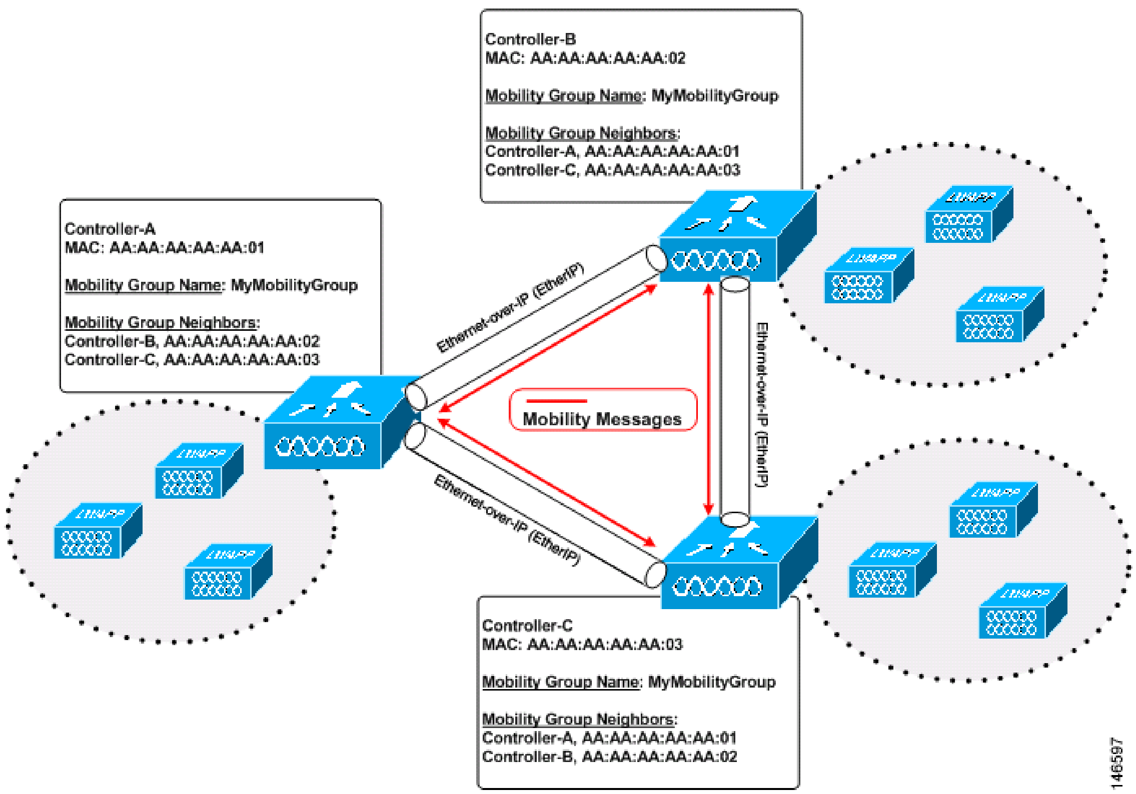
In inter-subnet roaming, WLANs on both anchor and foreign controllers need to have the same network access privileges and no source-based routing or source-based firewalls in place. Otherwise, the clients may have network connectivity issues after the handoff.

Overview of Mobility Groups

A mobility group is a set of controllers, identified by the same mobility group name, that defines the realm of seamless roaming for wireless clients. By creating a mobility group, you can enable multiple controllers in a network to dynamically share information and forward data traffic when inter-controller or inter-subnet roaming occurs. Controllers in the same mobility group can share the context and state of client devices as well as their list of access points so that they do not consider each other's access points as rogue devices. With this information, the network can support inter-controller wireless LAN roaming and controller redundancy. Figure 12-4 shows an example of a mobility group.

Note Controllers do not have to be of the same model to be a member of a mobility group. Mobility groups can be comprised of any combination of controller platforms.

Figure 12-4 A Single Mobility Group



As shown above, each controller is configured with a list of the other members of the mobility group. Whenever a new client joins a controller, the controller sends out a unicast message to all of the controllers in the mobility group. The controller to which the client was previously connected passes on the status of the client.

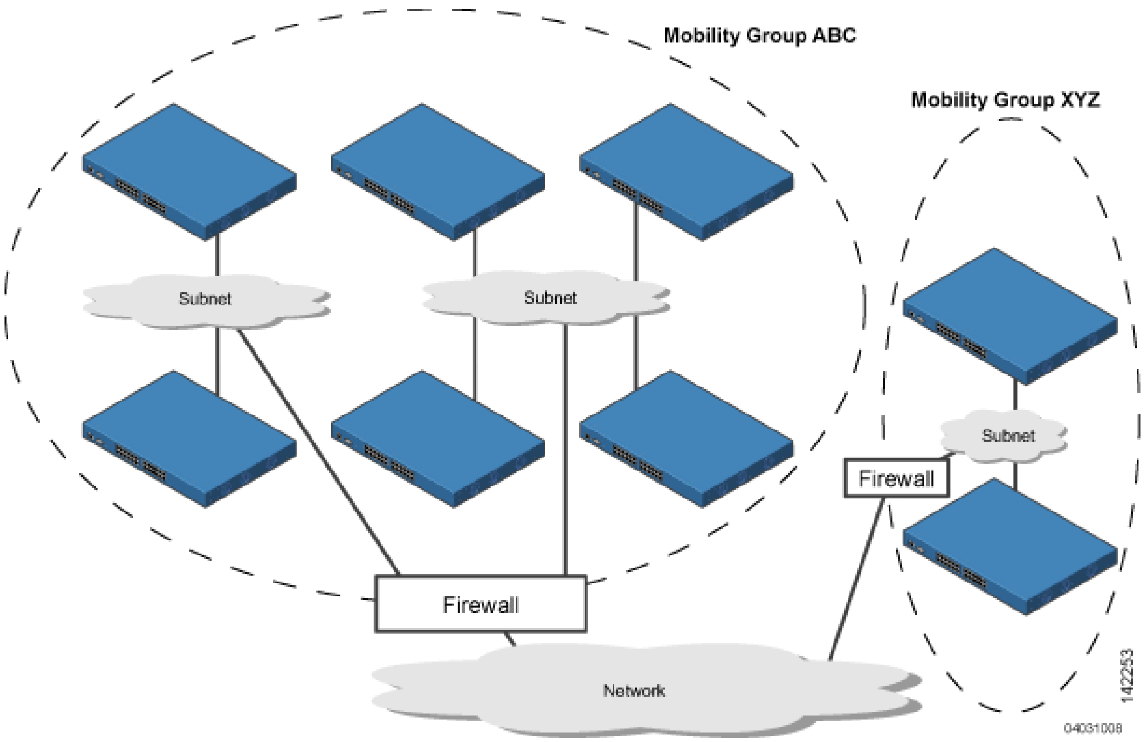
Controller software release 5.1 or later supports up to 24 controllers in a single mobility group. The number of access points supported in a mobility group is bound by the number of controllers and controller types in the group.

Examples:

1. A 4404-100 controller supports up to 100 access points. Therefore, a mobility group consisting of 24 4404-100 controllers supports up to 2400 access points (24 * 100 = 2400 access points).
2. A 4402-25 controller supports up to 25 access points, and a 4402-50 controller supports up to 50 access points. Therefore, a mobility group consisting of 12 4402-25 controllers and 12 4402-50 controllers supports up to 900 access points (12 * 25 + 12 * 50 = 300 + 600 = 900 access points).

Mobility groups enable you to limit roaming between different floors, buildings, or campuses in the same enterprise by assigning different mobility group names to different controllers within the same wireless network. Figure 12-5 shows the results of creating distinct mobility group names for two groups of controllers.

Figure 12-5 Two Mobility Groups



The controllers in the ABC mobility group recognize and communicate with each other through their access points and through their shared subnets. The controllers in the ABC mobility group do not recognize or communicate with the XYZ controllers, which are in a different mobility group. Likewise, the controllers in the XYZ mobility group do not recognize or communicate with the controllers in the ABC mobility group. This feature ensures mobility group isolation across the network.

Controllers can communicate across mobility groups and clients may roam between access points in different mobility groups, provided that the controllers are included in each other's mobility lists. A mobility list is a list of controllers configured on a controller that specifies members in different mobility groups. In the following example, controller 1 can communicate with either controller 2 or 3, but controller 2 and controller 3 can communicate only with controller 1 and not with each other. Similarly, clients can roam between controller 1 and controller 2 or between controller 1 and controller 3 but not between controller 2 and controller 3.

Example:

```
Controller 1                 Controller 2                 Controller 3
Mobility group: A            Mobility group: A            Mobility group: C
Mobility list:               Mobility list:               Mobility list:
   Controller 1 (group A)       Controller 1 (group A)       Controller 1 (group A)
   Controller 2 (group A)       Controller 2 (group A)       Controller 3 (group C)
   Controller 3 (group C)
```

Controller software release 5.1 or later supports up to 72 controllers in a controller's mobility list and seamless roaming across multiple mobility groups. During seamless roaming, the client maintains its IP address across all mobility groups; however, Cisco Centralized Key Management (CCKM) and public key cryptography (PKC) are supported only for intra-mobility-group roaming. When a client crosses a mobility group boundary during a roam, the client is fully authenticated, but the IP address is maintained, and EtherIP tunneling is initiated for Layer 3 roaming.

Note Controller software release 5.0 or later supports up to 48 controllers in a mobility list.

Determining When to Include Controllers in a Mobility Group

If it is possible for a wireless client in your network to roam from an access point joined to one controller to an access point joined to another controller, both controllers should be in the same mobility group.

Messaging among Mobility Groups

The controller provides inter-subnet mobility for clients by sending mobility messages to other member controllers. In controller software release 5.0 or later, two improvements have been made to mobility messaging, each of which is especially useful when sending messages to the full list of mobility members:

- Sending Mobile Announce messages within the same group first and then to other groups in the list

  The controller sends a Mobile Announce message to members in the mobility list each time a new client associates to it. In controller software releases prior to 5.0, the controller sends this message to all members in the list irrespective of the group to which they belong. However, in controller software release 5.0 or later, the controller sends the message only to those members that are in the same group as the controller (the local group) and then includes all of the other members while sending retries.

- Sending Mobile Announce messages using multicast instead of unicast

  In controller software releases prior to 5.0, the controller sends all mobility messages using unicast mode, which requires sending a copy of the messages to every mobility member. This behavior is not efficient because many messages (such as Mobile Announce, PMK Update, AP List Update, and IDS Shun) are meant for all members in the group. In controller software release 5.0 or later, the controller may be configured to use multicast to send the Mobile Announce messages. This behavior allows the controller to send only one copy of the message to the network, which destines it to the multicast group containing all the mobility members. To derive the maximum benefit from multicast messaging, Cisco recommends that it be enabled on all group members.

Using Mobility Groups with NAT Devices

In controller software releases prior to 4.2, mobility between controllers in the same mobility group does not work if one of the controllers is behind a network address translation (NAT) device. This behavior creates a problem for the guest anchor feature where one controller is expected to be outside the firewall.

Mobility message payloads carry IP address information about the source controller. This IP address is validated with the source IP address of the IP header. This behavior poses a problem when a NAT device is introduced in the network because it changes the source IP address in the IP header. Hence, in the guest WLAN feature, any mobility packet being routed through a NAT device is dropped because of the IP address mismatch.

In controller software release 4.2 or later, the mobility group lookup is changed to use the MAC address of the source controller. Because the source IP address is changed due to the mapping in the NAT device, the mobility group database is searched before a reply is sent to get the IP address of the requesting controller. This is done using the MAC address of the requesting controller.

When configuring the mobility group in a network where NAT is enabled, enter the IP address sent to the controller from the NAT device rather than the controller's management interface IP address. Also, make sure that the following ports are open on the firewall if you are using a firewall such as PIX:

- UDP 16666 for tunnel control traffic
- IP protocol 97 for user data traffic
- UDP 161 and 162 for SNMP

Note Client mobility among controllers works only if auto-anchor mobility (also called *guest tunneling*) or symmetric mobility tunneling is enabled. Asymmetric tunneling is not supported when mobility controllers are behind the NAT device. See the "Configuring Auto-Anchor Mobility" and "Using Symmetric Mobility Tunneling" sections for details on these mobility options.

Figure 12-6 shows an example mobility group configuration with a NAT device. In this example, all packets pass through the NAT device (that is, packets from the source to the destination and vice versa). Figure 12-7 shows an example mobility group configuration with two NAT devices. In this example, one NAT device is used between the source and the gateway, and the second NAT device is used between the destination and the gateway.

Figure 12-6 Mobility Group Configuration with One NAT Device

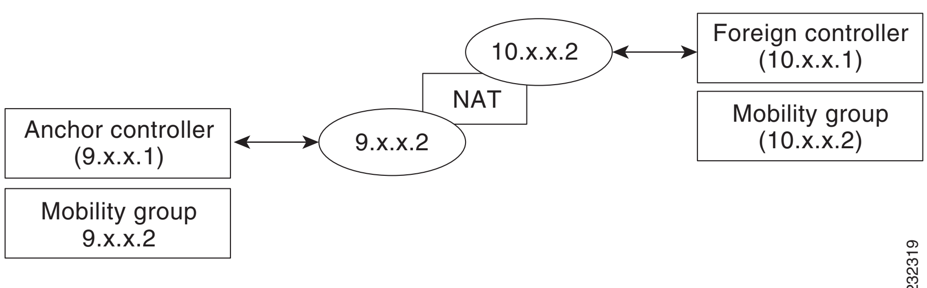
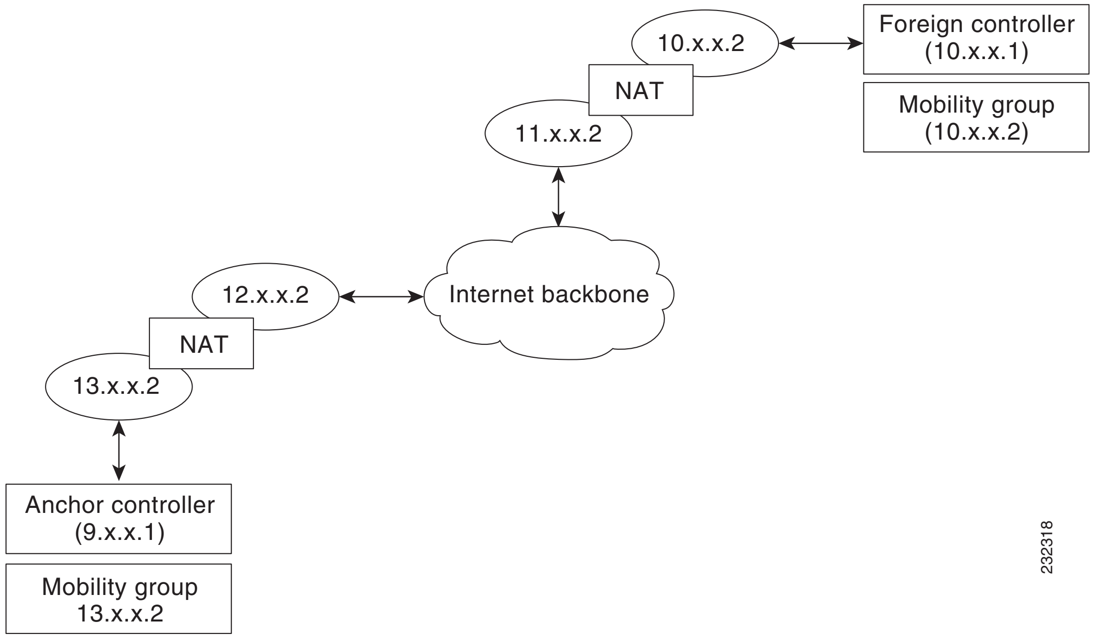


Figure 12-7 Mobility Group Configuration with Two NAT Devices



Configuring Mobility Groups

This section provides instructions for configuring controller mobility groups through either the GUI or the CLI.

Note You can also configure mobility groups using the Cisco Wireless Control System (WCS). Refer to the *Cisco Wireless Control System Configuration Guide* for instructions.

Prerequisites

Before you add controllers to a mobility group, you must verify that the following requirements have been met for all controllers that are to be included in the group:

- IP connectivity must exist between the management interfaces of all controllers.

  Note You can verify IP connectivity by pinging the controllers.

  Note Mobility control packets can use any interface address as the source, based on routing table. It is recommended that all controllers in the mobility group should have the management interface in the same subnet. A topology where one controller's management interface and other controller's dynamic interface are on same subnet not recommended for seamless mobility.

- All controllers must be configured with the same mobility group name.

Note The mobility group name is generally set at deployment time through the Startup Wizard. However, you can change it if necessary through the Default Mobility Domain Name field on the Controller > General page. The mobility group name is case sensitive.

Note For the Cisco WiSM, both controllers should be configured with the same mobility group name for seamless routing among 300 access points.

- Guest tunneling works only between controllers running the same software release or between controllers running software release 4.2 and controllers running any later software release (for example, 4.2 to 5.0, 4.2 to 5.1, 4.2 to 5.2, or 4.2 to 6.0). Guest tunneling does not work among controllers running other combinations of software.

Note If you inadvertently configure a controller that is running software release 5.2 or later with a failover controller that is running a different software release (such as 4.2, 5.0, or 5.1), the access point might take a long time to join the failover controller because the access point starts the discovery process in CAPWAP and then changes to LWAPP discovery.

- All controllers must be configured with the same virtual interface IP address.

Note If necessary, you can change the virtual interface IP address by editing the virtual interface name on the Controller > Interfaces page. See the *Configuring Ports and Interfaces* chapter for more information on the controller's virtual interface.

Note If all the controllers within a mobility group are not using the same virtual interface, inter-controller roaming may appear to work, but the hand-off does not complete, and the client loses connectivity for a period of time.

- You must have gathered the MAC address and IP address of every controller that is to be included in the mobility group. This information is necessary because you will be configuring all controllers with the MAC address and IP address of all the other mobility group members.

Note You can find the MAC and IP addresses of the other controllers to be included in the mobility group on the Controller > Mobility Groups page of each controller's GUI.

- When you configure mobility groups using a third-party firewall, Cisco PIX, or Cisco ASA, you need to open ports 16666, 12222, and 12223; IP protocols 50 and 97; and UDP port 500.

Note You cannot perform port address translation (PAT) on the firewall. You must configure one-to-one network address translation (NAT).

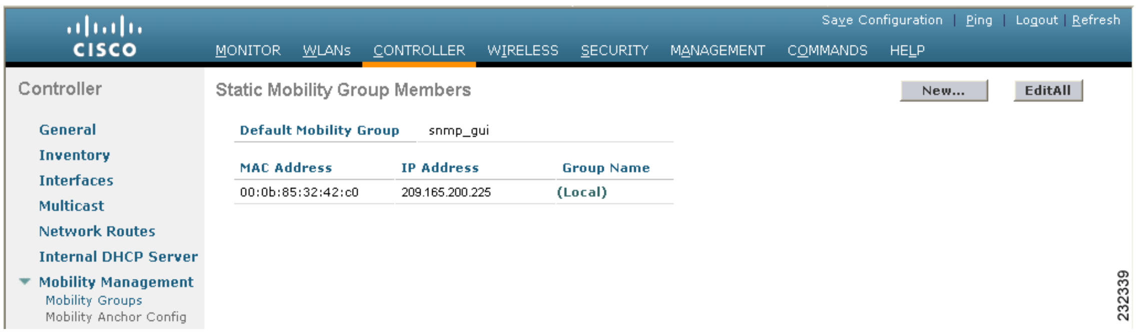
Using the GUI to Configure Mobility Groups

Follow these steps to configure mobility groups using the GUI.

Note See the "Using the CLI to Configure Mobility Groups" section on page 12-14 if you would prefer to configure mobility groups using the CLI.

Step 1 Choose **Controller** > **Mobility Management** > **Mobility Groups** to open the Static Mobility Group Members page (see Figure 12-8).

Figure 12-8 Static Mobility Group Members Page



This page shows the mobility group name in the Default Mobility Group field and lists the MAC address and IP address of each controller that is currently a member of the mobility group. The first entry is the local controller, which cannot be deleted.

Note If you want to delete any of the remote controllers from the mobility group, hover your cursor over the blue drop-down arrow for the desired controller and choose **Remove**.

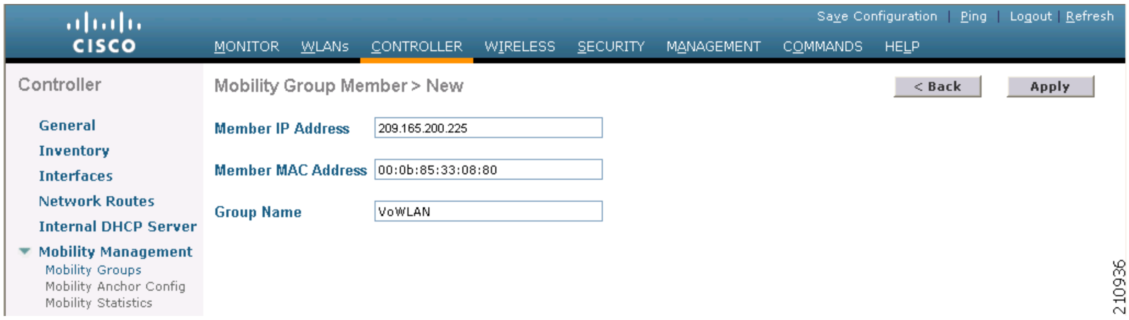
Step 2 Perform one of the following to add controllers to a mobility group:

- If you are adding only one controller or want to individually add multiple controllers, click **New** and go to Step 3.
- If you are adding multiple controllers and want to add them in bulk, click **EditAll** and go to Step 4.

Note The EditAll option enables you to enter the MAC and IP addresses of all the current mobility group members and then copy and paste all the entries from one controller to the other controllers in the mobility group.

Step 3 The Mobility Group Member > New page appears (see Figure 12-9).

Figure 12-9 Mobility Group Member > New Page



Follow these steps to add a controller to the mobility group:

a. In the Member IP Address field, enter the management interface IP address of the controller to be added.

> **Note** If you are configuring the mobility group in a network where network address translation (NAT) is enabled, enter the IP address sent to the controller from the NAT device rather than the controller's management interface IP address. Otherwise, mobility will fail among controllers in the mobility group.

b. In the Member MAC Address field, enter the MAC address of the controller to be added.

c. In the Group Name field, enter the name of the mobility group.

> **Note** The mobility group name is case sensitive.

d. Click **Apply** to commit your changes. The new controller is added to the list of mobility group members on the Static Mobility Group Members page.

e. Click **Save Configuration** to save your changes.

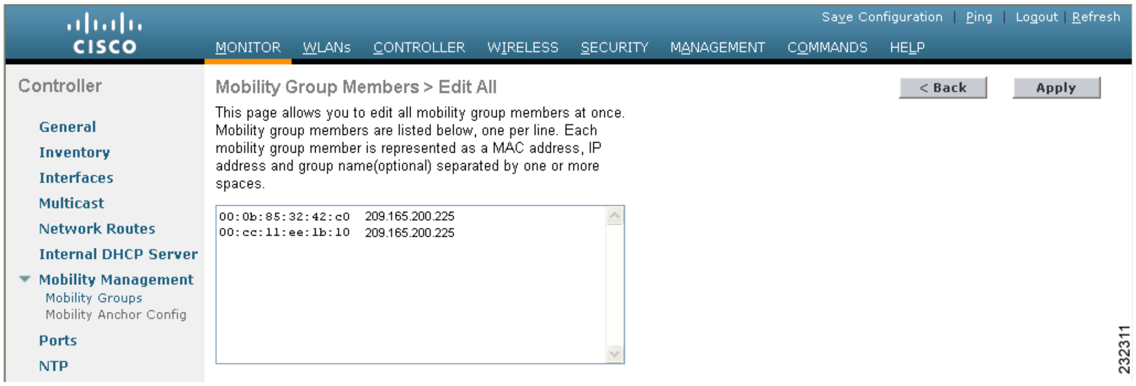
f. Repeat Step a through Step e to add all of the controllers in the mobility group.

g. Repeat this procedure on every controller to be included in the mobility group. All controllers in the mobility group must be configured with the MAC address and IP address of all other mobility group members.

Step 4 The Mobility Group Members > Edit All page (see Figure 12-10) lists the MAC address, IP address, and mobility group name (optional) of all the controllers currently in the mobility group. The controllers are listed one per line with the local controller at the top of the list.

> **Note** If desired, you can edit or delete any of the controllers in the list.

Figure 12-10 Mobility Group Members > Edit All Page



Follow these steps to add more controllers to the mobility group:

a. Click inside the edit box to start a new line.

b. Enter the MAC address, the management interface IP address, and the name of the mobility group for the controller to be added.

> **Note** These values should be entered on one line and separated by one or two spaces.

> **Note** The mobility group name is case sensitive.

c. Repeat Step a and Step b for each additional controller that you want to add to the mobility group.

d. Highlight and copy the complete list of entries in the edit box.

e. Click **Apply** to commit your changes. The new controllers are added to the list of mobility group members on the Static Mobility Group Members page.

f. Click **Save Configuration** to save your changes.

g. Paste the list into the edit box on the Mobility Group Members > Edit All page of all the other controllers in the mobility group and click **Apply** and **Save Configuration**.

Step 5 Choose **Multicast Messaging** to open the Mobility Multicast Messaging page (see Figure 12-11).

Figure 12-11 Mobility Multicast Messaging Page

The names of all the currently configured mobility groups appear in the middle of the page.

Step 6 On the Mobility Multicast Messaging page, check the **Enable Multicast Messaging** check box to enable the controller to use multicast mode to send Mobile Announce messages to the mobility members. If you leave it unchecked, the controller uses unicast mode to send the Mobile Announce messages. The default value is unchecked.

Step 7 If you enabled multicast messaging in the previous step, enter the multicast group IP address for the local mobility group in the Local Group Multicast IP Address field. This address is used for multicast mobility messaging.

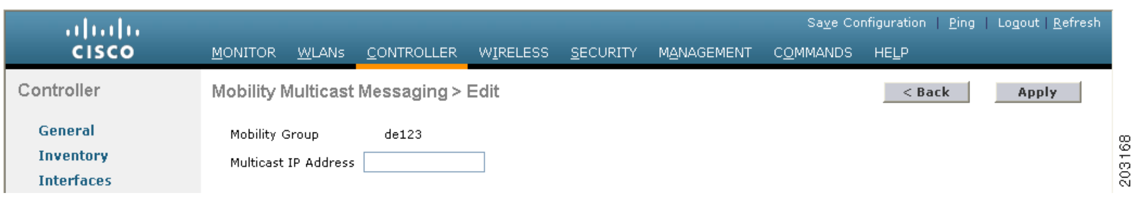
Note In order to use multicast messaging, you must configure the IP address for the local mobility group.

Step 8 Click **Apply** to commit your changes.

Step 9 If desired, you can also configure the multicast group IP address for non-local groups within the mobility list. To do so, click the name of a non-local mobility group to open the Mobility Multicast Messaging > Edit page (see Figure 12-12), and enter the multicast group IP address for the non-local mobility group in the Multicast IP Address field.

Note If you do not configure the multicast IP address for non-local groups, the controller uses unicast mode to send mobility messages to those members.

Figure 12-12 Mobility Multicast Messaging > Edit Page



Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Configure Mobility Groups

Follow these steps to configure mobility groups using the CLI.

Step 1 To check the current mobility settings, enter this command:

show mobility summary

Information similar to the following appears:

```
Symmetric Mobility Tunneling (current) .......... Enabled
Symmetric Mobility Tunneling (after reboot) ..... Enabled
Mobility Protocol Port.......................... 16666
Mobility Security Mode.......................... Disabled
Default Mobility Domain......................... snmp_gui
Multicast Mode ................................. Disabled
```

```
Mobility Domain ID for 802.11r.................. 0x66bd
Mobility Keepalive Interval..................... 10
Mobility Keepalive Count........................ 3
Mobility Group Members Configured............... 3
Mobility Control Message DSCP Value............. 0

Controllers configured in the Mobility Group
 MAC Address        IP Address       Group Name Multicast IP Status
 00:0b:85:32:42:c0 1.100.163.24     snmp_gui     0.0.0.0     Up
 00:cc:11:ee:1b:10 10.100.100.1    VoWLAN        0.0.0.0     Control and Data Path Down
 11:22:11:33:11:44 1.2.3.4         test          0.0.0.0     Control and Data Path Down
```

Step 2 To create a mobility group, enter this command:

config mobility group domain *domain_name*

Note Enter up to 31 case-sensitive ASCII characters for the group name. Spaces are not allowed in mobility group names.

Step 3 To add a group member, enter this command:

config mobility group member add *mac_address ip_address*

Note If you are configuring the mobility group in a network where network address translation (NAT) is enabled, enter the IP address sent to the controller from the NAT device rather than the controller's management interface IP address. Otherwise, mobility will fail among controllers in the mobility group.

Note Enter **config mobility group member delete** *mac_address* if you want to delete a group member.

Step 4 To enable or disable multicast mobility mode, enter this command:

config mobility multicast-mode {**enable** | **disable**} *local_group_multicast_address*

where *local_group_multicast_address* is the multicast group IP address for the local mobility group. This address is used for multicast mobility messaging.

If you enable multicast mobility mode, the controller uses multicast mode to send Mobile Announce messages to the local group. If you disable multicast mobility mode, the controller uses unicast mode to send the Mobile Announce messages to the local group. The default value is disabled.

Step 5 If desired, you can also configure the multicast group IP address for non-local groups within the mobility list. To do so, enter this command:

config mobility group multicast-address *group_name IP_address*

If you do not configure the multicast IP address for non-local groups, the controller uses unicast mode to send mobility messages to those members.

Step 6 To verify the mobility configuration, enter this command:

show mobility summary

Step 7 To save your settings, enter this command:

save config

Step 8 Repeat this procedure on every controller to be included in the mobility group. All controllers in the mobility group must be configured with the MAC address and IP address of all other mobility group members.

Step 9 To enable or disable debugging of multicast usage for mobility messages, enter this command:

debug mobility multicast {**enable** | **disable**}

Viewing Mobility Group Statistics

You can view three types of mobility group statistics from the controller GUI:

- Global statistics—Affect all mobility transactions
- Mobility initiator statistics—Generated by the controller initiating a mobility event
- Mobility responder statistics—Generated by the controller responding to a mobility event

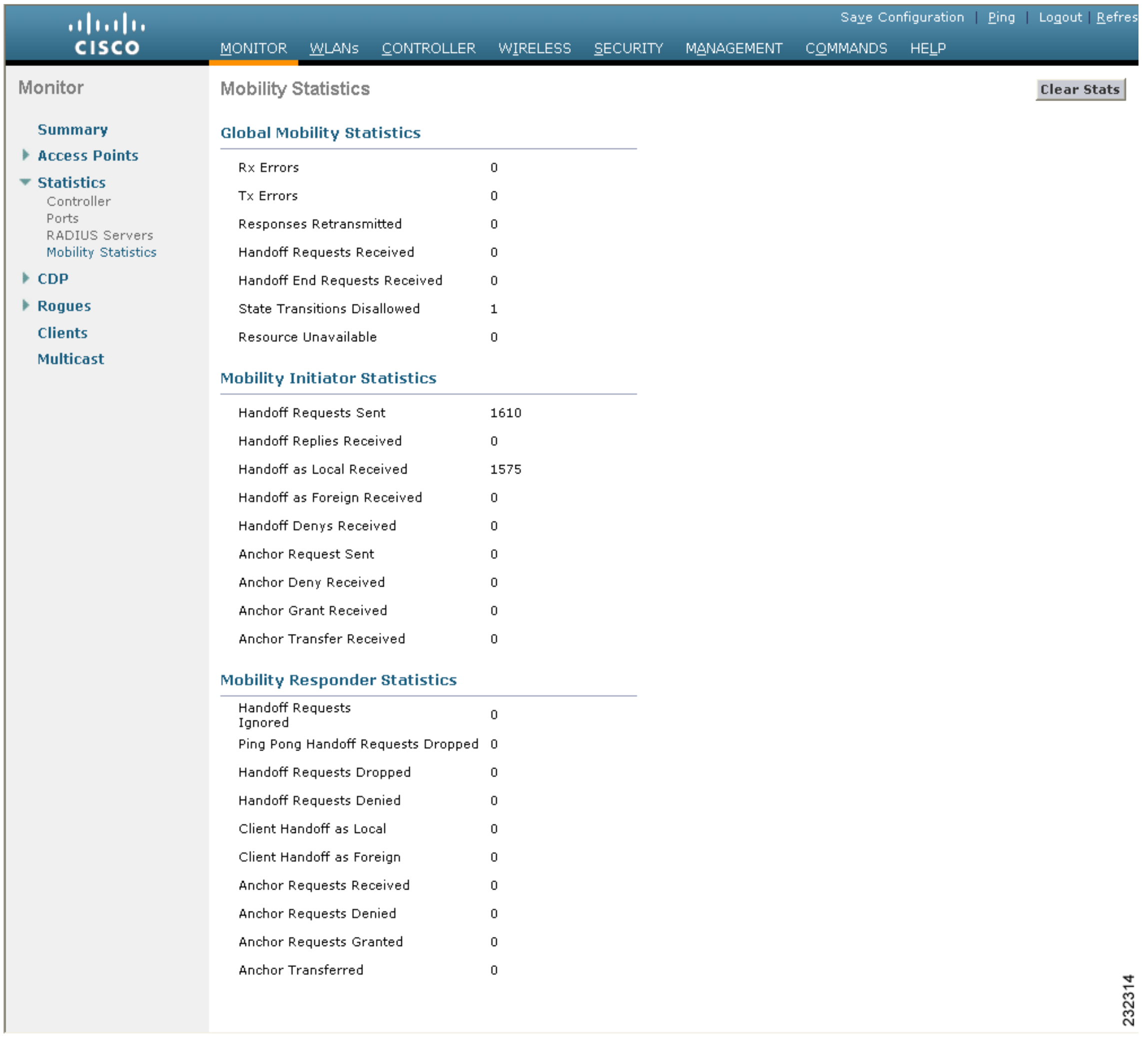
You can view mobility group statistics using the controller GUI or CLI.

Using the GUI to View Mobility Group Statistics

Using the controller GUI, follow these steps to view mobility group statistics.

Step 1 Choose **Monitor** > **Statistics** > **Mobility Statistics** to open the Mobility Statistics page (see Figure 12-13).

Figure 12-13 Mobility Statistics Page



Step 2 Refer to Table 12-1 for a description of each statistic.

Table 12-1 Mobility Statistics

Parameter	Description
Group Mobility Statistics	
Rx Errors	Generic protocol packet receive errors, such as packet too short or format incorrect.
Tx Errors	Generic protocol packet transmit errors, such as packet transmission fail.
Responses Retransmitted	The mobility protocol uses UDP, and it resends requests several times if it does not receive a response. Because of network or processing delays, the responder may receive one or more retry requests after it initially responds to a request. This field shows a count of the response resends.

Table 12-1 Mobility Statistics (continued)

Parameter	Description
Handoff Requests Received	The total number of handoff requests received, ignored, or responded to.
Handoff End Requests Received	The total number of handoff end requests received. These requests are sent by the anchor or foreign controller to notify the other about the close of a client session.
State Transitions Disallowed	The policy enforcement module (PEM) has denied a client state transition, usually resulting in the handoff being aborted.
Resource Unavailable	A necessary resource, such as a buffer, was unavailable, resulting in the handoff being aborted.
Mobility Initiator Statistics	
Handoff Requests Sent	The number of clients that have associated to the controller and have been announced to the mobility group.
Handoff Replies Received	The number of handoff replies that have been received in response to the requests sent.
Handoff as Local Received	The number of handoffs in which the entire client session has been transferred.
Handoff as Foreign Received	The number of handoffs in which the client session was anchored elsewhere.
Handoff Denys Received	The number of handoffs that were denied.
Anchor Request Sent	The number of anchor requests that were sent for a three-party (foreign-to-foreign) handoff. The handoff was received from another foreign controller, and the new controller is requesting the anchor to move the client.
Anchor Deny Received	The number of anchor requests that were denied by the current anchor.
Anchor Grant Received	The number of anchor requests that were approved by the current anchor.
Anchor Transfer Received	The number of anchor requests that closed the session on the current anchor and transferred the anchor back to the requestor.

Table 12-1 Mobility Statistics (continued)

Parameter	Description
Mobility Responder Statistics	
Handoff Requests Ignored	The number of handoff requests or client announcements that were ignored because the controller had no knowledge of that client.
Ping Pong Handoff Requests Dropped	The number of handoff requests that were denied because the handoff period was too short (3 seconds).
Handoff Requests Dropped	The number of handoff requests that were dropped due to either an incomplete knowledge of the client or a problem with the packet.
Handoff Requests Denied	The number of handoff requests that were denied.
Client Handoff as Local	The number of handoff responses sent while the client is in the local role.
Client Handoff as Foreign	The number of handoff responses sent while the client is in the foreign role.
Anchor Requests Received	The number of anchor requests received.
Anchor Requests Denied	The number of anchor requests denied.
Anchor Requests Granted	The number of anchor requests granted.
Anchor Transferred	The number of anchors transferred because the client has moved from a foreign controller to a controller on the same subnet as the current anchor.

Step 3 If you want to clear the current mobility statistics, click **Clear Stats**.

Using the CLI to View Mobility Group Statistics

Using the controller CLI, follow these steps to view mobility group statistics.

Step 1 To view mobility group statistics, enter this command:

show mobility statistics

Step 2 Refer to Table 12-1 for a description of each statistic.

Step 3 If you want to clear the current mobility statistics, enter this command:

clear stats mobility

Configuring Auto-Anchor Mobility

You can use auto-anchor mobility (also called *guest tunneling*) to improve load balancing and security for roaming clients on your wireless LANs. Under normal roaming conditions, client devices join a wireless LAN and are anchored to the first controller that they contact. If a client roams to a different subnet, the controller to which the client roamed sets up a foreign session for the client with the anchor controller. However, using the auto-anchor mobility feature, you can specify a controller or set of controllers as the anchor points for clients on a wireless LAN.

In auto-anchor mobility mode, a subset of a mobility group is specified as the anchor controllers for a WLAN. You can use this feature to restrict a WLAN to a single subnet, regardless of a client's entry point into the network. Clients can then access a guest WLAN throughout an enterprise but still be restricted to a specific subnet. Auto-anchor mobility can also provide geographic load balancing because the WLANs can represent a particular section of a building (such as a lobby, a restaurant, and so on), effectively creating a set of home controllers for a WLAN. Instead of being anchored to the first controller that they happen to contact, mobile clients can be anchored to controllers that control access points in a particular vicinity.

When a client first associates to a controller of a mobility group that has been preconfigured as a mobility anchor for a WLAN, the client associates to the controller locally, and a local session is created for the client. Clients can be anchored only to preconfigured anchor controllers of the WLAN. For a given WLAN, you should configure the same set of anchor controllers on all controllers in the mobility group.

When a client first associates to a controller of a mobility group that has not been configured as a mobility anchor for a WLAN, the client associates to the controller locally, a local session is created for the client, and the client is announced to the other controllers in the mobility list. If the announcement is not answered, the controller contacts one of the anchor controllers configured for the WLAN and creates a foreign session for the client on the local switch. Packets from the client are encapsulated through a mobility tunnel using EtherIP and sent to the anchor controller, where they are decapsulated and delivered to the wired network. Packets to the client are received by the anchor controller and forwarded to the foreign controller through a mobility tunnel using EtherIP. The foreign controller decapsulates the packets and forwards them to the client.

In controller software releases prior to 4.1, there is no automatic way of determining if a particular controller in a mobility group is unreachable. As a result, the foreign controller may continually send all new client requests to a failed anchor controller, and the clients remain connected to this failed controller until a session timeout occurs. In controller software release 4.1 or later, mobility list members can send ping requests to one another to check the data and control paths among them to find failed members and reroute clients. You can configure the number and interval of ping requests sent to each anchor controller. This functionality provides guest N+1 redundancy for guest tunneling and mobility failover for regular mobility.

If multiple Controllers are added as mobility anchors for a particular WLAN on a foreign Controller, the foregin Controller internally sorts the Controllers by their IP address. The Controller with the lowest IP address is the first anchor. For example, a typical ordered list would be 172.16.7.25, 172.16.7.28, 192.168.5.15. If the first client associates to the foreign controller's anchored WLAN, the client database entry is sent to the first anchor Controller in the list, the second client is sent to the second Controller in the list, and so on, until the end of the anchor list is reached. The process is repeated starting with the first anchor Controller. If any of the anchor Controllers is detected to be down, all the clients anchored to the Controller are deauthenticated, and the clients then go through the authentication/anchoring process again in a round-robin manner with the remaining Controllers in the anchor list. This functionality is also extended to regular mobility clients through mobility failover. This feature enables mobility group members to detect failed members and reroute clients.

Note A 2100 series controller cannot be designated as an anchor for a WLAN. However, a WLAN created on a 2100 series controller can have a 4400 series controller as its anchor.

Note The IPSec and L2TP Layer 3 security policies are unavailable for WLANs configured with a mobility anchor.

Guidelines for Using Auto-Anchor Mobility

Keep these guidelines in mind when you configure auto-anchor mobility:

- Controllers must be added to the mobility group member list before you can designate them as mobility anchors for a WLAN.
- You can configure multiple controllers as mobility anchors for a WLAN.
- You must disable the WLAN before configuring mobility anchors for it.
- Auto-anchor mobility supports web authorization but does not support other Layer 3 security types.
- The WLANs on both the foreign controller and the anchor controller must be configured with mobility anchors. On the anchor controller, configure the anchor controller itself as a mobility anchor. On the foreign controller, configure the anchor as a mobility anchor.
- Auto-anchor mobility is not supported for use with DHCP option 82.
- When using the guest N+1 redundancy and mobility failover features with a firewall, make sure that the following ports are open:
  - UDP 16666 for tunnel control traffic
  - IP Protocol 97 for user data traffic
  - UDP 161 and 162 for SNMP

Using the GUI to Configure Auto-Anchor Mobility

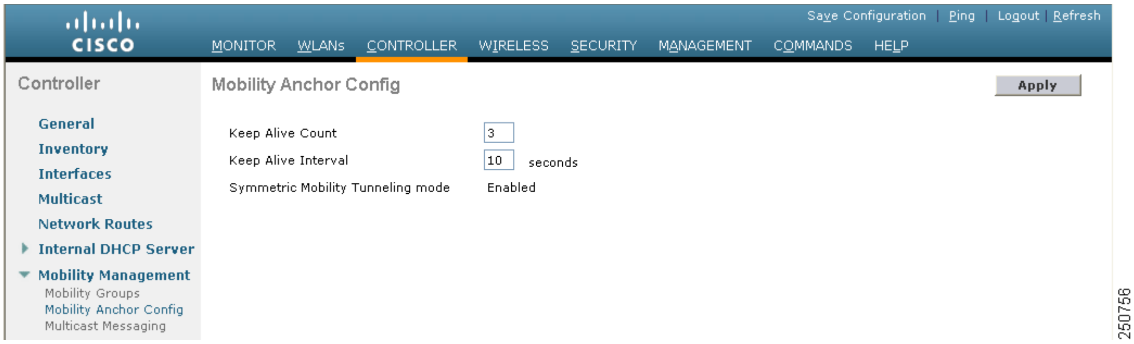
Follow these steps to create a new mobility anchor for a WLAN using the GUI.

Note See the "Using the CLI to Configure Auto-Anchor Mobility" section on page 12-23 if you would prefer to configure auto-anchor mobility using the CLI.

Step 1 Follow these steps to configure the controller to detect failed anchor controllers within a mobility group:

a. Choose **Controller** > **Mobility Management** > **Mobility Anchor Config** to open the Mobility Anchor Config page (see Figure 12-14).

Figure 12-14 Mobility Anchor Config Page



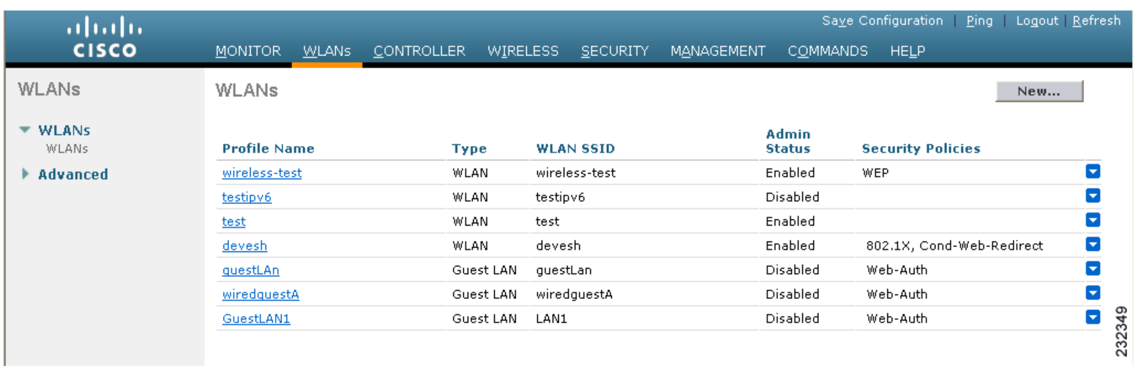
b. In the Keep Alive Count field, enter the number of times a ping request is sent to an anchor controller before the anchor is considered to be unreachable. The valid range is 3 to 20, and the default value is 3.

c. In the Keep Alive Interval field, enter the amount of time (in seconds) between each ping request sent to an anchor controller. The valid range is 1 to 30 seconds, and the default value is 10 seconds.

d. Click **Apply** to commit your changes.

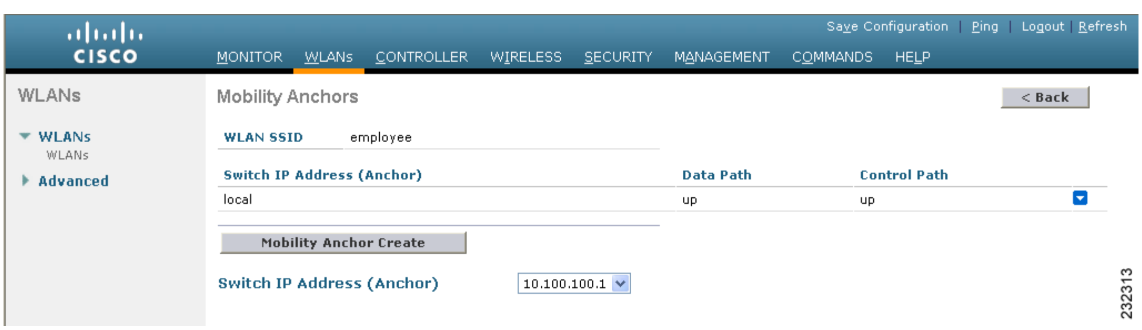
Step 2 Choose **WLANs** to open the WLANs page (see Figure 12-15).

Figure 12-15 WLANs Page



Step 3 Click the blue drop-down arrow for the desired WLAN or wired guest LAN and choose **Mobility Anchors**. The Mobility Anchors page appears (see Figure 12-16).

Figure 12-16 Mobility Anchors Page



This page lists the controllers that have already been configured as mobility anchors and shows the current state of their data and control paths. Controllers within a mobility group communicate among themselves control information over a well-known UDP port and exchange data traffic through an Ethernet-over-IP (EoIP) tunnel. Specifically, they send mpings, which test mobility control packet reachability over the management interface, over mobility UDP port 16666 and epings, which test the mobility data traffic over the management interface, over EoIP port 97. The Control Path field shows whether mpings have passed (up) or failed (down), and the Data Path field shows whether epings have passed (up) or failed (down). If the Data or Control Path field shows "down," the mobility anchor cannot be reached and is considered failed.

Step 4 Select the IP address of the controller to be designated a mobility anchor in the Switch IP Address (Anchor) drop-down box.

Step 5 Click **Mobility Anchor Create**. The selected controller becomes an anchor for this WLAN or wired guest LAN.

Note To delete a mobility anchor for a WLAN or wired guest LAN, hover your cursor over the blue drop-down arrow for the anchor and choose **Remove**.

Step 6 Click **Save Configuration** to save your changes.

Step 7 Repeat Step 4 and Step 6 to set any other controllers as mobility anchors for this WLAN or wired guest LAN.

Step 8 Configure the same set of mobility anchors on every controller in the mobility group.

Using the CLI to Configure Auto-Anchor Mobility

Use these commands to configure auto-anchor mobility using the CLI.

Note Refer to the "Using the GUI to Configure Auto-Anchor Mobility" section on page 12-21 for the valid ranges and default values of the parameters used in the CLI commands.

1. The controller is programmed to always detect failed mobility list members. To change the parameters for the ping exchange between mobility members, enter these commands:
   - **config mobility group keepalive count** *count*—Specifies the number of times a ping request is sent to a mobility list member before the member is considered to be unreachable. The valid range is 3 to 20, and the default value is 3.
   - **config mobility group keepalive interval** *seconds*—Specifies the amount of time (in seconds) between each ping request sent to a mobility list member. The valid range is 1 to 30 seconds, and the default value is 10 seconds.
2. Enter **config {wlan | guest-lan} disable** {*wlan_id* | *guest_lan_id*} to disable the WLAN or wired guest LAN for which you are configuring mobility anchors.

3. To create a new mobility anchor for the WLAN or wired guest LAN, enter one of these commands:
   - **config mobility group anchor add {wlan | guest-lan}** {*wlan_id* | *guest_lan_id*} *anchor_controller_ip_address*
   - **config {wlan | guest-lan} mobility anchor add** {*wlan_id* | *guest_lan_id*} *anchor_controller_ip_address*

   Note The *wlan_id* or *guest_lan_id* must exist and be disabled, and the *anchor_controller_ip_address* must be a member of the default mobility group.

   Note Auto-anchor mobility is enabled for the WLAN or wired guest LAN when you configure the first mobility anchor.

4. To delete a mobility anchor for the WLAN or wired guest LAN, enter one of these commands:
   - **config mobility group anchor delete {wlan | guest-lan}** {*wlan_id* | *guest_lan_id*} *anchor_controller_ip_address*
   - **config {wlan | guest-lan} mobility anchor delete** {*wlan_id* | *guest_lan_id*} *anchor_controller_ip_address*

   Note The *wlan_id* or *guest_lan_id* must exist and be disabled.

   Note Deleting the last anchor disables the auto-anchor mobility feature and resumes normal mobility for new associations.

5. To save your settings, enter this command:

   save config

6. To see a list and status of controllers configured as mobility anchors for a specific WLAN or wired guest LAN, enter this command:

   show mobility anchor {**wlan** | **guest-lan**} {*wlan_id* | *guest_lan_id*}

   Note The *wlan_id* and *guest_lan_id* parameters are optional and constrain the list to the anchors in a particular WLAN or guest LAN. To see all of the mobility anchors on your system, enter **show mobility anchor**.

   For example, information similar to the following appears for the **show mobility anchor** command:

```
Mobility Anchor Export List
WLAN ID     IP Address      Status
    1       10.50.234.2     UP
    1       10.50.234.6     UP
    2       10.50.234.2     UP
    2       10.50.234.3     CNTRL_DATA_PATH_DOWN

GLAN ID     IP Address      Status
    1       10.20.100.2     UP
    2       10.20.100.3     UP
```

The Status field shows one of these values:

- UP—The controller is reachable and able to pass data.
- CNTRL_PATH_DOWN—The mpings failed. The controller cannot be reached through the control path and is considered failed.
- DATA_PATH_DOWN—The epings failed. The controller cannot be reached and is considered failed.
- CNTRL_DATA_PATH_DOWN—Both the mpings and epings failed. The controller cannot be reached and is considered failed.

7. To see the status of all mobility group members, enter this command:

   show mobility summary

   Information similar to the following appears:

```
Mobility Keepalive interval...................... 10
Mobility Keepalive count......................... 3
Mobility Group members configured................ 3

Controllers configured in the mobility group
MAC Address        IP Address     Group Name     Status
00:0b:85:32:b1:80  10.10.1.1      local          Up
00:0b:85:33:a1:70  10.1.1.2       local          Data Path Down
00:0b:85:23:b2:30  10.20.1.2      local          Up
```

8. To troubleshoot mobility issues, enter these commands:

   - **debug mobility handoff** {**enable** | **disable**}—Debugs mobility handoff issues.
   - **debug mobility keep-alive** {**enable** | **disable**} **all**—Dumps the keepalive packets for all mobility anchors.
   - **debug mobility keep-alive** {**enable** | **disable**} *IP_address*—Dumps the keepalive packets for a specific mobility anchor.

WLAN Mobility Security Values

For any anchoring or mobility event, the WLAN security policy values on each controller must match. These values can be validated in the controller debugs. Table 12-2 lists the WLAN mobility security values and their corresponding security policy.

Table 12-2 WLAN Mobility Security Values

Security Hexadecimal Value	Security Policy
0x00000000	Security_None
0x00000001	Security_WEP
0x00000002	Security_802_1X
0x00000004	Security_IPSec*
0x00000008	Security_IPSec_Passthrough*
0x00000010	Security_Web
0x00000020	Security_PPTP*
0x00000040	Security_DHCP_Required

Table 12-2 WLAN Mobility Security Values (continued)

Security Hexadecimal Value	Security Policy
0x00000080	Security_WPA_NotUsed
0x00000100	Security_Cranite_Passthrough*
0x00000200	Security_Fortress_Passthrough*
0x00000400	Security_L2TP_IPSec*
0x00000800	Security_802_11i_NotUsed*
0x00001000	Security_Web_Passthrough

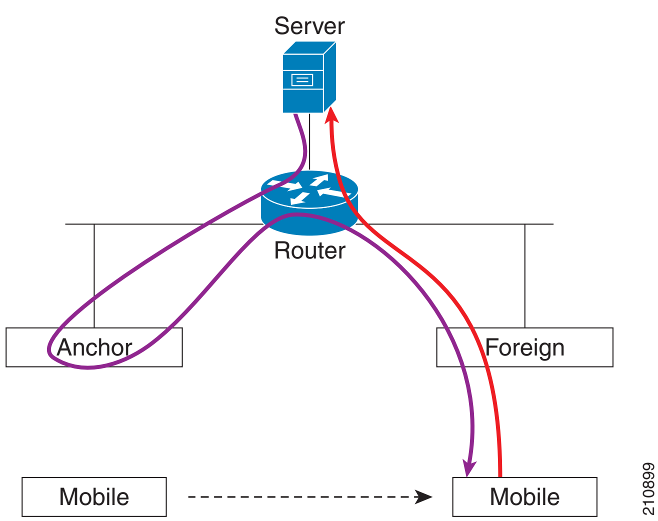
*Controllers running software release 6.0 do not support this security policy.

Using Symmetric Mobility Tunneling

Controller software releases 4.1 through 5.1 support both asymmetric and symmetric mobility tunneling. Controller software release 5.2 or later supports only symmetric mobility tunneling, which is now always enabled by default.

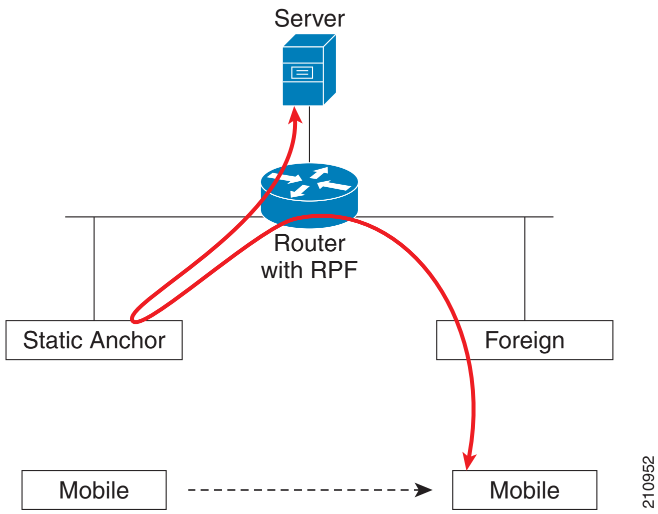
In asymmetric tunneling, client traffic to the wired network is routed directly through the foreign controller, as shown in Figure 12-17.

Figure 12-17 Asymmetric Tunneling or Uni-Directional Tunneling



Asymmetric tunneling breaks when an upstream router has reverse path filtering (RPF) enabled. In this case, the client traffic is dropped at the router because the RPF check ensures that the path back to the source address matches the path from which the packet is coming. When symmetric mobility tunneling is enabled, all client traffic is sent to the anchor controller and can then successfully pass the RPF check, as shown in Figure 12-18.

Figure 12-18 Symmetric Mobility Tunneling or Bi-Directional Tunneling



Symmetric mobility tunneling is also useful in the following situations:

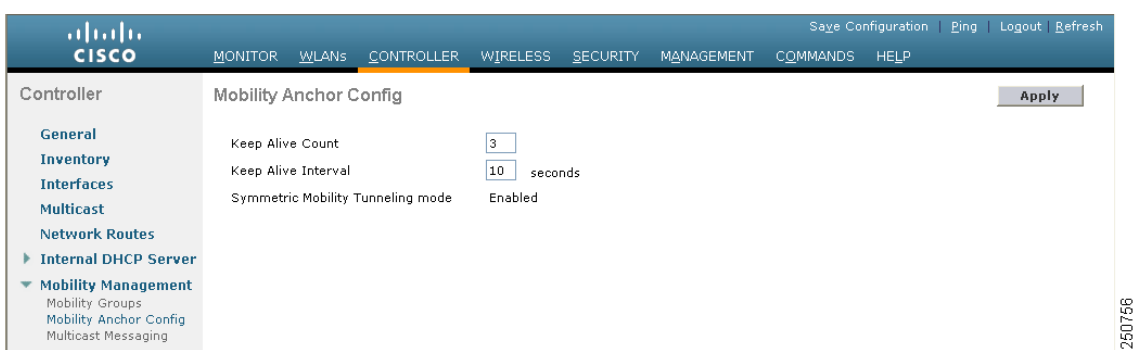
- If a firewall installation in the client packet path drops packets because the source IP address does not match the subnet on which the packets are received.
- If the access-point group VLAN on the anchor controller is different than the WLAN interface VLAN on the foreign controller. In this case, client traffic could be sent on an incorrect VLAN during mobility events.

> **Note** Although a 2100 series controller cannot be designated as an anchor for a WLAN when you are using auto-anchor mobility, it can serve as an anchor in symmetric mobility tunneling to process and forward the upstream client data traffic tunneled from the foreign controller.

Both the controller GUI and CLI show that symmetric mobility tunneling is enabled on the controller:

- To use the controller GUI to verify that symmetric mobility tunneling is enabled, choose **Controller** > **Mobility Management** > **Mobility Anchor Config** to open the Mobility Anchor Config page (see Figure 12-19). The Symmetric Mobility Tunneling Mode field shows Enabled.

Figure 12-19 Mobility Anchor Config Page



- To use the controller CLI to verify that symmetric mobility tunneling is enabled, enter this command:

  show mobility summary

  Information similar to the following appears:

```
Symmetric Mobility Tunneling (current) .......... Enabled
Symmetric Mobility Tunneling (after reboot) ..... Enabled
Mobility Protocol Port........................... 16666
Mobility Security Mode........................... Disabled
Default Mobility Domain.......................... User1
Mobility Keepalive interval...................... 10
Mobility Keepalive count......................... 3
Mobility Group members configured................ 7

Controllers configured in the Mobility Group
MAC Address         IP Address    Group Name      Status
00:0b:85:32:b0:80    10.28.8.30       User1        Up
00:0b:85:47:f6:00    10.28.16.10      User1        Up
00:16:9d:ca:d8:e0    10.28.32.10      User1        Up
00:18:73:34:a9:60    10.28.24.10      <local>      Up
00:18:73:36:55:00    10.28.8.10       User1        Up
00:1a:a1:c1:7c:e0    10.28.32.30      User1        Up
00:d0:2b:fc:90:20   10.28.32.61     User1         Control and Data Path Down
```

Running Mobility Ping Tests

Controllers in a mobility list communicate with each other by controlling information over a well-known UDP port and exchanging data traffic through an Ethernet-over-IP (EoIP) tunnel. Because UDP and EoIP are not reliable transport mechanisms, there is no guarantee that a mobility control packet or data packet will be delivered to a mobility peer. Mobility packets may be lost in transit due to a firewall filtering the UDP port or EoIP packets or due to routing issues.

Controller software release 4.0 or later enables you to test the mobility communication environment by performing mobility ping tests. These tests may be used to validate connectivity between members of a mobility group (including guest controllers). Two ping tests are available:

- **Mobility ping over UDP**—This test runs over mobility UDP port 16666. It tests whether the mobility control packet can be reached over the management interface.
- **Mobility ping over EoIP**—This test runs over EoIP. It tests the mobility data traffic over the management interface.

Only one mobility ping test per controller can be run at a given time.

> **Note** These ping tests are not Internet Control Message Protocol (ICMP) based. The term “ping” is used to indicate an echo request and an echo reply message.

Use these commands to run mobility ping tests using the controller CLI.

1. To test the mobility UDP control packet communication between two controllers, enter this command:

   mping *mobility_peer_IP_address*

   The *mobility_peer_IP_address* parameter must be the IP address of a controller that belongs to the mobility list.

2. To test the mobility EoIP data packet communication between two controllers, enter this command:

   eping *mobility_peer_IP_address*

   The *mobility_peer_IP_address* parameter must be the IP address of a controller that belongs to the mobility list.

3. To troubleshoot your controller for mobility ping, enter these commands:

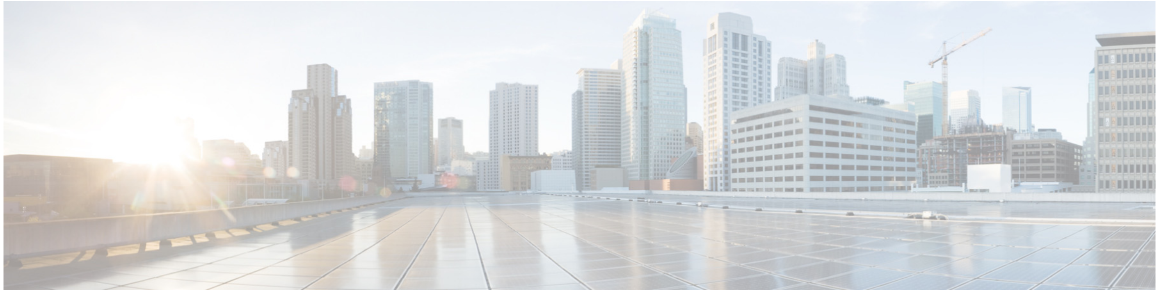
   config logging buffered debugging

   show logging

   To troubleshoot your controller for mobility ping over UDP, enter this command to display the mobility control packet:

   debug mobility handoff enable

   Note Cisco recommends using an ethereal trace capture when troubleshooting.



13

Configuring Hybrid REAP

This chapter describes hybrid REAP and explains how to configure this feature on controllers and access points. It contains these sections:

Americas Headquarters:
Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA

Overview of Hybrid REAP

Hybrid REAP is a wireless solution for branch office and remote office deployments. It enables customers to configure and control access points in a branch or remote office from the corporate office through a wide area network (WAN) link without deploying a controller in each office. The hybrid-REAP access points can switch client data traffic locally and perform client authentication locally when their connection to the controller is lost. When they are connected to the controller, they can also send traffic back to the controller.

Hybrid REAP is supported only on the 1130, 1140, 1240, 1250, and AP801 access points and on the 5500, 4400, and 2100 series controllers; the Catalyst 3750G Integrated Wireless LAN Controller Switch; the Cisco WiSM; and the Controller Network Module for Integrated Services Routers. Figure 1 illustrates a typical hybrid-REAP deployment.

Figure 1 Hybrid REAP Deployment

There is no deployment restriction on the number of hybrid-REAP access points per location. However, the minimum bandwidth restriction remains 128 kbps with the roundtrip latency no greater than 300 ms and the maximum transmission unit (MTU) no smaller than 500 bytes.

Hybrid-REAP Authentication Process

When a hybrid-REAP access point boots up, it looks for a controller. If it finds one, it joins the controller, downloads the latest software image and configuration from the controller, and initializes the radio. It saves the downloaded configuration in non-volatile memory for use in standalone mode.

A hybrid-REAP access point can learn the controller IP address in one of these ways:

- If the access point has been assigned an IP address from a DHCP server, it can discover a controller through the regular CAPWAP or LWAPP discovery process [Layer 3 broadcast, over-the-air provisioning (OTAP), DNS, or DHCP option 43].

Note OTAP does not work on the first boot out of the box. Refer to "The Controller Discovery Process" section on page 7 for more information.

- If the access point has been assigned a static IP address, it can discover a controller through any of the discovery process methods except DHCP option 43. If the access point cannot discover a controller through Layer 3 broadcast or OTAP, Cisco recommends DNS resolution. With DNS, any access point with a static IP address that knows of a DNS server can find at least one controller.
- If you want the access point to discover a controller from a remote network where CAPWAP or LWAPP discovery mechanisms are not available, you can use priming. This method enables you to specify (through the access point CLI) the controller to which the access point is to connect.

Note Refer to Chapter 7, "Controlling Lightweight Access Points" or the controller deployment guide at this URL for more information on how access points find controllers:

http://www.cisco.com/c/en/us/td/docs/wireless/technology/controller/deployment/guide/dep.html

When a hybrid-REAP access point can reach the controller (referred to as *connected mode*), the controller assists in client authentication. When a hybrid-REAP access point cannot access the controller, the access point enters standalone mode and authenticates clients by itself.

Note The LEDs on the access point change as the device enters different hybrid-REAP modes. Refer to the hardware installation guide for your access point for information on LED patterns.

When a client associates to a hybrid-REAP access point, the access point sends all authentication messages to the controller and either switches the client data packets locally (locally switched) or sends them to the controller (centrally switched), depending on the WLAN configuration. With respect to client authentication (open, shared, EAP, web authentication, and NAC) and data packets, the WLAN can be in any one of the following states depending on the configuration and state of controller connectivity:

- **central authentication, central switching**—In this state, the controller handles client authentication, and all client data is tunneled back to the controller. This state is valid only in connected mode.
- **central authentication, local switching**—In this state, the controller handles client authentication, and the hybrid-REAP access point switches data packets locally. After the client authenticates successfully, the controller sends a configuration command with a new payload to instruct the hybrid-REAP access point to start switching data packets locally. This message is sent per client. This state is applicable only in connected mode.
- **local authentication, local switching**—In this state, the hybrid-REAP access point handles client authentication and switches client data packets locally. This state is valid only in standalone mode.

  Note External webauth is not supported when using hybrid-REAP with local switching enabled on the WLAN.

- **authentication down, switching down**—In this state, the WLAN disassociates existing clients and stops sending beacon and probe responses. This state is valid only in standalone mode.
- **authentication down, local switching**—In this state, the WLAN rejects any new clients trying to authenticate, but it continues sending beacon and probe responses to keep existing clients alive. This state is valid only in standalone mode.

When a hybrid-REAP access point enters standalone mode, WLANs that are configured for open, shared, WPA-PSK, or WPA2-PSK authentication enter the "local authentication, local switching" state and continue new client authentications. In controller software release 4.2 or later, this is also true for WLANs that are configured for 802.1X, WPA-802.1X, WPA2-802.1X, or CCKM, but these authentication types require that an external RADIUS server be configured. Other WLANs enter either the "authentication down, switching down" state (if the WLAN was configured for central switching) or the "authentication down, local switching" state (if the WLAN was configured for local switching).

When hybrid-REAP access points are connected to the controller (rather than in standalone mode), the controller uses its primary RADIUS servers and accesses them in the order specified on the RADIUS Authentication Servers page or in the **config radius auth add** CLI command (unless the server order is overridden for a particular WLAN). However, in order to support 802.1X EAP authentication, hybrid-REAP access points in standalone mode need to have their own backup RADIUS server to authenticate clients. This backup RADIUS server may or may not be the one used by the controller. You can configure a backup RADIUS server for individual hybrid-REAP access points in standalone mode by using the controller CLI or for groups of hybrid-REAP access points in standalone mode by using either the GUI or CLI. A backup server configured for an individual access point overrides the backup RADIUS server configuration for a hybrid-REAP group.

When a hybrid-REAP access point enters standalone mode, it disassociates all clients that are on centrally switched WLANs. For web-authentication WLANs, existing clients are not disassociated, but the hybrid-REAP access point stops sending beacons when the number of associated clients reaches zero (0). It also sends disassociation messages to new clients associating to web-authentication WLANs. Controller-dependent activities such as network access control (NAC) and web authentication (guest access) are disabled, and the access point does not send any intrusion detection system (IDS) reports to the controller. Furthermore, most radio resource management (RRM) features (such as neighbor discovery; noise, interference, load, and coverage measurements; use of the neighbor list; and rogue containment and detection) are disabled. However, a hybrid-REAP access point supports dynamic frequency selection in standalone mode.

Note If your controller is configured for NAC, clients can associate only when the access point is in connected mode. When NAC is enabled, you need to create an unhealthy (or quarantined) VLAN so that the data traffic of any client that is assigned to this VLAN passes through the controller, even if the WLAN is configured for local switching. After a client is assigned to a quarantined VLAN, all of its data packets are centrally switched. See the "Configuring Dynamic Interfaces" section on page 18 for information on creating quarantined VLANs and the "Configuring NAC Out-of-Band Integration" section on page 66 for information on configuring NAC out-of-band support.

The hybrid-REAP access point maintains client connectivity even after entering standalone mode. However, once the access point re-establishes a connection with the controller, it disassociates all clients, applies new configuration information from the controller, and reallows client connectivity.

Hybrid REAP Guidelines

Keep these guidelines in mind when using hybrid REAP:

- A hybrid-REAP access point can be deployed with either a static IP address or a DHCP address. In the case of DHCP, a DHCP server must be available locally and must be able to provide the IP address for the access point at bootup.
- Hybrid REAP supports up to four fragmented packets or a minimum 500-byte maximum transmission unit (MTU) WAN link.

- Roundtrip latency must not exceed 300 milliseconds (ms) between the access point and the controller, and CAPWAP control packets must be prioritized over all other traffic.
- The controller can send multicast packets in the form of unicast or multicast packets to the access point. In hybrid-REAP mode, the access point can receive multicast packets only in unicast form.
- To use CCKM fast roaming with hybrid-REAP access points, you need to configure hybrid-REAP groups. See the "Configuring Hybrid-REAP Groups" section on page 16 for more information.
- Hybrid-REAP access points support a 1-1 network address translation (NAT) configuration. They also support port address translation (PAT) for all features except true multicast. Multicast is supported across NAT boundaries when configured using the Unicast option. Hybrid-REAP access points also support a many-to-one NAT/PAT boundary, except when you want true multicast to operate for all centrally switched WLANs.

Note Although NAT and PAT are supported for hybrid-REAP access points, they are not supported on the corresponding controller. Cisco does not support configurations in which the controller is behind a NAT/PAT boundary.

- VPN and PPTP are supported for locally switched traffic, provided that these security types are accessible locally at the access point.
- Hybrid-REAP access points support multiple SSIDs. Refer to the "Using the CLI to Create WLANs" section on page 6 for more information.
- NAC out-of-band integration is supported only on WLANs configured for hybrid-REAP central switching. It is not supported for use on WLANs configured for hybrid-REAP local switching. Refer to the "Configuring NAC Out-of-Band Integration" section on page 66 for more information.
- The primary and secondary controllers for a hybrid-REAP access point must have the same configuration. Otherwise, the access point might lose its configuration, and certain features (such as WLAN override, AP group VLANs, static channel number, and so on) might not operate correctly. In addition, make sure to duplicate the SSID of the hybrid-REAP access point and its index number on both controllers.
- QoS per-user bandwidth contracts are not supported for H-REAP locally switched WLANs. QoS per-user bandwidth contracts are only supported for centrally switched WLANs.

Configuring Hybrid REAP

To configure hybrid REAP, you must follow the instructions in these sections in the order provided:

- Configuring the Switch at the Remote Site, page 5
- Configuring the Controller for Hybrid REAP, page 6
- Configuring an Access Point for Hybrid REAP, page 11
- Connecting Client Devices to the WLANs, page 15

Configuring the Switch at the Remote Site

Follow these steps to prepare the switch at the remote site.

Step 1 Attach the access point that will be enabled for hybrid REAP to a trunk or access port on the switch.

Note The sample configuration below shows the hybrid-REAP access point connected to a trunk port on the switch.

Step 2 Refer to the sample configuration below to configure the switch to support the hybrid-REAP access point.

In this sample configuration, the hybrid-REAP access point is connected to trunk interface FastEthernet 1/0/2 with native VLAN 100. The access point needs IP connectivity on the native VLAN. The remote site has local servers/resources on VLAN 101. A DHCP pool in created in the local switch for both VLANs in the switch. The first DHCP pool (NATIVE) will be used by the hybrid-REAP access point, and the second DHCP pool (LOCAL-SWITCH) will be used by the clients when they associate to a WLAN that is locally switched. The bolded text in the sample configuration illustrates these settings.

Note The addresses in this sample configuration are for illustration purposes only. The addresses that you use must fit into your upstream network.

Sample local switch configuration:

```
ip dhcp pool NATIVE
   network 10.10.100.0 255.255.255.0
   default-router 10.10.100.1
!
ip dhcp pool LOCAL-SWITCH
   network 10.10.101.0 255.255.255.0
   default-router 10.10.101.1
!
interface FastEthernet1/0/1
 description Uplink port
 no switchport
 ip address 10.10.98.2 255.255.255.0
 spanning-tree portfast
!
interface FastEthernet1/0/2
 description the Access Point port
 switchport trunk encapsulation dot1q
 switchport trunk native vlan 100
 switchport trunk allowed vlan 100,101
 switchport mode trunk
 spanning-tree portfast
!
interface Vlan100
 ip address 10.10.100.1 255.255.255.0
 ip helper-address 10.10.100.1
!
interface Vlan101
 ip address 10.10.101.1 255.255.255.0
 ip helper-address 10.10.101.1
end
```

Configuring the Controller for Hybrid REAP

This section provides instructions for configuring the controller for hybrid REAP using either the GUI or the CLI.

Using the GUI to Configure the Controller for Hybrid REAP

The controller configuration for hybrid REAP consists of creating centrally switched and locally switched WLANs. Follow the steps in this section to use the GUI to configure the controller for these WLANs. This procedure uses these three WLANs as examples:

WLAN	Security	Switching	Interface Mapping (VLAN)
employee	WPA1+WPA2	Central	management (centrally switched VLAN)
employee-local	WPA1+WPA2 (PSK)	Local	101 (locally switched VLAN)
guest-central	Web authentication	Central	management (centrally switched VLAN)

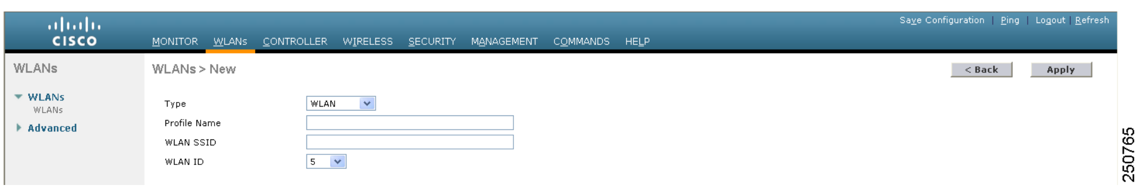
Note See the "Using the CLI to Configure the Controller for Hybrid REAP" section on page 11 if you would prefer to configure the controller for hybrid REAP using the CLI.

Step 1 Follow these steps to create a centrally switched WLAN. In our example, this is the first WLAN (employee).

a. Choose **WLANs** to open the WLANs page.

b. Choose **Create New** from the drop-down box and click **Go** to open the WLANs > New page (see Figure 2).

Figure 2 WLANs > New Page



c. From the Type drop-down box, choose **WLAN**.

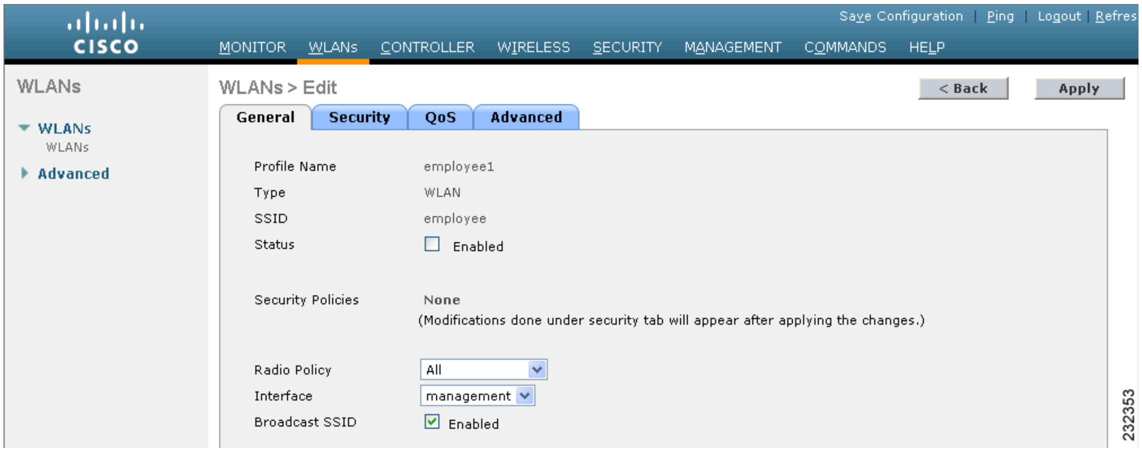
d. Enter a unique profile name for the WLAN in the Profile Name field.

e. Enter a name for the WLAN in the WLAN SSID field.

f. From the WLAN ID drop-down box, choose the ID number for this WLAN.

g. Click **Apply** to commit your changes. The WLANs > Edit page appears (see Figure 3).

Figure 3 WLANs > Edit Page



h. Modify the configuration parameters for this WLAN using the various WLANs > Edit tabs. In our employee WLAN example, you would need to choose **WPA+WPA2** for Layer 2 Security from the Security > Layer 2 tabs and then set the WPA+WPA2 parameters.

Note Be sure to enable this WLAN by checking the **Status** check box on the General tab.

Note If NAC is enabled and you created a quarantined VLAN and want to use it for this WLAN, be sure to select it from the Interface drop-down box on the General tab.

i. Click **Apply** to commit your changes.

j. Click **Save Configuration** to save your changes.

Step 2 Follow these steps to create a locally switched WLAN. In our example, this is the second WLAN (employee-local).

a. Follow the substeps in Step 1 to create a new WLAN. In our example, this WLAN is named “employee-local.”

b. When the WLANs > Edit page appears, modify the configuration parameters for this WLAN. In our employee WLAN example, you would need to choose **WPA+WPA2** for Layer 2 Security from the Security > Layer 2 tabs and then set the WPA+WPA2 parameters.

Note Be sure to enable this WLAN by checking the **Status** check box on the General tab. Also, be sure to enable local switching by checking the **H-REAP Local Switching** check box on the Advanced tab. When you enable local switching, any hybrid-REAP access point that advertises this WLAN is able to locally switch data packets (instead of tunneling them to the controller).

Note When you enable hybrid-REAP local switching, the **Learn Client IP Address** check box is enabled by default. However, if the client is configured with Fortress Layer 2 encryption, the controller cannot learn the client IP address, and the controller periodically drops the client. Disable this option so that the controller maintains the client connection without waiting to learn the client IP address. The ability to disable this option is supported only with hybrid-REAP local switching; it is not supported with hybrid-REAP central switching.

Note For hybrid-REAP access points, the interface mapping at the controller for WLANs configured for H-REAP Local Switching is inherited at the access point as the default VLAN tagging. This can be easily changed per SSID, per hybrid-REAP access point. Non-hybrid-REAP access points tunnel all traffic back to the controller, and VLAN tagging is dictated by each WLAN's interface mapping.

c. Click **Apply** to commit your changes.

d. Click **Save Configuration** to save your changes.

Step 3 Follow these steps if you also want to create a centrally switched WLAN that is used for guest access. In our example, this is the third WLAN (guest-central). You might want to tunnel guest traffic to the controller so you can exercise your corporate data policies for unprotected guest traffic from a central site.

Note The *Managing User Accounts* chapter provides additional information on creating guest user accounts.

a. Follow the substeps in Step 1 to create a new WLAN. In our example, this WLAN is named "guest-central."

b. When the WLANs > Edit page appears, modify the configuration parameters for this WLAN. In our employee WLAN example, you would need to choose **None** for both Layer 2 Security and Layer 3 Security on the Security > Layer 2 and Security > Layer 3 tabs and check the **Web Policy** check box and make sure **Authentication** is selected on the Layer 3 tab.

Note If you are using an external web server, you must configure a preauthentication access control list (ACL) on the WLAN for the server and then choose this ACL as the WLAN preauthentication ACL on the Layer 3 tab. See the *Configuring Security Solutions* chapter for more information on ACLs.

Note Make sure to enable this WLAN by checking the **Status** check box on the General tab.

c. Click **Apply** to commit your changes.

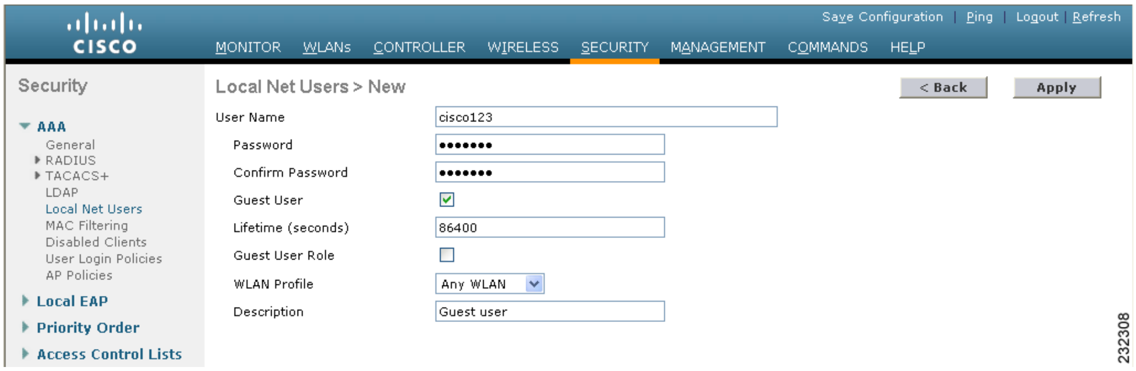
d. Click **Save Configuration** to save your changes.

e. If you want to customize the content and appearance of the login page that guest users will see the first time they access this WLAN, follow the instructions in the *Configuring Security Solutions* chapter.

f. To add a local user to this WLAN, choose **Security** > **AAA** > **Local Net Users**.

g. When the Local Net Users page appears, click **New**. The Local Net Users > New page appears (see Figure 4).

Figure 4 Local Net Users > New Page



h. In the User Name and Password fields, enter a username and password for the local user.

i. In the Confirm Password field, re-enter the password.

j. Check the **Guest User** check box to enable this local user account.

k. In the Lifetime field, enter the amount of time (in seconds) for this user account to remain active.

l. If you are adding a new user, you checked the Guest User check box, and you want to assign a QoS role to this guest user, check the **Guest User Role** check box. The default setting is unchecked.

Note If you do not assign a QoS role to a guest user, the bandwidth contracts for this user are defined in the QoS profile for the WLAN.

m. If you are adding a new user and you checked the Guest User Role check box, choose the QoS role that you want to assign to this guest user from the Role drop-down box. If you want to create a new QoS role, see the "Configuring Quality of Service Roles" section on page 70 for instructions.

n. From the WLAN Profile drop-down box, choose the name of the WLAN that is to be accessed by the local user. If you choose **Any WLAN**, which is the default setting, the user can access any of the configured WLANs.

o. In the Description field, enter a descriptive title for the local user (such as "Guest user").

p. Click **Apply** to commit your changes.

q. Click **Save Configuration** to save your changes.

Step 4 Go to the "Configuring an Access Point for Hybrid REAP" section on page 11 to configure up to six access points for hybrid REAP.

Using the CLI to Configure the Controller for Hybrid REAP

Use these commands to configure the controller for hybrid REAP:

- **config wlan h-reap local-switching** *wlan_id* **enable**—Configures the WLAN for local switching.

  Note When you enable hybrid-REAP local switching, the controller waits to learn the client IP address by default. However, if the client is configured with Fortress Layer 2 encryption, the controller cannot learn the client IP address, and the controller periodically drops the client. Use this command to disable the client IP address learning feature so that the controller maintains the client connection without waiting to learn the client IP address: **config wlan h-reap learn-ipaddr** *wlan_id* **disable**. The ability to disable this feature is supported only with hybrid-REAP local switching; it is not supported with hybrid-REAP central switching. If you later want to re-enable this feature, enter this command: **config wlan h-reap learn-ipaddr** *wlan_id* **enable**.

- **config wlan h-reap local-switching** *wlan_id* **disable**—Configures the WLAN for central switching. This is the default value.

Note Go to the "Configuring an Access Point for Hybrid REAP" section on page 11 to configure up to six access points for hybrid REAP.

Use these commands to obtain hybrid-REAP information:

- **show ap config general** *Cisco_AP*—Shows VLAN configurations.
- **show wlan wlan_id**—Shows whether the WLAN is locally or centrally switched.
- **show client detail** *client_mac*—Shows whether the client is locally or centrally switched.

Use these commands to obtain debug information:

- **debug hreap aaa** {**event** | **error**} {**enable** | **disable**}—Enables or disables debugging of hybrid-REAP backup RADIUS server events or errors.
- **debug hreap cckm** {**enable** | **disable**}—Enables or disables debugging of hybrid-REAP CCKM.
- **debug hreap group** {**enable** | **disable**}—Enables or disables debugging of hybrid-REAP groups.
- **debug pem state** {**enable** | **disable**}—Enables or disables debugging of the policy manager state machine.
- **debug pem events** {**enable** | **disable**}—Enables or disables debugging of policy manager events.

Configuring an Access Point for Hybrid REAP

This section provides instructions for configuring an access point for hybrid REAP using either the controller GUI or CLI.

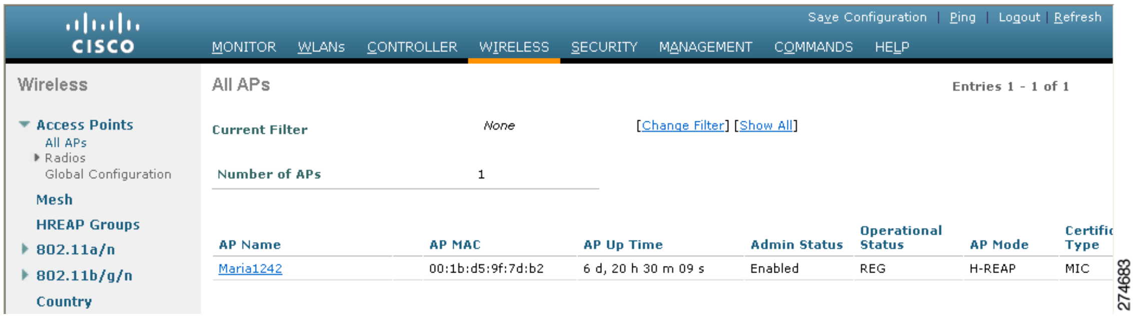
Using the GUI to Configure an Access Point for Hybrid REAP

Follow these steps to configure an access point for hybrid REAP using the controller GUI.

Step 1 Make sure that the access point has been physically added to your network.

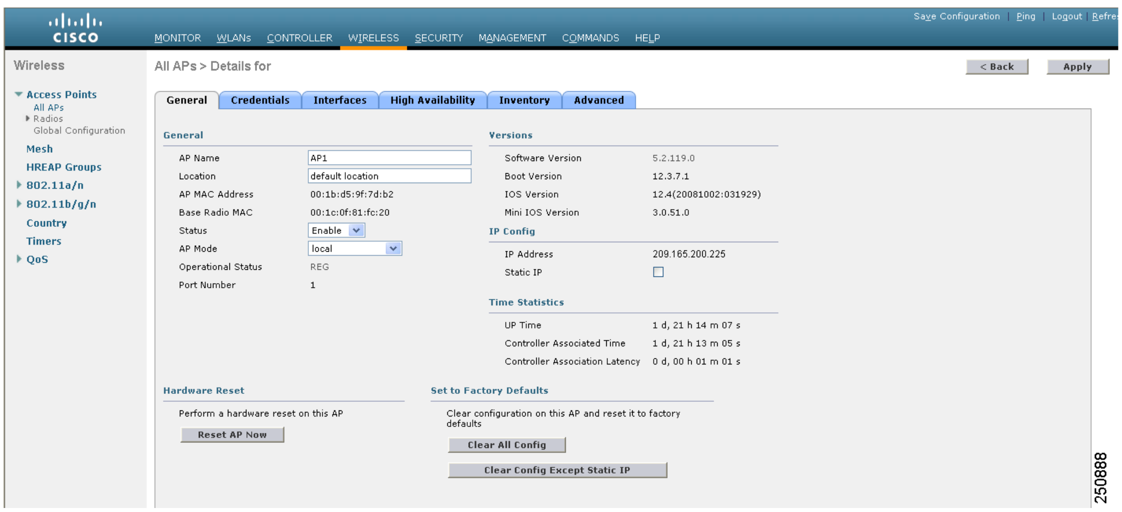
Step 2 Choose **Wireless** to open the All APs page (see Figure 5).

Figure 5 All APs Page



Step 3 Click the name of the desired access point. The All APs > Details (General) page appears (see Figure 6).

Figure 6 All APs > Details for (General) Page



Step 4 Choose **H-REAP** from the AP Mode drop-down box to enable hybrid REAP for this access point.

Note The last parameter on the Inventory tab indicates whether this access point can be configured for hybrid REAP. Only the 1130, 1140, 1240, and 1250 access points support hybrid REAP.

Step 5 Click **Apply** to commit your changes and to cause the access point to reboot.

Step 6 Choose the **H-REAP** tab to open the All APs > Details for (H-REAP) page (see Figure 7).

Figure 7 All APs > Details for (H-REAP) Page

If the access point belongs to a hybrid-REAP group, the name of the group appears in the HREAP Group Name field.

Step 7 Check the **VLAN Support** check box and enter the number of the native VLAN on the remote network (such as 100) in the **Native VLAN ID** field.

Note By default, a VLAN is not enabled on the hybrid-REAP access point. Once hybrid REAP is enabled, the access point inherits the VLAN ID associated to the WLAN. This configuration is saved in the access point and received after the successful join response. By default, the native VLAN is 1. One native VLAN must be configured per hybrid-REAP access point in a VLAN-enabled domain. Otherwise, the access point cannot send and receive packets to and from the controller.

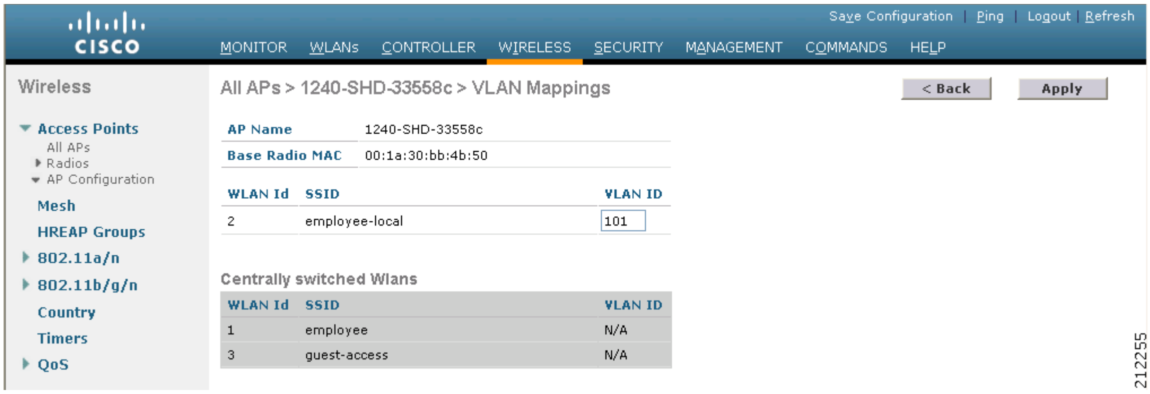
Note To preserve the VLAN mappings in the access point after an upgrade or downgrade, it is necessary that the access point join is restricted to the controller for which it is primed. That is, no other discoverable controller with a different configuration should be available by other means. Similarly, at the time the access point joins, if it moves across controllers which have different VLAN mappings, the VLAN mappings at the access point may get mismatched.

Step 8 Click **Apply** to commit your changes. The access point temporarily loses its connection to the controller while its Ethernet port is reset.

Step 9 Click the name of the same access point and then choose the **H-REAP** tab.

Step 10 Click **VLAN Mappings** to open the All APs > *Access Point Name* > VLAN Mappings page (see Figure 8).

Figure 8 All APs > Access Point Name > VLAN Mappings Page



Step 11 Enter the number of the VLAN from which the clients will get an IP address when doing local switching (VLAN 101, in this example) in the VLAN ID field.

Step 12 Click **Apply** to commit your changes.

Step 13 Click **Save Configuration** to save your changes.

Step 14 Repeat this procedure for any additional access points that need to be configured for hybrid REAP at the remote site.

Using the CLI to Configure an Access Point for Hybrid REAP

Use these commands on the controller to configure an access point for hybrid REAP:

- **config ap mode h-reap** *Cisco_AP*—Enables hybrid REAP for this access point.
- **config ap h-reap radius auth set** {**primary** | **secondary**} *ip_address auth_port secret Cisco_AP*—Configures a primary or secondary RADIUS server for a specific hybrid-REAP access point.

  Note Only the Session Timeout RADIUS attribute is supported in standalone mode. All other attributes as well as RADIUS accounting are not supported.

  Note To delete a RADIUS server that is configured for a hybrid-REAP access point, enter this command: **config ap h-reap radius auth delete** {**primary** | **secondary**} *Cisco_AP*

- **config ap h-reap vlan wlan** *wlan_id vlan-id Cisco_AP*—Enables you to assign a VLAN ID to this hybrid-REAP access point. By default, the access point inherits the VLAN ID associated to the WLAN.
- **config ap h-reap vlan** {**enable** | **disable**} *Cisco_AP*—Enables or disables VLAN tagging for this hybrid-REAP access point. By default, VLAN tagging is not enabled. Once VLAN tagging is enabled on the hybrid-REAP access point, WLANs enabled for local switching inherit the VLAN assigned at the controller.

- **config ap h-reap vlan native** *vlan-id Cisco_AP*—Enables you to configure a native VLAN for this hybrid-REAP access point. By default, no VLAN is set as the native VLAN. One native VLAN must be configured per hybrid-REAP access point (when VLAN tagging is enabled). Make sure the switchport to which the access point is connected has a corresponding native VLAN configured as well. If the hybrid-REAP access point's native VLAN setting and the upstream switchport native VLAN do not match, the access point cannot transmit packets to and from the controller.

Note To preserve the VLAN mappings in the access point after an upgrade or downgrade, it is necessary that the access point join is restricted to the controller for which it is primed. That is, no other discoverable controller with a different configuration should be available by other means. Similarly, at the time the access point joins, if it moves across controllers which have different VLAN mappings, the VLAN mappings at the access point may get mismatched.

Use these commands on the hybrid-REAP access point to obtain status information:

- **show capwap reap status**—Shows the status of the hybrid-REAP access point (connected or standalone).
- **show capwap reap association**—Shows the list of clients associated to this access point and their SSIDs.

Use these commands on the hybrid-REAP access point to obtain debug information:

- **debug capwap reap**—Shows general hybrid-REAP activities.
- **debug capwap reap mgmt**—Shows client authentication and association messages.
- **debug capwap reap load**—Shows payload activities, which is useful when the hybrid-REAP access point boots up in standalone mode.
- **debug dot11 mgmt interface**—Shows 802.11 management interface events.
- **debug dot11 mgmt msg**—Shows 802.11 management messages.
- **debug dot11 mgmt ssid**—Shows SSID management events.
- **debug dot11 mgmt state-machine**—Shows the 802.11 state machine.
- **debug dot11 mgmt station**—Shows client events.

Connecting Client Devices to the WLANs

Follow the instructions for your client device to create profiles to connect to the WLANs you created in the "Configuring the Controller for Hybrid REAP" section on page 6.

In our example, you would create three profiles on the client:

1. To connect to the "employee" WLAN, you would create a client profile that uses WPA/WPA2 with PEAP-MSCHAPV2 authentication. Once the client becomes authenticated, it should get an IP address from the management VLAN of the controller.
2. To connect to the "local-employee" WLAN, you would create a client profile that uses WPA/WPA2 authentication. Once the client becomes authenticated, it should get an IP address from VLAN 101 on the local switch.
3. To connect to the "guest-central" WLAN, you would create a client profile that uses open authentication. Once the client becomes authenticated, it should get an IP address from VLAN 101 on the network local to the access point. Once the client connects, the local user can type any http

address in the web browser. The user is automatically directed to the controller to complete the web-authentication process. When the web login page appears, the user enters his or her username and password.

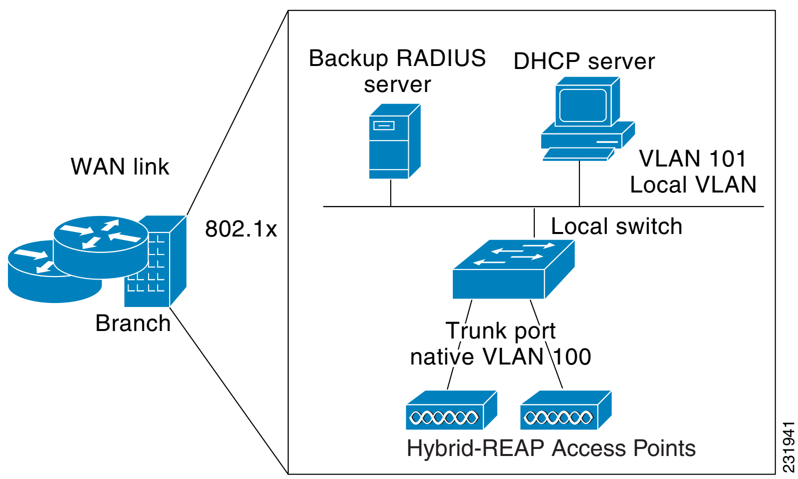
To see if a client's data traffic is being locally or centrally switched, choose **Monitor > Clients** on the controller GUI, click the **Detail** link for the desired client, and look at the Data Switching parameter under AP Properties.

Configuring Hybrid-REAP Groups

In order to better organize and manage your hybrid-REAP access points, you can create hybrid-REAP groups and assign specific access points to them. Per controller, you can configure up to 20 hybrid-REAP groups with up to 25 access points per group.

All of the hybrid-REAP access points in a group share the same backup RADIUS server, CCKM, and local authentication configuration information. This feature is helpful if you have multiple hybrid-REAP access points in a remote office or on the floor of a building and you want to configure them all at once. For example, you can configure a backup RADIUS server for a hybrid-REAP group rather than having to configure the same server on each access point. Figure 9 illustrates a typical hybrid-REAP group deployment with a backup RADIUS server in the branch office.

Figure 9 Hybrid-REAP Group Deployment



Hybrid-REAP Groups and Backup RADIUS Servers

You can configure the controller to allow a hybrid-REAP access point in standalone mode to perform full 802.1X authentication to a backup RADIUS server. You can configure a primary backup RADIUS server or both a primary and secondary backup RADIUS server. These servers are used only when the hybrid-REAP access point is not connected to the controller.

Hybrid-REAP Groups and CCKM

Hybrid-REAP groups are required for CCKM fast roaming to work with hybrid-REAP access points. CCKM fast roaming is achieved by caching a derivative of the master key from a full EAP authentication so that a simple and secure key exchange can occur when a wireless client roams to a different access point. This feature prevents the need to perform a full RADIUS EAP authentication as the client roams from one access point to another. The hybrid-REAP access points need to obtain the CCKM cache information for all the clients that might associate so they can process it quickly instead of sending it back to the controller. If, for example, you have a controller with 300 access points and 100 clients that might associate, sending the CCKM cache for all 100 clients is not practical. If you create a hybrid-REAP group comprising a limited number of access points (for example, you create a group for four access points in a remote office), the clients roam only among those four access points, and the CCKM cache is distributed among those four access points only when the clients associate to one of them.

Note CCKM fast roaming among hybrid-REAP and non-hybrid-REAP access points is not supported. Refer to the "WPA1 and WPA2" section on page 25 for information on configuring CCKM.

Hybrid-REAP Groups and Local Authentication

You can configure the controller to allow a hybrid-REAP access point in standalone mode to perform LEAP or EAP-FAST authentication for up to 100 statically configured users. The controller sends the static list of usernames and passwords to each hybrid-REAP access point when it joins the controller. Each access point in the group authenticates only its own associated clients.

This feature is ideal for customers who are migrating from an autonomous access point network to a lightweight hybrid-REAP access point network and are not interested in maintaining a large user database nor adding another hardware device to replace the RADIUS server functionality available in the autonomous access point.

Note This feature can be used in conjunction with the hybrid-REAP backup RADIUS server feature. If a hybrid-REAP group is configured with both a backup RADIUS server and local authentication, the hybrid-REAP access point always attempts to authenticate clients using the primary backup RADIUS server first, followed by the secondary backup RADIUS server (if the primary is not reachable), and finally the hybrid-REAP access point itself (if the primary and secondary are not reachable).

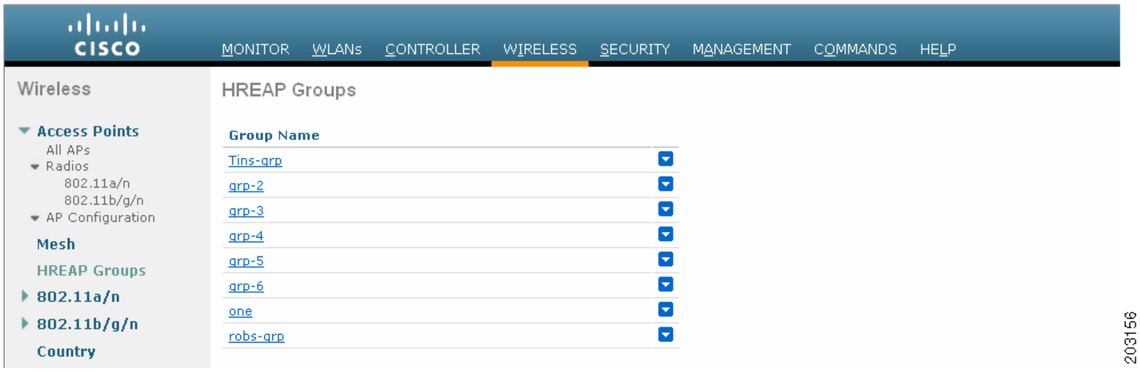
Follow the instructions in this section to configure hybrid-REAP groups using the controller GUI or CLI.

Using the GUI to Configure Hybrid-REAP Groups

Follow these steps to configure hybrid-REAP groups using the controller GUI.

Step 1 Choose **Wireless > HREAP Groups** to open the HREAP Groups page (see Figure 10).

Figure 10 HREAP Groups Page



This page lists any hybrid-REAP groups that have already been created.

Note If you want to delete an existing group, hover your cursor over the blue drop-down arrow for that group and choose **Remove**.

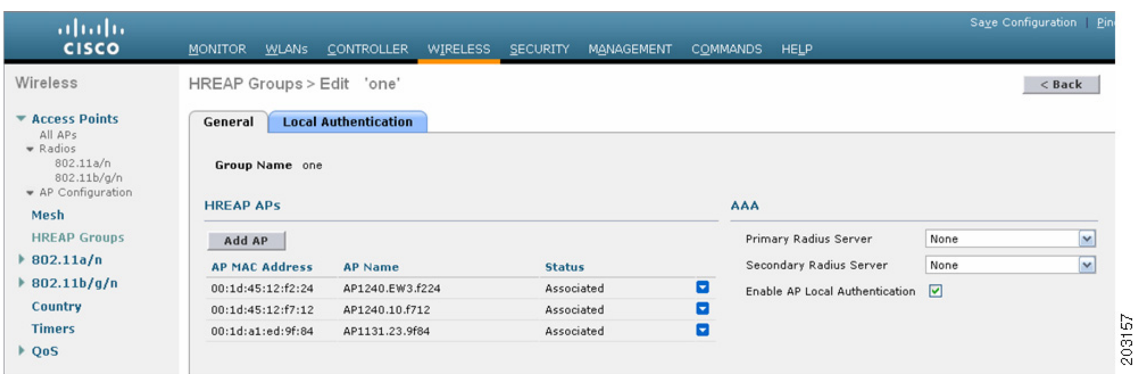
Step 2 To create a new hybrid-REAP group, click **New**.

Step 3 When the HREAP Groups > New page appears, enter the name of the new group in the Group Name field. You can enter up to 32 alphanumeric characters.

Step 4 Click **Apply** to commit your changes. The new group appears on the HREAP Groups page.

Step 5 To edit the properties of a group, click the name of the desired group. The HREAP Groups > Edit (General) page appears (see Figure 11).

Figure 11 HREAP Groups > Edit (General) Page

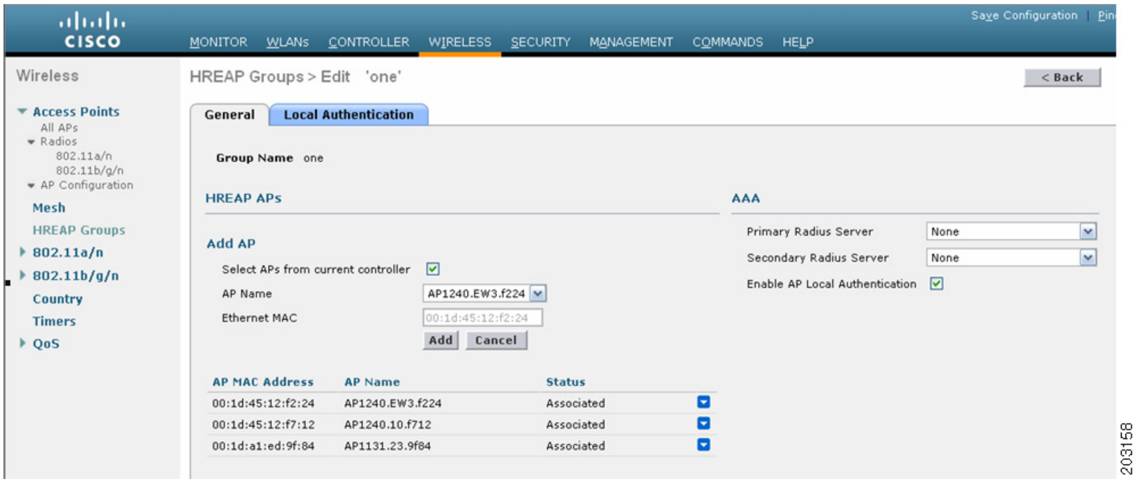


Step 6 If you want to configure a primary RADIUS server for this group (for example, the access points are using 802.1X authentication), choose the desired server from the Primary RADIUS Server drop-down list. Otherwise, leave the field set to the default value of None.

Step 7 If you want to configure a secondary RADIUS server for this group, choose the server from the Secondary RADIUS Server drop-down list. Otherwise, leave the field set to the default value of None.

Step 8 To add an access point to the group, click **Add AP**. Additional fields appear on the page under “Add AP” (see Figure 12).

Figure 12 HREAP Groups > Edit (General) Page



Step 9 Perform one of the following:

- To choose an access point that is connected to this controller, check the **Select APs from Current Controller** check box and choose the name of the access point from the AP Name drop-down box.

  Note If you choose an access point on this controller, the MAC address of the access point is automatically entered in the Ethernet MAC field to prevent any mismatches from occurring.

- To choose an access point that is connected to a different controller, leave the **Select APs from Current Controller** check box unchecked and enter its MAC address in the Ethernet MAC field.

  Note If the hybrid-REAP access points within a group are connected to different controllers, all of the controllers must belong to the same mobility group.

Step 10 Click **Add** to add the access point to this hybrid-REAP group. The access point's MAC address, name, and status appear at the bottom of the page.

Note If you want to delete an access point, hover your cursor over the blue drop-down arrow for that access point and choose **Remove**.

Step 11 Click **Apply** to commit your changes.

Step 12 Repeat Step 9 through Step 11 if you want to add more access points to this hybrid-REAP group.

Step 13 If you want to enable local authentication for a hybrid-REAP group, follow these steps:

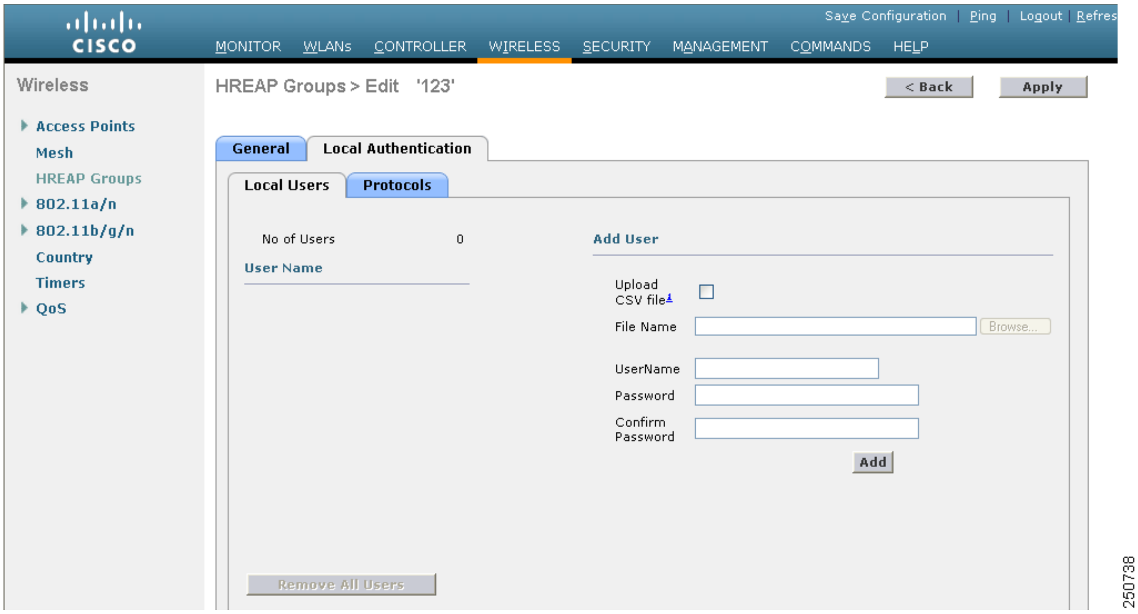
a. Make sure that the Primary RADIUS Server and Secondary RADIUS Server parameters are set to **None**.

b. Check the **Enable AP Local Authentication** check box to enable local authentication for this hybrid-REAP group. The default value is unchecked.

c. Click **Apply** to commit your changes.

d. Choose the **Local Authentication** tab to open the HREAP Groups > Edit (Local Authentication > Local Users) page (see Figure 13).

Figure 13 HREAP Groups > Edit (Local Authentication > Local Users) Page



e. To add clients that you want to be able to authenticate using LEAP or EAP-FAST, perform one of the following:

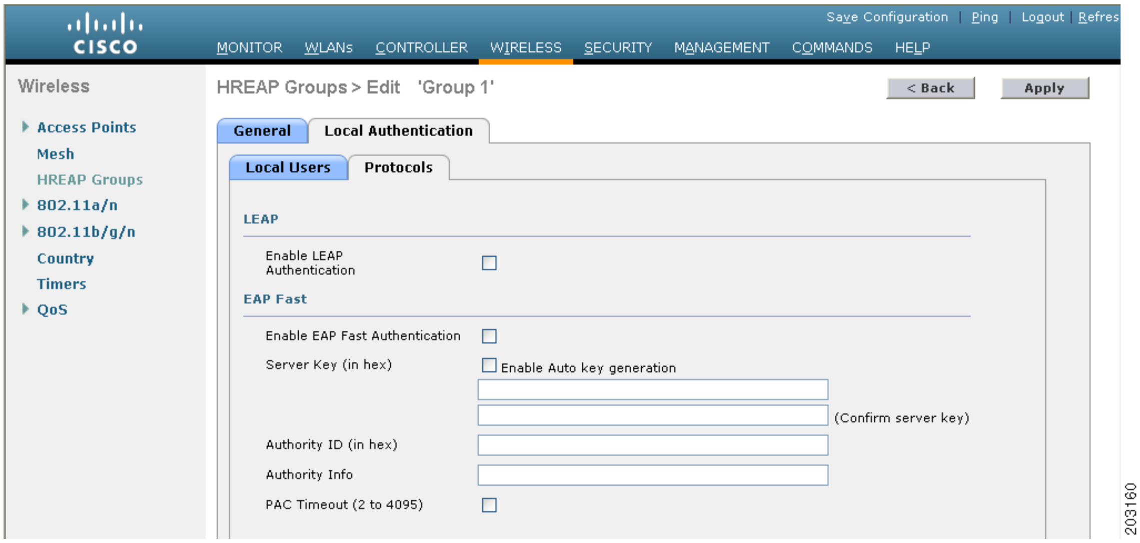
- Upload a comma-separated values (CSV) file by checking the **Upload CSV File** check box, clicking the **Browse** button to browse to an CSV file that contains usernames and passwords (each line of the file needs to be in the following format: username, password), and clicking **Add** to upload the CSV file. The clients' names appear on the left side of the page under the "User Name" heading.
- Add clients individually by entering the client's username in the User Name field and a password for the client in the Password and Confirm Password fields, and clicking **Add** to add this client to the list of supported local users. The client name appears on the left side of the page under the "User Name" heading.

Note You can add up to 100 clients.

f. Click **Apply** to commit your changes.

g. Choose the **Protocols** tab to open the HREAP Groups > Edit (Local Authentication > Protocols) page (see Figure 14).

Figure 14 HREAP Groups > Edit (Local Authentication > Protocols) Page



h. To allow a hybrid-REAP access point to authenticate clients using LEAP, check the **Enable LEAP Authentication** check box; then go to Step n.

i. To allow a hybrid-REAP access point to authenticate clients using EAP-FAST, check the **Enable EAP-FAST Authentication** check box; then go to the next step. The default value is unchecked.

j. Perform one of the following, depending on how you want protected access credentials (PACs) to be provisioned:

- To use manual PAC provisioning, enter the server key used to encrypt and decrypt PACs in the Server Key and Confirm Server Key fields. The key must be 32 hexadecimal characters.
- To allow PACs to be sent automatically to clients that do not have one during PAC provisioning, check the **Enable Auto Key Generation** check box.

k. In the Authority ID field, enter the authority identifier of the EAP-FAST server. The identifier must be 32 hexadecimal characters.

l. In the Authority Info field, enter the authority identifier of the EAP-FAST server in text format. You can enter up to 32 hexadecimal characters.

m. To specify a PAC timeout value, check the **PAC Timeout** check box and enter the number of seconds for the PAC to remain viable in the edit box. The default value is unchecked, and the valid range is 2 to 4095 seconds when enabled.

n. Click **Apply** to commit your changes.

Step 14 Click **Save Configuration** to save your changes.

Step 15 Repeat this procedure if you want to add more hybrid-REAP groups.

Note To see if an individual access point belongs to a hybrid-REAP group, you can choose **Wireless** > **Access Points** > **All APs** > the name of the desired access point > the **H-REAP** tab. If the access point belongs to a hybrid-REAP group, the name of the group appears in the HREAP Group Name field.

Using the CLI to Configure Hybrid-REAP Groups

Follow these steps to configure hybrid-REAP groups using the controller CLI.

Step 1 To add or delete a hybrid-REAP group, enter this command:

config hreap group *group_name* {**add** | **delete**}

Step 2 To configure a primary or secondary RADIUS server for the hybrid-REAP group, enter this command:

config hreap group *group_name* **radius server** {**add** | **delete**} {**primary** | **secondary**} *server_index*

Step 3 To add an access point to the hybrid-REAP group, enter this command:

config hreap group *group_name* **ap** {**add** | **delete**} *ap_mac*

Step 4 To configure local authentication for a hybrid-REAP group, follow these steps:

a. Make sure that a primary and secondary RADIUS server are not configured for the hybrid-REAP group.

b. To enable or disable local authentication for this hybrid-REAP group, enter this command:

config hreap group *group_name* **radius ap** {**enable** | **disable**}

c. To enter the username and password of a client that you want to be able to authenticate using LEAP or EAP-FAST, enter this command:

config hreap group *group_name* **radius ap user add** *username* **password** *password*

> **Note** You can add up to 100 clients.

d. To allow a hybrid-REAP access point to authenticate clients using LEAP or to disable this behavior, enter this command:

config hreap group *group_name* **radius ap leap** {**enable** | **disable**}

e. To allow a hybrid-REAP access point to authenticate clients using EAP-FAST or to disable this behavior, enter this command:

config hreap group *group_name* **radius ap eap-fast** {**enable** | **disable**}

f. Enter one of the following commands, depending on how you want PACs to be provisioned:

- **config hreap group** *group_name* **radius ap server-key** *key*—Specifies the server key used to encrypt and decrypt PACs. The key must be 32 hexadecimal characters.
- **config hreap group** *group_name* **radius ap server-key auto**—Allows PACs to be sent automatically to clients that do not have one during PAC provisioning.

g. To specify the authority identifier of the EAP-FAST server, enter this command:

config hreap group *group_name* **radius ap authority id** *id*

where *id* is 32 hexadecimal characters.

h. To specify the authority identifier of the EAP-FAST server in text format, enter this command:

config hreap group *group_name* **radius ap authority info** *info*

where *info* is up to 32 hexadecimal characters.

i. To specify the number of seconds for the PAC to remain viable, enter this command:

config hreap group *group_name* **radius ap pac-timeout** *timeout*

where *timeout* is a value between 2 and 4095 seconds (inclusive) or 0. A value of 0, which the default value, disables the PAC timeout.

Step 5 To save your changes, enter this command:

save config

Step 6 To see the current list of hybrid-REAP groups, enter this command:

show hreap group summary

Information similar to the following appears:

```
HREAP Group Summary: Count 2

Group Name     # Aps
Group 1        1
Group 2        1
```

Step 7 To see the details for a specific hybrid-REAP group, enter this command:

show hreap group detail *group_name*

Information similar to the following appears:

```
Number of Ap's in Group: 3

00:1d:45:12:f2:24    AP1240.EW3.f224  Joined
00:1d:45:12:f7:12    AP1240.10.f712     Joined
00:1d:a1:ed:9f:84    AP1131.23.9f84     Joined


Group Radius Servers Settings:
 Primary Server Index........................... Disabled
 Secondary Server Index......................... Disabled

Group Radius AP Settings:
AP RADIUS server............ Enabled
EAP-FAST Auth............... Enabled
LEAP Auth................... Enabled
Server Key Auto Generated... No
Server Key.................     <hidden>
Authority ID............... 436973636f0000000000000000000
Authority Info............. Cisco A_ID
PAC Timeout................ 0
Number of User's in Group: 20

                   1cisco                    2cisco
                   3cisco                    4cisco
                    cisco                     test1
                   test10                    test11
                   test12                    test13
                   test14                    test15
                    test2                     test3
                    test4                     test5
                    test6                     test7
                   test8                   test9
```

Safety Considerations and Translated Safety Warnings

This appendix lists safety considerations and translations of the safety warnings that apply to the Cisco UWN Solution products. The following safety considerations and safety warnings appear in this appendix:

Safety Considerations

Keep these guidelines in mind when installing Cisco UWN Solution products:

- The Cisco lightweight access points with or without external antenna ports are only intended for installation in Environment A as defined in IEEE 802.3af. All interconnected equipment must be contained within the same building including the interconnected equipment's associated LAN connections.
- For lightweight access points provided with optional external antenna ports, make sure that all external antennas and their associated wiring are located entirely indoors. These lightweight access points and their optional external antennas are not suitable for outdoor use.
- Make sure that plenum-mounted lightweight access points are powered using Power over Ethernet (PoE) to comply with safety regulations.
- For all controllers, verify that the ambient temperature remains between 0 and 40° C (32 and 104° F), taking into account the elevated temperatures that occur when they are installed in a rack.
- When multiple controllers are mounted in an equipment rack, be sure that the power source is sufficiently rated to safely run all of the equipment in the rack.
- Verify the integrity of the ground before installing controllers in an equipment rack.
- Lightweight access points are suitable for use in environmental air space in accordance with Section 300.22.C of the National Electrical Code, and Sections 2-128, 12-010(3) and 12-100 of the Canadian Electrical Code, Part 1, C22.1.

Warning Definition

Warning **IMPORTANT SAFETY INSTRUCTIONS**

This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Use the statement number provided at the end of each warning to locate its translation in the translated safety warnings that accompanied this device. Statement 1071

SAVE THESE INSTRUCTIONS

Waarschuwing **BELANGRIJKE VEILIGHEIDSINSTRUCTIES**

Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van de standaard praktijken om ongelukken te voorkomen. Gebruik het nummer van de verklaring onderaan de waarschuwing als u een vertaling van de waarschuwing die bij het apparaat wordt geleverd, wilt raadplegen.

BEWAAR DEZE INSTRUCTIES

Varoitus **TÄRKEITÄ TURVALLISUUSOHJEITA**

Tämä varoitusmerkki merkitsee vaaraa. Tilanne voi aiheuttaa ruumiillisia vammoja. Ennen kuin käsittelet laitteistoa, huomioi sähköpiirien käsittelemiseen liittyvät riskit ja tutustu onnettomuuksien yleisiin ehkäisytapoihin. Turvallisuusvaroitusten käännökset löytyvät laitteen mukana toimitettujen käännettyjen turvallisuusvaroitusten joukosta varoitusten lopussa näkyvien lausuntonumeroiden avulla.

SÄILYTÄ NÄMÄ OHJEET

Attention **IMPORTANTES INFORMATIONS DE SÉCURITÉ**

Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures ou des dommages corporels. Avant de travailler sur un équipement, soyez conscient des dangers liés aux circuits électriques et familiarisez-vous avec les procédures couramment utilisées pour éviter les accidents. Pour prendre connaissance des traductions des avertissements figurant dans les consignes de sécurité traduites qui accompagnent cet appareil, référez-vous au numéro de l'instruction situé à la fin de chaque avertissement.

CONSERVEZ CES INFORMATIONS

Warnung **WICHTIGE SICHERHEITSHINWEISE**

Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu Verletzungen führen kann. Machen Sie sich vor der Arbeit mit Geräten mit den Gefahren elektrischer Schaltungen und den üblichen Verfahren zur Vorbeugung vor Unfällen vertraut. Suchen Sie mit der am Ende jeder Warnung angegebenen Anweisungsnummer nach der jeweiligen Übersetzung in den übersetzten Sicherheitshinweisen, die zusammen mit diesem Gerät ausgeliefert wurden.

BEWAHREN SIE DIESE HINWEISE GUT AUF.

Avvertenza **IMPORTANTI ISTRUZIONI SULLA SICUREZZA**

Questo simbolo di avvertenza indica un pericolo. La situazione potrebbe causare infortuni alle persone. Prima di intervenire su qualsiasi apparecchiatura, occorre essere al corrente dei pericoli relativi ai circuiti elettrici e conoscere le procedure standard per la prevenzione di incidenti. Utilizzare il numero di istruzione presente alla fine di ciascuna avvertenza per individuare le traduzioni delle avvertenze riportate in questo documento.

CONSERVARE QUESTE ISTRUZIONI

Advarsel **VIKTIGE SIKKERHETSINSTRUKSJONER**

Dette advarselssymbolet betyr fare. Du er i en situasjon som kan føre til skade på person. Før du begynner å arbeide med noe av utstyret, må du være oppmerksom på farene forbundet med elektriske kretser, og kjenne til standardprosedyrer for å forhindre ulykker. Bruk nummeret i slutten av hver advarsel for å finne oversettelsen i de oversatte sikkerhetsadvarslene som fulgte med denne enheten.

TA VARE PÅ DISSE INSTRUKSJONENE

Aviso **INSTRUÇÕES IMPORTANTES DE SEGURANÇA**

Este símbolo de aviso significa perigo. Você está em uma situação que poderá ser causadora de lesões corporais. Antes de iniciar a utilização de qualquer equipamento, tenha conhecimento dos perigos envolvidos no manuseio de circuitos elétricos e familiarize-se com as práticas habituais de prevenção de acidentes. Utilize o número da instrução fornecido ao final de cada aviso para localizar sua tradução nos avisos de segurança traduzidos que acompanham este dispositivo.

GUARDE ESTAS INSTRUÇÕES

¡Advertencia! **INSTRUCCIONES IMPORTANTES DE SEGURIDAD**

Este símbolo de aviso indica peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considere los riesgos de la corriente eléctrica y familiarícese con los procedimientos estándar de prevención de accidentes. Al final de cada advertencia encontrará el número que le ayudará a encontrar el texto traducido en el apartado de traducciones que acompaña a este dispositivo.

GUARDE ESTAS INSTRUCCIONES

Varning! **VIKTIGA SÄKERHETSANVISNINGAR**

Denna varningssignal signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanliga förfaranden för att förebygga olyckor. Använd det nummer som finns i slutet av varje varning för att hitta dess översättning i de översatta säkerhetsvarningar som medföljer denna anordning.

SPARA DESSA ANVISNINGAR

FONTOS BIZTONSÁGI ELOÍRÁSOK

Ez a figyelmezeto jel veszélyre utal. Sérülésveszélyt rejto helyzetben van. Mielott bármely berendezésen munkát végezte, legyen figyelemmel az elektromos áramkörök okozta kockázatokra, és ismerkedjen meg a szokásos balesetvédelmi eljárásokkal. A kiadványban szereplo figyelmeztetések fordítása a készülékhez mellékelt biztonsági figyelmeztetések között található; a fordítás az egyes figyelmeztetések végén látható szám alapján keresheto meg.

ORIZZE MEG EZEKET AZ UTASÍTÁSOKAT!

Предупреждение **ВАЖНЫЕ ИНСТРУКЦИИ ПО СОБЛЮДЕНИЮ ТЕХНИКИ БЕЗОПАСНОСТИ**

Этот символ предупреждения обозначает опасность. То есть имеет место ситуация, в которой следует опасаться телесных повреждений. Перед эксплуатацией оборудования выясните, каким опасностям может подвергаться пользователь при использовании электрических цепей, и ознакомьтесь с правилами техники безопасности для предотвращения возможных несчастных случаев. Воспользуйтесь номером заявления, приведенным в конце каждого предупреждения, чтобы найти его переведенный вариант в переводе предупреждений по безопасности, прилагаемом к данному устройству.

СОХРАНИТЕ ЭТИ ИНСТРУКЦИИ

警告 重要的安全性说明

此警告符号代表危险。您正处于可能受到严重伤害的工作环境中。在您使用设备开始工作之前，必须充分意识到触电的危险，并熟练掌握防止事故发生的标准工作程序。请根据每项警告结尾提供的声明号码来找到此设备的安全性警告说明的翻译文本。

请保存这些安全性说明

警告 安全上の重要な注意事項

「危険」の意味です。人身事故を予防するための注意事項が記述されています。装置の取り扱い作業を行うときは、電気回路の危険性に注意し、一般的な事故防止策に留意してください。警告の各国語版は、各注意事項の番号を基に、装置に付属の「Translated Safety Warnings」を参照してください。

これらの注意事項を保管しておいてください。

Class 1 Laser Product Warning

Note The 1000BASE-SX and 1000BASE-LX SFP modules contain Class 1 Lasers (Laser Klasse 1) according to EN 60825-1+A1+A2.

Warning **Class 1 laser product.** Statement 1008

Waarschuwing **Klasse-1 laser produkt.**

Varoitus **Luokan 1 lasertuote.**

Attention **Produit laser de classe 1.**

Warnung **Laserprodukt der Klasse 1.**

Avvertenza **Prodotto laser di Classe 1.**

Advarsel **Laserprodukt av klasse 1.**

Aviso **Produto laser de classe 1.**

¡Advertencia! **Producto láser Clase I.**

Varning! **Laserprodukt av klass 1.**

Class 1 besorolású lézeres termék.

Предупреждение Лазерное устройство класса 1.

警告 这是 1 类激光产品。

警告 クラス1レーザー製品です。

주의 클래스 1 레이저 제품.

Aviso **Produto a laser de classe 1.**

Advarsel **Klasse 1 laserprodukt.**

تحذير **Class 1 Laser منتج ١**

Upozorenje **Laserski proizvod klase 1**

Upozornění **Laserový výrobek třídy 1.**

Προειδοποίηση Προϊόν λέιζερ κατηγορίας 1.

הרהזא .Class 1 מוצר לייזר

Opomena Ласерски производ од класа 1.

Ostrzeżenie **Produkt laserowy klasy 1.**

Upozornenie **Laserový výrobok triedy 1.**

Class 1 besorolású lézeres termék.

Предупреждение Лазерное устройство класса 1.

警告 这是 1 类激光产品。

警告 クラス1レーザー製品です。

주의 클래스 1 레이저 제품.

تحذير **Class 1 Laser ١ منتج**

Upozorenje **Laserski proizvod klase 1**

Upozornění **Laserový výrobek třídy 1.**

Προειδοποίηση Προϊόν λέιζερ κατηγορίας 1.

אזהרה מוצר לייזר Class 1.

Opomena Ласерски производ од класа 1.

Ostrzeżenie **Produkt laserowy klasy 1.**

Upozornenie **Laserový výrobok triedy 1.**

Ground Conductor Warning

Warning **This equipment must be grounded. Never defeat the ground conductor or operate the equipment in the absence of a suitably installed ground conductor. Contact the appropriate electrical inspection authority or an electrician if you are uncertain that suitable grounding is available.** Statement 1024

Waarschuwing **Deze apparatuur dient geaard te zijn. De aardingsleiding mag nooit buiten werking worden gesteld en de apparatuur mag nooit bediend worden zonder dat er een op de juiste wijze geïnstalleerde aardingsleiding aanwezig is. Neem contact op met de bevoegde instantie voor elektrische inspecties of met een elektricien als u er niet zeker van bent dat er voor passende aarding gezorgd is.**

Varoitus **Laitteiden on oltava maadoitettuja. Älä koskaan ohita maajohdinta tai käytä laitteita ilman oikein asennettua maajohdinta. Ota yhteys sähkötarkastusviranomaiseen tai sähköasentajaan, jos olet epävarma maadoituksen sopivuudesta.**

Attention **Cet équipement doit être mis à la masse. Ne jamais rendre inopérant le conducteur de masse ni utiliser l'équipement sans un conducteur de masse adéquatement installé. En cas de doute sur la mise à la masse appropriée disponible, s'adresser à l'organisme responsable de la sécurité électrique ou à un électricien.**

Warnung **Dieses Gerät muss geerdet sein. Auf keinen Fall den Erdungsleiter unwirksam machen oder das Gerät ohne einen sachgerecht installierten Erdungsleiter verwenden. Wenn Sie sich nicht sicher sind, ob eine sachgerechte Erdung vorhanden ist, wenden Sie sich an die zuständige Inspektionsbehörde oder einen Elektriker.**

Avvertenza **Questa apparecchiatura deve essere dotata di messa a terra. Non escludere mai il conduttore di protezione né usare l'apparecchiatura in assenza di un conduttore di protezione installato in modo corretto. Se non si è certi della disponibilità di un adeguato collegamento di messa a terra, richiedere un controllo elettrico presso le autorità competenti o rivolgersi a un elettricista.**

Advarsel **Dette utstyret må jordes. Omgå aldri jordingslederen og bruk aldri utstyret uten riktig montert jordingsleder. Ta kontakt med fagfolk innen elektrisk inspeksjon eller med en elektriker hvis du er usikker på om det finnes velegnet jordning.**

Aviso **Este equipamento deve ser aterrado. Nunca anule o fio terra nem opere o equipamento sem um aterramento adequadamente instalado. Em caso de dúvida com relação ao sistema de aterramento disponível, entre em contato com os serviços locais de inspeção elétrica ou um eletricista qualificado.**

¡Advertencia! **Este equipo debe estar conectado a tierra. No inhabilite el conductor de tierra ni haga funcionar el equipo si no hay un conductor de tierra instalado correctamente. Póngase en contacto con la autoridad correspondiente de inspección eléctrica o con un electricista si no está seguro de que haya una conexión a tierra adecuada.**

Varning! **Denna utrustning måste jordas. Koppla aldrig från jordledningen och använd aldrig utrustningen utan en på lämpligt sätt installerad jordledning. Om det föreligger osäkerhet huruvida lämplig jordning finns skall elektrisk besiktningsauktoritet eller elektriker kontaktas.**

A berendezés csak megfelelő védőföldeléssel működtethető. Ne iktassa ki a földelés csatlakozóját, és ne üzemeltesse a berendezést szabályosan felszerelt földelő vezeték nélkül! Ha nem biztos benne, hogy megfelelő földelés áll rendelkezésbe, forduljon a helyi elektromos hatóságokhoz vagy egy villanyszerelőhöz.

Предупреждение Данное устройство должно быть заземлено. Никогда не отключайте провод заземления и не пользуйтесь оборудованием при отсутствии правильно подключенного провода заземления. За сведениями об имеющихся возможностях заземления обратитесь к соответствующим контролирующим организациям по энергоснабжению или к инженеру-электрику.

警告 此设备必须接地。切勿使接地导体失效，或者在没有正确安装接地导体的情况下操作该设备。如果您不能肯定接地导体是否正常发挥作用，请咨询有关电路检测方面的权威人士或电工。

警告 この装置はアース接続する必要があります。アース導体を破損しないよう注意し、アース導体を正しく取り付けないまま装置を稼働させないでください。アース接続が適正であるかどうか分からない場合には、電気検査機関または電気技術者に相談してください。

A berendezés csak megfelelő védőföldeléssel működtethető. Ne iktassa ki a földelés csatlakozóját, és ne üzemeltesse a berendezést szabályosan felszerelt földelő vezeték nélkül! Ha nem biztos benne, hogy megfelelő földelés áll rendelkezésbe, forduljon a helyi elektromos hatóságokhoz vagy egy villanyszerelőhöz.

Предупреждение Данное устройство должно быть заземлено. Никогда не отключайте провод заземления и не пользуйтесь оборудованием при отсутствии правильно подключенного провода заземления. За сведениями об имеющихся возможностях заземления обратитесь к соответствующим контролирующим организациям по энергоснабжению или к инженеру-электрику.

警告 此设备必须接地。切勿使接地导体失效，或者在没有正确安装接地导体的情况下操作该设备。如果您不能肯定接地导体是否正常发挥作用，请咨询有关电路检测方面的权威人士或电工。

警告 この装置はアース接続する必要があります。アース導体を破損しないよう注意し、アース導体を正しく取り付けないまま装置を稼働させないでください。アース接続が適正であるかどうか分からない場合には、電気検査機関または電気技術者に相談してください。

Chassis Warning for Rack-Mounting and Servicing

Warning **To prevent bodily injury when mounting or servicing this unit in a rack, you must take special precautions to ensure that the system remains stable. The following guidelines are provided to ensure your safety:**

- **This unit should be mounted at the bottom of the rack if it is the only unit in the rack.**
- **When mounting this unit in a partially filled rack, load the rack from the bottom to the top with the heaviest component at the bottom of the rack.**
- **If the rack is provided with stabilizing devices, install the stabilizers before mounting or servicing the unit in the rack.** Statement 1006

Waarschuwing **Om lichamelijk letsel te voorkomen wanneer u dit toestel in een rek monteert of het daar een servicebeurt geeft, moet u speciale voorzorgsmaatregelen nemen om ervoor te zorgen dat het toestel stabiel blijft. De onderstaande richtlijnen worden verstrekt om uw veiligheid te verzekeren:**

- **Dit toestel dient onderaan in het rek gemonteerd te worden als het toestel het enige in het rek is.**
- **Wanneer u dit toestel in een gedeeltelijk gevuld rek monteert, dient u het rek van onderen naar boven te laden met het zwaarste onderdeel onderaan in het rek.**
- **Als het rek voorzien is van stabiliseringshulpmiddelen, dient u de stabilisatoren te monteren voordat u het toestel in het rek monteert of het daar een servicebeurt geeft.**

Varoitus **Kun laite asetetaan telineeseen tai huolletaan sen ollessa telineessä, on noudatettava erityisiä varotoimia järjestelmän vakavuuden säilyttämiseksi, jotta vältytään loukkaantumiselta. Noudata seuraavia turvallisuusohjeita:**

- **Jos telineessä ei ole muita laitteita, aseta laite telineen alaosaan.**
- **Jos laite asetetaan osaksi täytettyyn telineeseen, aloita kuormittaminen sen alaosasta kaikkein raskaimmalla esineellä ja siirry sitten sen yläosaan.**
- **Jos telinettä varten on vakaimet, asenna ne ennen laitteen asettamista telineeseen tai sen huoltamista siinä.**

Attention **Pour éviter toute blessure corporelle pendant les opérations de montage ou de réparation de cette unité en casier, il convient de prendre des précautions spéciales afin de maintenir la stabilité du système. Les directives ci-dessous sont destinées à assurer la protection du personnelþ:**

- **Si cette unité constitue la seule unité montée en casier, elle doit être placée dans le bas.**
- **Si cette unité est montée dans un casier partiellement rempli, charger le casier de bas en haut en plaçant l'élément le plus lourd dans le bas.**
- **Si le casier est équipé de dispositifs stabilisateurs, installer les stabilisateurs avant de monter ou de réparer l'unité en casier.**

Warnung **Zur Vermeidung von Körperverletzung beim Anbringen oder Warten dieser Einheit in einem Gestell müssen Sie besondere Vorkehrungen treffen, um sicherzustellen, daß das System stabil bleibt. Die folgenden Richtlinien sollen zur Gewährleistung Ihrer Sicherheit dienen:**

- **Wenn diese Einheit die einzige im Gestell ist, sollte sie unten im Gestell angebracht werden.**
- **Bei Anbringung dieser Einheit in einem zum Teil gefüllten Gestell ist das Gestell von unten nach oben zu laden, wobei das schwerste Bauteil unten im Gestell anzubringen ist.**
- **Wird das Gestell mit Stabilisierungszubehör geliefert, sind zuerst die Stabilisatoren zu installieren, bevor Sie die Einheit im Gestell anbringen oder sie warten.**

Avvertenza **Per evitare infortuni fisici durante il montaggio o la manutenzione di questa unità in un supporto, occorre osservare speciali precauzioni per garantire che il sistema rimanga stabile. Le seguenti direttive vengono fornite per garantire la sicurezza personale:**

- **Questa unità deve venire montata sul fondo del supporto, se si tratta dell'unica unità da montare nel supporto.**
- **Quando questa unità viene montata in un supporto parzialmente pieno, caricare il supporto dal basso all'alto, con il componente più pesante sistemato sul fondo del supporto.**
- **Se il supporto è dotato di dispositivi stabilizzanti, installare tali dispositivi prima di montare o di procedere alla manutenzione dell'unità nel supporto.**

Advarsel **Unngå fysiske skader under montering eller reparasjonsarbeid på denne enheten når den befinner seg i et kabinett. Vær nøye med at systemet er stabilt. Følgende retningslinjer er gitt for å verne om sikkerheten:**

- **Denne enheten bør monteres nederst i kabinettet hvis dette er den eneste enheten i kabinettet.**
- **Ved montering av denne enheten i et kabinett som er delvis fylt, skal kabinettet lastes fra bunnen og opp med den tyngste komponenten nederst i kabinettet.**
- **Hvis kabinettet er utstyrt med stabiliseringsutstyr, skal stabilisatorene installeres før montering eller utføring av reparasjonsarbeid på enheten i kabinettet.**

Aviso **Para se prevenir contra danos corporais ao montar ou reparar esta unidade numa estante, deverá tomar precauções especiais para se certificar de que o sistema possui um suporte estável. As seguintes directrizes ajudá-lo-ão a efectuar o seu trabalho com segurança:**

- **Esta unidade deverá ser montada na parte inferior da estante, caso seja esta a única unidade a ser montada.**
- **Ao montar esta unidade numa estante parcialmente ocupada, coloque os itens mais pesados na parte inferior da estante, arrumando-os de baixo para cima.**
- **Se a estante possuir um dispositivo de estabilização, instale-o antes de montar ou reparar a unidade.**

¡Advertencia! **Para evitar lesiones durante el montaje de este equipo sobre un bastidor, o posteriormente durante su mantenimiento, se debe poner mucho cuidado en que el sistema quede bien estable. Para garantizar su seguridad, proceda según las siguientes instrucciones:**

- **Colocar el equipo en la parte inferior del bastidor, cuando sea la única unidad en el mismo.**
- **Cuando este equipo se vaya a instalar en un bastidor parcialmente ocupado, comenzar la instalación desde la parte inferior hacia la superior colocando el equipo más pesado en la parte inferior.**
- **Si el bastidor dispone de dispositivos estabilizadores, instalar éstos antes de montar o proceder al mantenimiento del equipo instalado en el bastidor.**

Varning! **För att undvika kroppsskada när du installerar eller utför underhållsarbete på denna enhet på en ställning måste du vidta särskilda försiktighetsåtgärder för att försäkra dig om att systemet står stadigt. Följande riktlinjer ges för att trygga din säkerhet:**

- **Om denna enhet är den enda enheten på ställningen skall den installeras längst ned på ställningen.**
- **Om denna enhet installeras på en delvis fylld ställning skall ställningen fyllas nedifrån och upp, med de tyngsta enheterna längst ned på ställningen.**
- **Om ställningen är försedd med stabiliseringsdon skall dessa monteras fast innan enheten installeras eller underhålls på ställningen.**

A készülék rackbe történő beszerelése és karbantartása során bekövetkező sérülések elkerülése végett speciális óvintézkedésekkel meg kell őrizni a rendszer stabilitását. A személyes biztonsága érdekében tartsa be a következő szabályokat:

- **Ha a rackben csak ez az egy készülék található, a rack aljába kell beszerelni.**
- **Ha nincs teljesen tele az a rack, amelybe beszerelik a készüléket, alulról fölfelé haladva töltse fel a racket úgy, hogy a legnehezebb készülék kerüljön a rack aljába.**
- **Ha stabilizáló eszközök is tartoznak a rackhez, szerelje fel a stabilizátorokat, mielőtt beszerelné az egységet a rackbe, vagy karbantartást végezne rajta.**

Предупреждение Во избежание травм при монтаже и обслуживании устройства в стойке следует принять особые меры предосторожности, чтобы убедиться в устойчивости оборудования.
Для обеспечения безопасности работ необходимо соблюдать следующие правила.

- Если в стойке находится одно устройство, оно должно быть установлено в нижней части.
- При монтаже устройств в частично заполненную стойку устанавливайте оборудование снизу вверх, размещая наиболее тяжелые устройства в нижней части.
- Если стойка снабжена приспособлениями для стабилизации, их необходимо установить до начала монтажа или обслуживания оборудования.

警告 为避免在机架中安装或维修该部件时使身体受伤，您必须采取特殊的预防措施确保系统固定。以下是确保安全的原则：

- 如果此部件是机架中唯一的部件，应将其安装在机架的底部。
- 如果在部分装满的机架中安装此部件，请按从下往上的顺序安装各个部件，并且最重的组件应安装在机架的底部。
- 如果机架配有固定装置，请先装好固定装置，然后再在机架中安装或维修部件。

警告 この装置をラックに設置したり保守作業を行ったりするときは、人身事故を防ぐため、システムが安定しているかどうかを十分に確認する必要があります。次の注意事項に従ってください。

- ラックにこの装置を単独で設置する場合は、ラックの一番下に設置します。
- ラックに別の装置がすでに設置されている場合は、最も重量のある装置を一番下にして、重い順に下から上へ設置します。
- ラックに安定器具が付属している場合は、その安定器具を取り付けてから、装置をラックに設置するか、またはラック内の装置の保守作業を行ってください。

주의 이 장치를 랙에 장착하거나 서비스할 때 신체 부상을 방지하려면, 시스템이 안정된 상태를 유지하도록 특별히 주의해야 합니다. 사용자의 안전을 위해 다음 지침 사항을 준수하십시오.

- 이 장치가 랙에 장착되는 유일한 것일 경우, 랙의 맨 아래 부분에 장착되어야 합니다.
- 부분적으로 차 있는 랙에 이 장치를 장착할 경우, 가장 무거운 장치를 랙의 맨 아래 부분부터 차례로 장착하십시오.
- 안정기가 랙과 함께 제공되는 경우, 이 안정기를 설치한 후 이 장치를 랙에 장착하거나 서비스하십시오

Aviso **Para evitar lesões corporais ao montar ou dar manutenção a esta unidade em um rack, é necessário tomar todas as precauções para garantir a estabilidade do sistema. As seguintes orientações são fornecidas para garantir a sua segurança:**

- **Se esta for a única unidade, ela deverá ser montada na parte inferior do rack.**
- **Ao montar esta unidade em um rack parcialmente preenchido, carregue-o de baixo para cima com o componente mais pesado em sua parte inferior.**
- **Se o rack contiver dispositivos estabilizadores, instale-os antes de montar ou dar manutenção à unidade existente.**

Advarsel **For at forhindre legemesbeskadigelse ved montering eller service af denne enhed i et rack, skal du sikre at systemet står stabilt. Følgende retningslinjer er også for din sikkerheds skyld:**

- **Enheden skal monteres i bunden af dit rack, hvis det er den eneste enhed i racket.**
- **Ved montering af denne enhed i et delvist fyldt rack, skal enhederne installeres fra bunden og opad med den tungeste enhed nederst.**
- **Hvis racket leveres med stabiliseringsenheder, skal disse installeres for enheden monteres eller serviceres i racket.**

تحذير

لتجنب حدوث أي إصابات عند تركيب هذه الوحدة، يجب اتباع بعض الاحتياطات لضمان عمل النظام بشكل سليم.
يتم ذكر الإرشادات التالية لضمان الأمان.
يجب تركيب هذه الوحدة في الجزء السفلي من الدولاب المتضمن قضبان إذا كانت هذه الوحدة هي الوحيدة في الدولاب الذي يحتوي على قضبان.
عند تركيب هذه الوحدة في دولاب شبه ممتلئ، قم برفع الدولاب من الجزء السفلي لأعلى بحيث يكون الجزء الأثقل وزناً أسفل الدولاب.
إذا كان الدولاب المتضمن قضباناً يحتوي على أجهزة حفظ التوازن، قم بتثبيت هذه الأجهزة قبل تركيب الوحدة في الدولاب.

Upozorenje **Kako ne bi došlo do tjelesnih ozljeda kod postavljanja ili servisiranja uređaja na polici, potrebno je poduzeti mjere predostrožnosti kako bi sustav uvijek bio stabilan. Sigurnost se može osigurati poštivanjem sljedećih smjernica:**

- **Ovaj uređaj treba ugraditi na dno police, ukoliko je to jedini uređaj na polici.**
- **Kod ugradnje uređaja u policu na kojoj se već nalaze drugi uređaji, policu treba opremati počevši od dna, te tako da se na dno stave najteži dijelovi.**
- **Ukoliko su na polici ugrađeni stabilizatori, njih montirajte prije ugradnje ili servisiranja uređaja na polici.**

Upozornění **Abyste předešli poranění osob při montáži nebo opravě zařízení v montážním rámu, musíte dodržovat zvláštní preventivní opatření pro zajištění udržení stability systému. Pro zajištění bezpečnosti obsluhy jsou určeny následující zásady:**

- **Pokud je toto zařízení jedinou jednotkou v montážním rámu, musí být namontováno na nejnižší místo rámu.**
- **Pokud je toto zařízení montováno do částečně obsazeného montážního rámu, obsazujte montážní rám ve směru zdola nahoru tak, aby byla nejtěžší součást nejníže.**
- **Pokud je montážní rám vybaven stabilizačními zařízeními, nainstalujte stabilizátory ještě před montáží nebo opravou zařízení v montážním rámu.**

Προειδοποίηση Για να αποφύγετε τον τραυματισμό κατά την τοποθέτηση ή τη συντήρηση αυτής της συσκευής σε αρθρωτό σύστημα, πρέπει να λάβετε ειδικές προφυλάξεις για να διασφαλίσετε τη σταθερότητα του συστήματος. Οι παρακάτω οδηγίες παρέχονται για να εξασφαλίσουν την ασφάλειά σας:

- Αυτή η συσκευή πρέπει να τοποθετείται στο κάτω μέρος του αρθρωτού συστήματος αν είναι η μοναδική συσκευή σε αυτό.
- Όταν τοποθετείτε αυτήν τη συσκευή σε εν μέρει γεμάτο αρθρωτό σύστημα, τοποθετήστε συσκευές στο αρθρωτό σύστημα από κάτω προς τα επάνω, με τη βαρύτερη συσκευή στο κάτω μέρος του συστήματος.
- Εάν το αρθρωτό σύστημα διαθέτει διατάξεις σταθεροποίησης, τοποθετήστε τους σταθεροποιητές πριν τοποθετήσετε ή συντηρήσετε τη συσκευή στο αρθρωτό σύστημα.

אזהרה כדי למנוע פציעה בעת הרכבת יחידה זו במעמד או טיפול בה, עליך לנקוט אמצעי זהירות מיוחדים כדי להבטיח את יציבות המערכת. הקווים המנחים הבאים ניתנים על מנת להבטיח את ביטחונך:

• אם יחידה זו היא יחידה בודדת במעמד, יש להרכיב את היחידה בחלקו התחתון של המעמד.

• בעת הרכבת יחידה זו במעמד המלא בחלקו, טען את המעמד החל בחלק התחתון וכלפי מעלה כאשר הרכיב הכבד ביותר נמצא בחלקו התחתון של המעמד.

• אם המעמד מסופק עם התקני ייצוב, התקן את המייצבים לפני הרכבה היחידה במעמד או טיפול בה.

Opomena За да се не повредите кога го монтирате или го сервисирате уредот на полица, мора да бидете особено претпазливи за да ја обезбедите стабилноста на системот. Следите напатствија се дадени за да ја осигураат Вашата безбедност:

- Уредот треба да се монтира најдолу на полицата ако е единствен уред на полицата.
- Кога го монтирате уредот на делумно пополнета полица, полнете ја полицата од дното кон врвот со најтешката компонента на дното на полицата.
- Ако полицата има стабилизаторски делови, наместете ги стабилизаторите пред да го монтирате или сервисирате уредот на полицата.

Ostrzeżenie **Aby zapobiec urazom podczas montażu lub serwisowania tego urządzenia w stojaku, należy zastosować szczególne środki ostrożności w celu zapewnienia stabilności układu. Poniżej przedstawiono wskazówki, których przestrzeganie zapewni bezpieczeństwo:**

- **Jeśli urządzenie to jest jedynym urządzeniem w stojaku, powinno być zamontowane na dole.**
- **W przypadku montażu urządzenia w częściowo zapełnionym stojaku należy instalować kolejne urządzenia od najniższego do najwyższego, przy czym element najcięższy powinien być zamontowany najniżej w stojaku.**
- **Jeśli stojak jest wyposażony w elementy stabilizujące, należy zamontować stabilizatory przed przystąpieniem do montażu lub serwisowania urządzeń w stojaku.**

Upozornenie **Aby ste predišli poraneniu osôb pri montáži alebo oprave zariadenia v montážnom ráme, musíte dodržiavať zvláštne preventívne opatrenia na zaistenie udržania stability systému. Na zaistenie bezpečnosti obsluhy sú určené nasledujúce zásady:**

- **Pokiaľ je toto zariadenie jedinou jednotkou v montážnom ráme, musí byť namontované na najnižšie miesto v ráme.**
- **Pokiaľ je toto zariadenie montované do čiastočne obsadeného montážneho rámu, obsadzujte montážny rám v smere zdola nahor tak, aby bola najťažšia súčasť najnižšie.**
- **Pokiaľ je montážny rám vybavený stabilizačnými zariadeniami, nainštalujte stabilizátory ešte pred montážou alebo opravou zariadenia v montážnom ráme.**

A készülék rackbe történő beszerelése és karbantartása során bekövetkező sérülések elkerülése végett speciális óvintézkedésekkel meg kell őrizni a rendszer stabilitását. A személyes biztonsága érdekében tartsa be a következő szabályokat:

- **Ha a rackben csak ez az egy készülék található, a rack aljába kell beszerelni.**
- **Ha nincs teljesen tele az a rack, amelybe beszerelik a készüléket, alulról fölfelé haladva töltse fel a racket úgy, hogy a legnehezebb készülék kerüljön a rack aljába.**
- **Ha stabilizáló eszközök is tartoznak a rackhez, szerelje fel a stabilizátorokat, mielőtt beszerelné az egységet a rackbe, vagy karbantartást végezne rajta.**

Предупреждение Во избежание травм при монтаже и обслуживании устройства в стойке следует принять особые меры предосторожности, чтобы убедиться в устойчивости оборудования. Для обеспечения безопасности работ необходимо соблюдать следующие правила.

- Если в стойке находится одно устройство, оно должно быть установлено в нижней части.
- При монтаже устройств в частично заполненную стойку устанавливайте оборудование снизу вверх, размещая наиболее тяжелые устройства в нижней части.
- Если стойка снабжена приспособлениями для стабилизации, их необходимо установить до начала монтажа или обслуживания оборудования.

警告 为避免在机架中安装或维修该部件时使身体受伤，您必须采取特殊的预防措施确保系统固定。以下是确保安全的原则：

- 如果此部件是机架中唯一的部件，应将其安装在机架的底部。
- 如果在部分装满的机架中安装此部件，请按从下往上的顺序安装各个部件，并且最重的组件应安装在机架的底部。
- 如果机架配有固定装置，请先装好固定装置，然后再在机架中安装或维修部件。

警告 この装置をラックに設置したり保守作業を行ったりするときは、人身事故を防ぐため、システムが安定しているかどうかを十分に確認する必要があります。次の注意事項に従ってください。

- ラックにこの装置を単独で設置する場合は、ラックの一番下に設置します。
- ラックに別の装置がすでに設置されている場合は、最も重量のある装置を一番下にして、重い順に下から上へ設置します。
- ラックに安定器具が付属している場合は、その安定器具を取り付けてから、装置をラックに設置するか、またはラック内の装置の保守作業を行ってください。

주의 이 장치를 랙에 장착하거나 서비스할 때 신체 부상을 방지하려면, 시스템이 안정된 상태를 유지하도록 특별히 주의해야 합니다. 사용자의 안전을 위해 다음 지침 사항을 준수하십시오.
- 이 장치가 랙에 장착되는 유일한 것일 경우, 랙의 맨 아래 부분에 장착되어야 합니다.
- 부분적으로 차 있는 랙에 이 장치를 장착할 경우, 가장 무거운 장치를 랙의 맨 아래 부분부터 차례로 장착하십시오.
- 안정기가 랙과 함께 제공되는 경우, 이 안정기를 설치한 후 이 장치를 랙에 장착하거나 서비스하십시오

تحذير لتجنب حدوث أي إصابات عند تركيب هذه الوحدة، يجب اتباع بعض الاحتياطات لضمان عمل النظام بشكل سليم. يتم ذكر الإرشادات التالية لضمان الأمان.
يجب تركيب هذه الوحدة في الجزء السفلي من الدولاب المتضمن قضبان إذا كانت هذه الوحدة هي الوحدة الوحيدة في الدولاب الذي يحتوي على قضبان.
عند تركيب هذه الوحدة في دولاب شبه ممتلئ، قم برفع الدولاب من الجزء السفلي لأعلى بحيث يكون الجزء الأثقل وزناً أسفل الدولاب.
إذا كان الدولاب المتضمن قضباناً يحتوي على أجهزة حفظ التوازن، قم بتثبيت هذه الأجهزة قبل تركيب الوحدة في الدولاب.

Upozorenje **Kako ne bi došlo do tjelesnih ozljeda kod postavljanja ili servisiranja uređaja na polici, potrebno je poduzeti mjere predostrožnosti kako bi sustav uvijek bio stabilan. Sigurnost se može osigurati poštivanjem sljedećih smjernica:**
- **Ovaj uređaj treba ugraditi na dno police, ukoliko je to jedini uređaj na polici.**
- **Kod ugradnje uređaja u policu na kojoj se već nalaze drugi uređaji, policu treba oprematі počevši od dna, te tako da se na dno stave najteži dijelovi.**
- **Ukoliko su na polici ugrađeni stabilizatori, njih montirajte prije ugradnje ili servisiranja uređaja na polici.**

Upozornění **Abyste předešli poranění osob při montáži nebo opravě zařízení v montážním rámu, musíte dodržovat zvláštní preventivní opatření pro zajištění udržení stability systému. Pro zajištění bezpečnosti obsluhy jsou určeny následující zásady:**
- **Pokud je toto zařízení jedinou jednotkou v montážním rámu, musí být namontováno na nejnižší místo rámu.**
- **Pokud je toto zařízení montováno do částečně obsazeného montážního rámu, obsazujte montážní rám ve směru zdola nahoru tak, aby byla nejtěžší součást nejníže.**
- **Pokud je montážní rám vybaven stabilizačními zařízeními, nainstalujte stabilizátory ještě před montáží nebo opravou zařízení v montážním rámu.**

Προειδοποίηση

Για να αποφύγετε τον τραυματισμό κατά την τοποθέτηση ή τη συντήρηση αυτής της συσκευής σε αρθρωτό σύστημα, πρέπει να λάβετε ειδικές προφυλάξεις για να διασφαλίσετε τη σταθερότητα του συστήματος. Οι παρακάτω οδηγίες παρέχονται για να εξασφαλίσουν την ασφάλειά σας:

- Αυτή η συσκευή πρέπει να τοποθετείται στο κάτω μέρος του αρθρωτού συστήματος αν είναι η μοναδική συσκευή σε αυτό.
- Όταν τοποθετείτε αυτήν τη συσκευή σε εν μέρει γεμάτο αρθρωτό σύστημα, τοποθετήστε συσκευές στο αρθρωτό σύστημα από κάτω προς τα επάνω, με τη βαρύτερη συσκευή στο κάτω μέρος του συστήματος.
- Εάν το αρθρωτό σύστημα διαθέτει διατάξεις σταθεροποίησης, τοποθετήστε τους σταθεροποιητές πριν τοποθετήσετε ή συντηρήσετε τη συσκευή στο αρθρωτό σύστημα.

אזהרה

כדי למנוע פציעה בעת הרכבת יחידה זו במעמד או טיפול בה, עליך לנקוט אמצעי זהירות מיוחדים כדי להבטיח את יציבות המערכת. הקווים המנחים הבאים ניתנים על מנת להבטיח את ביטחונך:

- אם יחידה זו היא יחידה בודדת במעמד, יש להרכיב את היחידה בחלקו התחתון של המעמד.
- בעת הרכבת יחידה זו במעמד המלא בחלקו, טען את המעמד החל בחלק התחתון וכלפי מעלה כאשר הרכיב הכבד ביותר נמצא בחלקו התחתון של המעמד.
- אם המעמד מסופק עם התקני ייצוב, התקן את המייצבים לפני הרכבה היחידה במעמד או טיפול בה.

Opomena

За да се не повредите кога го монтирате или го сервисирате уредот на полица, мора да бидете особено претпазливи за да ја обезбедите стабилноста на системот. Следите напатствија се дадени за да ја осигураат Вашата безбедност:

- Уредот треба да се монтира најдолу на полицата ако е единствен уред на полицата.
- Кога го монтирате уредот на делумно пополнета полица, полнете ја полицата од дното кон врвот со најтешката компонента на дното на полицата.
- Ако полицата има стабилизаторски делови, наместете ги стабилизаторите пред да го монтирате или сервисирате уредот на полицата.

Ostrzeżenie **Aby zapobiec urazom podczas montażu lub serwisowania tego urządzenia w stojaku, należy zastosować szczególne środki ostrożności w celu zapewnienia stabilności układu. Poniżej przedstawiono wskazówki, których przestrzeganie zapewni bezpieczeństwo:**

- **Jeśli urządzenie to jest jedynym urządzeniem w stojaku, powinno być zamontowane na dole.**
- **W przypadku montażu urządzenia w częściowo zapełnionym stojaku należy instalować kolejne urządzenia od najniższego do najwyższego, przy czym element najcięższy powinien być zamontowany najniżej w stojaku.**
- **Jeśli stojak jest wyposażony w elementy stabilizujące, należy zamontować stabilizatory przed przystąpieniem do montażu lub serwisowania urządzeń w stojaku.**

Upozornenie **Aby ste predišli poraneniu osôb pri montáži alebo oprave zariadenia v montážnom ráme, musíte dodržiavať zvláštne preventívne opatrenia na zaistenie udržania stability systému. Na zaistenie bezpečnosti obsluhy sú určené nasledujúce zásady:**

- **Pokiaľ je toto zariadenie jedinou jednotkou v montážnom ráme, musí byť namontované na najnižšie miesto v ráme.**
- **Pokiaľ je toto zariadenie montované do čiastočne obsadeného montážneho rámu, obsadzujte montážny rám v smere zdola nahor tak, aby bola najťažšia súčasť najnižšie.**
- **Pokiaľ je montážny rám vybavený stabilizačnými zariadeniami, nainštalujte stabilizátory ešte pred montážou alebo opravou zariadenia v montážnom ráme.**

Battery Handling Warning

Warning **There is the danger of explosion if the controller battery is replaced incorrectly. Replace the battery only with the same or equivalent type recommended by the manufacturer. Dispose of used batteries according to the manufacturer's instructions.** Statement 1015

Waarschuwing **Er is ontploffingsgevaar als de batterij verkeerd vervangen wordt. Vervang de batterij slechts met hetzelfde of een equivalent type dat door de fabrikant aanbevolen is. Gebruikte batterijen dienen overeenkomstig fabrieksvoorschriften weggeworpen te worden.**

Varoitus **Räjähdyksen vaara, jos akku on vaihdettu väärään akkuun. Käytä vaihtamiseen ainoastaan saman- tai vastaavantyyppistä akkua, joka on valmistajan suosittelema. Hävitä käytetyt akut valmistajan ohjeiden mukaan.**

Attention **Danger d'explosion si la pile n'est pas remplacée correctement. Ne la remplacer que par une pile de type semblable ou équivalent, recommandée par le fabricant. Jeter les piles usagées conformément aux instructions du fabricant.**

Warnung **Bei Einsetzen einer falschen Batterie besteht Explosionsgefahr. Ersetzen Sie die Batterie nur durch den gleichen oder vom Hersteller empfohlenen Batterietyp. Entsorgen Sie die benutzten Batterien nach den Anweisungen des Herstellers.**

Avvertenza **Pericolo di esplosione se la batteria non è installata correttamente. Sostituire solo con una di tipo uguale o equivalente, consigliata dal produttore. Eliminare le batterie usate secondo le istruzioni del produttore.**

Advarsel **Det kan være fare for eksplosjon hvis batteriet skiftes på feil måte. Skift kun med samme eller tilsvarende type som er anbefalt av produsenten. Kasser brukte batterier i henhold til produsentens instruksjoner.**

Aviso **Existe perigo de explosão se a bateria for substituída incorrectamente. Substitua a bateria por uma bateria igual ou de um tipo equivalente recomendado pelo fabricante. Destrua as baterias usadas conforme as instruções do fabricante.**

¡Advertencia! **Existe peligro de explosión si la batería se reemplaza de manera incorrecta. Reemplazar la batería exclusivamente con el mismo tipo o el equivalente recomendado por el fabricante. Desechar las baterías gastadas según las instrucciones del fabricante.**

Varning! **Explosionsfara vid felaktigt batteribyte. Ersätt endast batteriet med samma batterityp som rekommenderas av tillverkaren eller motsvarande. Följ tillverkarens anvisningar vid kassering av använda batterier.**

Robbanásveszélyt idézhet elő, ha helytelenül cserélik ki az akkumulátort. Csak a gyártó által javasolttal megegyező vagy azzal egyenértékű típusúra cserélje ki az akkumulátort! A használt akkumulátorok kidobásakor tartsa be a gyártó előírásait!

Предупреждение При неправильной замене батареи возможен взрыв. Для замены следует использовать батарею того же или аналогичного типа, рекомендованного изготовителем. Утилизацию батареи необходимо производить в соответствии с указаниями изготовителя.

警告 电池更换不当会有爆炸危险。请只用同类电池或制造商推荐的功能相当的电池更换原有电池。请按制造商的说明处理废旧电池。

警告 不適切なバッテリに交換すると、爆発の危険性があります。製造元が推奨するものと同じまたは同等のバッテリだけを使用してください。使用済みのバッテリは、製造元が指示する方法に従って処分してください。

Robbanásveszélyt idézhet elő, ha helytelenül cserélik ki az akkumulátort. Csak a gyártó által javasolttal megegyező vagy azzal egyenértékű típusúra cserélje ki az akkumulátort! A használt akkumulátorok kidobásakor tartsa be a gyártó előírásait!

Предупреждение При неправильной замене батареи возможен взрыв. Для замены следует использовать батарею того же или аналогичного типа, рекомендованного изготовителем. Утилизацию батареи необходимо производить в соответствии с указаниями изготовителя.

警告 电池更换不当会有爆炸危险。请只用同类电池或制造商推荐的功能相当的电池更换原有电池。请按制造商的说明处理废旧电池。

警告 不適切なバッテリに交換すると、爆発の危険性があります。製造元が推奨するものと同じまたは同等のバッテリだけを使用してください。使用済みのバッテリは、製造元が指示する方法に従って処分してください。

Equipment Installation Warning

Warning **Only trained and qualified personnel should be allowed to install, replace, or service this equipment.** Statement 1030

Waarschuwing **Deze apparatuur mag alleen worden geïnstalleerd, vervangen of hersteld door bevoegd geschoold personeel.**

Varoitus **Tämän laitteen saa asentaa, vaihtaa tai huoltaa ainoastaan koulutettu ja laitteen tunteva henkilökunta.**

Attention **Il est vivement recommandé de confier l'installation, le remplacement et la maintenance de ces équipements à des personnels qualifiés et expérimentés.**

Warnung **Das Installieren, Ersetzen oder Bedienen dieser Ausrüstung sollte nur geschultem, qualifiziertem Personal gestattet werden.**

Avvertenza **Questo apparato può essere installato, sostituito o mantenuto unicamente da un personale competente.**

Advarsel **Bare opplært og kvalifisert personell skal foreta installasjoner, utskiftninger eller service på dette utstyret.**

Aviso **Apenas pessoal treinado e qualificado deve ser autorizado a instalar, substituir ou fazer a revisão deste equipamento.**

¡Advertencia! **Solamente el personal calificado debe instalar, reemplazar o utilizar este equipo.**

Varning! **Endast utbildad och kvalificerad personal bör få tillåtelse att installera, byta ut eller reparera denna utrustning.**

A berendezést csak szakképzett személyek helyezhetik üzembe, cserélhetik és tarthatják karban.

Предупреждение Установку, замену и обслуживание этого оборудования может осуществлять только специально обученный квалифицированный персонал.

警告 只有经过培训且具有资格的人员才能进行此设备的安装、更换和维修。

警告 この装置の設置、交換、保守は、訓練を受けた相応の資格のある人が行ってください。

주의 교육을 받고 자격을 갖춘 사람만 이 장비를 설치, 교체, 또는 서비스를 수행해야 합니다.

Aviso **Somente uma equipe treinada e qualificada tem permissão para instalar, substituir ou dar manutenção a este equipamento.**

Advarsel **Kun uddannede personer må installere, udskifte komponenter i eller servicere dette udstyr.**

تحذير يسمح للفنيين المتخصصين فقط بتركيب المعدة أو استبدالها أو إجراء الصيانة عليها.

Upozorenje **Uređaj smije ugrađivati, mijenjati i servisirati samo za to obučeno i osposobljeno servisno osoblje.**

Upozornění **Instalaci, výměnu nebo opravu tohoto zařízení smějí provádět pouze proškolené a kvalifikované osoby.**

Προειδοποίηση Η τοποθέτηση, η αντικατάσταση και η συντήρηση του εξοπλισμού επιτρέπεται να γίνονται μόνο από καταρτισμένο προσωπικό με τα κατάλληλα προσόντα.

אזהרה

Opomena Местењето, заменувањето и сервисирањето на оваа опрема треба да му биде дозволено само на обучен и квалификуван персонал.

Ostrzeżenie **Do instalacji, wymiany i serwisowania tych urządzeń mogą być dopuszczone wyłącznie osoby wykwalifikowane i przeszkolone.**

Upozornenie **Inštaláciu, výmenu alebo opravu tohto zariadenia smú vykonávať iba vyškolené a kvalifikované osoby.**

A berendezést csak szakképzett személyek helyezhetik üzembe, cserélhetik és tarthatják karban.

Предупреждение Установку, замену и обслуживание этого оборудования может осуществлять только специально обученный квалифицированный персонал.

警告 只有经过培训且具有资格的人员才能进行此设备的安装、更换和维修。

警告 この装置の設置、交換、保守は、訓練を受けた相応の資格のある人が行ってください。

주의 교육을 받고 자격을 갖춘 사람만 이 장비를 설치, 교체, 또는 서비스를 수행해야 합니다.

تحذير يسمح للفنيين المتخصصين فقط بتركيب المعدة أو استبدالها أو إجراء الصيانة عليها.

Upozorenje **Uređaj smije ugrađivati, mijenjati i servisirati samo za to obučeno i osposobljeno servisno osoblje.**

Upozornění **Instalaci, výměnu nebo opravu tohoto zařízení smějí provádět pouze proškolené a kvalifikované osoby.**

Προειδοποίηση Η τοποθέτηση, η αντικατάσταση και η συντήρηση του εξοπλισμού επιτρέπεται να γίνονται μόνο από καταρτισμένο προσωπικό με τα κατάλληλα προσόντα.

אזהרה

Opomena Местењето, заменувањето и сервисирањето на оваа опрема треба да му биде дозволено само на обучен и квалификуван персонал.

Ostrzeżenie	**Do instalacji, wymiany i serwisowania tych urządzeń mogą być dopuszczone wyłącznie osoby wykwalifikowane i przeszkolone.**
Upozornenie	**Inštaláciu, výmenu alebo opravu tohto zariadenia smú vykonávať iba vyškolené a kvalifikované osoby.**

More Than One Power Supply Warning for 5500 and 4400 Series Controllers

Warning	**The wireless lan controller might have more than one power supply connection. All connections must be removed to de-energize the unit.** Statement 1028
Waarschuwing	**Deze eenheid kan meer dan één stroomtoevoeraansluiting bevatten. Alle aansluitingen dienen ontkoppeld te worden om de eenheid te ontkrachten.**
Varoitus	**Tässä laitteessa voi olla useampia kuin yksi virtakytkentä. Kaikki liitännät on irrotettava, jotta jännite poistetaan laitteesta.**
Attention	**Cette unité peut avoir plus d'une connexion d'alimentation. Pour supprimer toute tension et tout courant électrique de l'unité, toutes les connexions d'alimentation doivent être débranchées.**
Warnung	**Dieses Gerät kann mehr als eine Stromzufuhr haben. Um sicherzustellen, dass der Einheit kein Strom zugeführt wird, müssen alle Verbindungen entfernt werden.**
Avvertenza	**Questa unità può avere più di una connessione all'alimentazione elettrica. Tutte le connessioni devono essere staccate per togliere la corrente dall'unità.**
Advarsel	**Denne enheten kan ha mer enn én strømtilførselskobling. Alle koblinger må fjernes fra enheten for å utkoble all strøm.**
Aviso	**Esta unidade poderá ter mais de uma conexão de fonte de energia. Todas as conexões devem ser removidas para desligar a unidade.**
¡Advertencia!	**Puede que esta unidad tenga más de una conexión para fuentes de alimentación. Para cortar por completo el suministro de energía, deben desconectarse todas las conexiones.**
Varning!	**Denna enhet har eventuellt mer än en strömförsörjningsanslutning. Alla anslutningar måste tas bort för att göra enheten strömlös.**
Figyelem	**Előfordulhat, hogy a készülék többszörösen van csatlakoztatva az áramforráshoz. A készülék áramtalanításához mindegyik csatlakozást meg kell szüntetni.**

Предупреждение В данном устройстве может использоваться несколько подключений к электросети. Чтобы обесточить устройство, необходимо отключить все эти подключения.

警告 此部件连接的电源可能不止一个。必须将所有电源断开才能停止给该部件供电。

警告 この装置には、複数の電源が接続されている場合があります。装置の電源を完全にオフにするには、すべての電源を切断する必要があります。

주의 본 장치에는 2개 이상의 전원 공급 연결 단자가 있을 수 있습니다. 이 장치의 전원을 차단하려면 모든 연결 단자를 제거해야 합니다.

Aviso **Esta unidade pode ter mais de uma conexão de fonte de alimentação. Todas as conexões devem ser removidas para interromper a alimentação da unidade.**

Advarsel **Denne enhed har muligvis mere end en strømforsyningstilslutning. Alle tilslutninger skal fjernes for at aflade strømmen fra enheden.**

تحذير قد تتضمن هذه الوحدة أكثر من اتصال بمورد الطاقة. يجب فصل كافة التوصيلات حتى يمكن إفراغ طاقة الوحدة.

Upozorenje **Uređaj može imati više priključaka za izvore napajanja. Za potpuno isključivanje napajanja potrebno je iskopčati sve priključke.**

Upozornění **Toto zařízení může být připojeno k více než jednomu zdroji napájení. Aby se zařízení zcela odpojilo od proudu, musí být odpojeno od všech zdrojů napájení.**

Προειδοποίηση Αυτή η συσκευή ίσως να έχει περισσότερες συνδέσεις τροφοδοσίας.
Για να απενεργοποιηθεί η συσκευή, πρέπει να αφαιρεθούν όλες οι συνδέσεις.

אזהרה ייתכן שביחידה זו קיים יותר מחיבור אחד לספק כוח. יש להסיר את כל החיבורים כדי להפסיק את אספקת המתח ליחידה.

Opomena Уредот може да има повеќе од еден приклучок за напојување. Сите приклучоци мора да се извадат за да се прекине доводот на енергија во уредот.

Ostrzeżenie **To urządzenie może mieć podłączone więcej niż jedno źródło zasilania. Aby całkowicie odciąć dopływ energii do urządzenia, należy odłączyć wszystkie źródła zasilania.**

Upozornenie **Toto zariadenie môže byť pripojené k viac ako jednému zdroju napájania. Aby sa zariadenie odpojilo od prúdu, musí byť odpojené od všetkých zdrojov.**

Előfordulhat, hogy a készülék többszörösen van csatlakoztatva az áramforráshoz. A készülék áramtalanításához mindegyik csatlakozást meg kell szüntetni.

Предупреждение В данном устройстве может использоваться несколько подключений к электросети. Чтобы обесточить устройство, необходимо отключить все эти подключения.

警告 此部件连接的电源可能不止一个。必须将所有电源断开才能停止给该部件供电。

警告 この装置には、複数の電源が接続されている場合があります。装置の電源を完全にオフにするには、すべての電源を切断する必要があります。

주의 본 장치에는 2개 이상의 전원 공급 연결 단자가 있을 수 있습니다. 이 장치의 전원을 차단하려면 모든 연결 단자를 제거해야 합니다.

تحذير قد تتضمن هذه الوحدة أكثر من اتصال بمورد الطاقة. يجب فصل كافة التوصيلات حتى يمكن إفراغ طاقة الوحدة.

Upozorenje **Uređaj može imati više priključaka za izvore napajanja. Za potpuno isključivanje napajanja potrebno je iskopčati sve priključke.**

Upozornění **Toto zařízení může být připojeno k více než jednomu zdroji napájení. Aby se zařízení zcela odpojilo od proudu, musí být odpojeno od všech zdrojů napájení.**

Προειδοποίηση Αυτή η συσκευή ίσως να έχει περισσότερες συνδέσεις τροφοδοσίας. Για να απενεργοποιηθεί η συσκευή, πρέπει να αφαιρεθούν όλες οι συνδέσεις.

אזהרה ייתכן שביחידה זו קיים יותר מחיבור אחד לספק כוח. יש להסיר את כל החיבורים כדי להפסיק את אספקת המתח ליחידה.

Opomena Уредот може да има повеќе од еден приклучок за напојување. Сите приклучоци мора да се извадат за да се прекине доводот на енергија во уредот.

Ostrzeżenie	**To urządzenie może mieć podłączone więcej niż jedno źródło zasilania. Aby całkowicie odciąć dopływ energii do urządzenia, należy odłączyć wszystkie źródła zasilania.**
Upozornenie	**Toto zariadenie môže byť pripojené k viac ako jednému zdroju napájania. Aby sa zariadenie odpojilo od prúdu, musí byť odpojené od všetkých zdrojov.**

Declarations of Conformity and Regulatory Information

This appendix provides declarations of conformity and regulatory information for the products in the Cisco UWN Solution.

This appendix contains these sections:

Regulatory Information for Lightweight Access Points

This section contains regulatory information for lightweight access points. The information is in these sections:

Manufacturers Federal Communication Commission Declaration of Conformity Statement

FC Tested To Comply With FCC Standards

FOR HOME OR OFFICE USE

FCC Certification number:

LDK102057

Manufacturer:

Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA

This device complies with Part 15 rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits of a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and radiates radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference. However, there is no guarantee that interference will not occur. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase separation between the equipment and receiver.
- Connect the equipment to an outlet on a circuit different from which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician.

Caution The Part 15 radio device operates on a non-interference basis with other devices operating at this frequency when using the integrated antennas. Any changes or modification to the product not expressly approved by Cisco could void the user's authority to operate this device.

Caution Within the 5.15-to-5.25-GHz band (5-GHz radio channels 34 to 48) the U-NII devices are restricted to indoor operations to reduce any potential for harmful interference to co-channel Mobile Satellite System (MSS) operations.

Department of Communications—Canada

Certification number:

2461B-102057

Canadian Compliance Statement

This Class B Digital apparatus meets all the requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numerique de la classe B respecte les exigences du Reglement sur le material broilleur du Canada.

This device complies with Class B Limits of Industry Canada. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Cisco Aironet 2.4-GHz Access Points are certified to the requirements of RSS-210 for 2.4-GHz spread spectrum devices, and Cisco Aironet 54-Mbps, 5-GHz Access Points are certified to the requirements of RSS-210 for 5-GHz spread spectrum devices.The use of this device in a system operating either partially or completely outdoors may require the user to obtain a license for the system according to the Canadian regulations. For further information, contact your local Industry Canada office.

European Community, Switzerland, Norway, Iceland, and Liechtenstein

Declaration of Conformity with Regard to the R&TTE Directive 1999/5/EC

English:	This equipment is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.
Deutsch:	Dieses Gerät entspricht den grundlegenden Anforderungen und den weiteren entsprecheneden Vorgaben der Richtlinie 1999/5/EU.
Dansk:	Dette udstyr er i overensstemmelse med de væsentlige krav og andre relevante bestemmelser i Directiv 1999/5/EF.
Español:	Este equipo cumple con los requisitos esenciales asi como con otras disposiciones de la Directive 1999/5/EC.
Έλληνας:	Αυτός ο εξοπλισμός συμμορφώνεται με τις ουσιώδεις απαιτήσεις και τις λοιπές διατάξεις της Οδηγίας 1999/5/EK.
Français:	Cet appareil est conforme aux exigencies essentialles et aux autres dispositions pertinantes de la Directive 1999/5/EC.
Íslenska:	Þessi búnaður samrýmist lögboðnum kröfum og öðrum ákvæðum tilskipunar 1999/5/ESB.
Italiano:	Questo apparato é conforme ai requisiti essenziali ed agli altri principi sanciti dalla Direttiva 1999/5/EC.
Nederlands:	Deze apparatuur voldoet aan de belangrijkste eisen en andere voorzieningen van richtlijn 1999/5/EC.
Norsk:	Dette utstyret er i samsvar med de grunnleggende krav og andre relevante bestemmelser i EU-directiv 1999/5/EC.
Português:	Este equipamento satisfaz os requisitos essenciais e outras provisões da Directiva 1999/5/EC.
Suomalainen:	Tämä laite täyttää direktiivin 1999/5/EY oleelliset vaatimukset ja on siinä asetettujen muidenkin ehtojen mukainen.
Svenska:	Denna utrustning är i överensstämmelse med de väsentliga kraven och andra relevanta bestämmelser i Direktiv 1999/5/EC.

For 2.4-GHz radios, the following standards were applied:

- Radio: EN 300.328-1, EN 300.328-2
- EMC: EN 301.489-1, EN 301.489-17
- Safety: EN 60950

Note This equipment is intended to be used in all EU and EFTA countries. Outdoor use may be restricted to certain frequencies and/or may require a license for operation. For more details, contact Cisco Corporate Compliance.

For 54-Mbps, 5-GHz access points, the following standards were applied:

- Radio: EN 301.893
- EMC: EN 301.489-1, EN 301.489-17
- Safety: EN 60950

The following CE mark is affixed to the access point with a 2.4-GHz radio and a 54-Mbps, 5-GHz radio:

Declaration of Conformity for RF Exposure

The radio has been found to be compliant to the requirements set forth in CFR 47 Sections 2.1091, and 15.247 (b) (4) addressing RF Exposure from radio frequency devices as defined in Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields. The equipment should be installed more than 20 cm (7.9 in.) from your body or nearby persons.

The access point must be installed to maintain a minimum 20 cm (7.9 in.) co-located separation distance from other FCC approved indoor/outdoor antennas used with the access point. Any antennas or transmitters not approved by the FCC cannot be co-located with the access point. The access point's co-located 2.4-GHz and 5-GHz integrated antennas support a minimum separation distance of 8 cm (3.2 in.) and are compliant with the applicable FCC RF exposure limit when transmitting simultaneously.

Note Dual antennas used for diversity operation are not considered co-located.

Guidelines for Operating Controllers in Japan

This section provides guidelines for avoiding interference when operating Cisco Aironet 5500, 4400, and 2100 series controllers in Japan. These guidelines are provided in both Japanese and English.

VCCI Class A Warning for 5500 Series Controllers and 4400 Series Controllers in Japan

Warning **This is a Class A product based on the standard of the Voluntary Control Council for Interference by Information Technology Equipment (VCCI). If this equipment is used in a domestic environment, radio disturbance may arise. When such trouble occurs, the user may be required to take corrective actions.**

警告

VCCI Class B Warning for 2100 Series Controllers in Japan

Warning **This is a Class B product based on the standard of the Voluntary Control Council for Interference from Information Technology Equipment (VCCI). If this is used near a radio or television receiver in a domestic environment, it may cause radio interference. Install and use the equipment according to the instruction manual.**

警告

Power Cable and AC Adapter Warning for Japan

Warning **When installing the product, please use the provided or designated connection cables/power cables/AC adaptors. Using any other cables/adaptors could cause a malfunction or a fire. Electrical Appliance and Material Safety Law prohibits the use of UL-certified cables (that have the "UL" shown on the code) for any other electrical devices than products designated by CISCO. The use of cables that are certified by Electrical Appliance and Material Safety Law (that have "PSE" shown on the code) is not limited to CISCO-designated products.**

警告

Guidelines for Operating Controllers and Access Points in Japan

This section provides guidelines for avoiding interference when operating controllers and access points in Japan. These guidelines are provided in both Japanese and English.

Japanese Translation

English Translation

This equipment operates in the same frequency bandwidth as industrial, scientific, and medical devices such as microwave ovens and mobile object identification (RF-ID) systems (licensed premises radio stations and unlicensed specified low-power radio stations) used in factory production lines.

1. Before using this equipment, make sure that no premises radio stations or specified low-power radio stations of RF-ID are used in the vicinity.
2. If this equipment causes RF interference to a premises radio station of RF-ID, promptly change the frequency or stop using the device; contact the number below and ask for recommendations on avoiding radio interference, such as setting partitions.
3. If this equipment causes RF interference to a specified low-power radio station of RF-ID, contact the number below.

   Contact Number: 03-5549-6500

Administrative Rules for Cisco Aironet Access Points in Taiwan

This section provides administrative rules for operating Cisco Aironet access points in Taiwan. The rules are provided in both Chinese and English.

Access Points with IEEE 802.11a Radios

Chinese Translation

本設備限於室內使用

English Translation

This equipment is limited for indoor use.

All Access Points

Chinese Translation

低功率電波輻射性電機管理辦法

第十二條　經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。

第十四條　低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。

前項合法通信，指依電信法規定作業之無線電信。

低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

127048

English Translation

Administrative Rules for Low-power Radio-Frequency Devices

Article 12

For those low-power radio-frequency devices that have already received a type-approval, companies, business units or users should not change its frequencies, increase its power or change its original features and functions.

Article 14

The operation of the low-power radio-frequency devices is subject to the conditions that no harmful interference is caused to aviation safety and authorized radio station; and if interference is caused, the user must stop operating the device immediately and can't re-operate it until the harmful interference is clear.

The authorized radio station means a radio-communication service operating in accordance with the Communication Act.

The operation of the low-power radio-frequency devices is subject to the interference caused by the operation of an authorized radio station, by another intentional or unintentional radiator, by industrial, scientific and medical (ISM) equipment, or by an incidental radiator.

Declaration of Conformity Statements

All the Declaration of Conformity statements related to this product can be found at the following URL:

http://www.ciscofax.com

FCC Statement for Cisco 5500 Series Wireless LAN Controllers

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case users will be required to correct the interference at their own expense.

FCC Statement for Cisco 4400 Series Wireless LAN Controllers

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Statement for Cisco 2100 Series Wireless LAN Controllers

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help. [cfr reference 15.105]

End User License and Warranty

This appendix describes the end user license and warranty that apply to the Cisco UWN Solution products:

- Cisco 2100 Series Wireless LAN Controllers
- Cisco 4400 Series Wireless LAN Controllers
- Cisco 5500 Series Wireless LAN Controllers
- Cisco Wireless Services Modules

This appendix contains these sections:

End User License Agreement

IMPORTANT: PLEASE READ THIS END USER LICENSE AGREEMENT CAREFULLY. DOWNLOADING, INSTALLING OR USING CISCO OR CISCO-SUPPLIED SOFTWARE CONSTITUTES ACCEPTANCE OF THIS AGREEMENT.

CISCO IS WILLING TO LICENSE THE SOFTWARE TO YOU ONLY UPON THE CONDITION THAT YOU ACCEPT ALL OF THE TERMS CONTAINED IN THIS LICENSE AGREEMENT. BY DOWNLOADING OR INSTALLING THE SOFTWARE, OR USING THE EQUIPMENT THAT CONTAINS THIS SOFTWARE, YOU ARE BINDING YOURSELF AND THE BUSINESS ENTITY THAT YOU REPRESENT (COLLECTIVELY, "CUSTOMER") TO THIS AGREEMENT. IF YOU DO NOT AGREE TO ALL OF THE TERMS OF THIS AGREEMENT, THEN CISCO IS UNWILLING TO LICENSE THE SOFTWARE TO YOU AND (A) DO NOT DOWNLOAD, INSTALL OR USE THE SOFTWARE, AND (B) YOU MAY RETURN THE SOFTWARE FOR A FULL REFUND, OR, IF THE SOFTWARE IS SUPPLIED AS PART OF ANOTHER PRODUCT, YOU MAY RETURN THE ENTIRE PRODUCT FOR A FULL REFUND. YOUR RIGHT TO RETURN AND REFUND EXPIRES 30 DAYS AFTER PURCHASE FROM CISCO OR AN AUTHORIZED CISCO RESELLER, AND APPLIES ONLY IF YOU ARE THE ORIGINAL END USER PURCHASER.

The following terms of this End User License Agreement ("Agreement") govern Customer's access and use of the Software, except to the extent (a) there is a separate signed agreement between Customer and Cisco governing Customer's use of the Software or (b) the Software includes a separate "click-accept" license agreement as part of the installation and/or download process. To the extent of a conflict between the provisions of the foregoing documents, the order of precedence shall be (1) the signed agreement, (2) the click-accept agreement, and (3) this End User License Agreement.

License. Conditioned upon compliance with the terms and conditions of this Agreement, Cisco Systems, Inc. or its subsidiary licensing the Software instead of Cisco Systems, Inc. ("Cisco"), grants to Customer a nonexclusive and nontransferable license to use for Customer's internal business purposes the Software and the Documentation for which Customer has paid the required license fees. "Documentation" means written information (whether contained in user or technical manuals, training materials, specifications or otherwise) specifically pertaining to the Software and made available by Cisco with the Software in any manner (including on CD-ROM, or on-line).

Customer's license to use the Software shall be limited to, and Customer shall not use the Software in excess of, a single hardware chassis or card or that number of agent(s), concurrent users, sessions, IP addresses, port(s), seat(s), server(s) or site(s), as set forth in the applicable Purchase Order which has been accepted by Cisco and for which Customer has paid to Cisco the required license fee.

Unless otherwise expressly provided in the Documentation, Customer shall use the Software solely as embedded in, for execution on, or (where the applicable documentation permits installation on non-Cisco equipment) for communication with Cisco equipment owned or leased by Customer and used for Customer's internal business purposes. NOTE: For evaluation or beta copies for which Cisco does not charge a license fee, the above requirement to pay license fees does not apply.

General Limitations. This is a license, not a transfer of title, to the Software and Documentation, and Cisco retains ownership of all copies of the Software and Documentation. Customer acknowledges that the Software and Documentation contain trade secrets of Cisco, its suppliers or licensors, including but not limited to the specific internal design and structure of individual programs and associated interface information. Accordingly, except as otherwise expressly provided under this Agreement, Customer shall have no right, and Customer specifically agrees not to:

(i) transfer, assign or sublicense its license rights to any other person or entity, or use the Software on unauthorized or secondhand Cisco equipment, and Customer acknowledges that any attempted transfer, assignment, sublicense or use shall be void;

(ii) make error corrections to or otherwise modify or adapt the Software or create derivative works based upon the Software, or permit third parties to do the same;

(iii) reverse engineer or decompile, decrypt, disassemble or otherwise reduce the Software to human-readable form, except to the extent otherwise expressly permitted under applicable law notwithstanding this restriction;

(iv) use or permit the Software to be used to perform services for third parties, whether on a service bureau or time sharing basis or otherwise, without the express written authorization of Cisco; or

(v) disclose, provide, or otherwise make available trade secrets contained within the Software and Documentation in any form to any third party without the prior written consent of Cisco. Customer shall implement reasonable security measures to protect such trade secrets; or

(vi) use the Software to develop any software application intended for resale which employs the Software.

To the extent required by law, and at Customer's written request, Cisco shall provide Customer with the interface information needed to achieve interoperability between the Software and another independently created program, on payment of Cisco's applicable fee, if any. Customer shall observe strict obligations of confidentiality with respect to such information and shall use such information in compliance with any applicable terms and conditions upon which Cisco makes such information available. Customer is granted no implied licenses to any other intellectual property rights other than as specifically granted herein.

Software, Upgrades and Additional Copies. For purposes of this Agreement, “Software” shall include (and the terms and conditions of this Agreement shall apply to) computer programs, including firmware, as provided to Customer by Cisco or an authorized Cisco reseller, and any upgrades, updates, bug fixes or modified versions thereto (collectively, “Upgrades”) or backup copies of the Software licensed or provided to Customer by Cisco or an authorized Cisco reseller. NOTWITHSTANDING ANY OTHER PROVISION OF THIS AGREEMENT: (1) CUSTOMER HAS NO LICENSE OR RIGHT TO USE ANY ADDITIONAL COPIES OR UPGRADES UNLESS CUSTOMER, AT THE TIME OF ACQUIRING SUCH COPY OR UPGRADE, ALREADY HOLDS A VALID LICENSE TO THE ORIGINAL SOFTWARE AND HAS PAID THE APPLICABLE FEE FOR THE UPGRADE OR ADDITIONAL COPIES; (2) USE OF UPGRADES IS LIMITED TO CISCO EQUIPMENT FOR WHICH CUSTOMER IS THE ORIGINAL END USER PURCHASER OR LESSEE OR WHO OTHERWISE HOLDS A VALID LICENSE TO USE THE SOFTWARE WHICH IS BEING UPGRADED; AND (3) THE MAKING AND USE OF ADDITIONAL COPIES IS LIMITED TO NECESSARY BACKUP PURPOSES ONLY.

Proprietary Notices. Customer agrees to maintain and reproduce all copyright and other proprietary notices on all copies, in any form, of the Software in the same form and manner that such copyright and other proprietary notices are included on the Software. Except as expressly authorized in this Agreement, Customer shall not make any copies or duplicates of any Software without the prior written permission of Cisco.

Open Source Content. Customer acknowledges that the Software contains open source or publicly available content under separate license and copyright requirements which are located either in an attachment to this license, the Software README file or the Documentation. Customer agrees to comply with such separate license and copyright requirements.

Third Party Beneficiaries. Certain Cisco or Cisco affiliate suppliers are intended third party beneficiaries of this Agreement. The terms and conditions herein are made expressly for the benefit of and are enforceable by Cisco’s suppliers; provided, however, that suppliers are not in any contractual relationship with Customer. Cisco’s suppliers include without limitation: (a) Hifn, Inc., a Delaware corporation with principal offices at 750 University Avenue, Los Gatos, California and (b) Wind River Systems, Inc., and its suppliers. Additional suppliers may be provided in subsequent updates of Documentation supplied to Customer.

Term and Termination. This Agreement and the license granted herein shall remain effective until terminated. Customer may terminate this Agreement and the license at any time by destroying all copies of Software and any Documentation. Customer's rights under this Agreement will terminate immediately without notice from Cisco if Customer fails to comply with any provision of this Agreement. Cisco and its suppliers are further entitled to obtain injunctive relief if Customer's use of the Software is in violation of any license restrictions. Upon termination, Customer shall destroy all copies of Software and Documentation in its possession or control. All confidentiality obligations of Customer and all limitations of liability and disclaimers and restrictions of warranty shall survive termination of this Agreement. In addition, the provisions of the sections titled "U.S. Government End User Purchasers" and "General Terms Applicable to the Limited Warranty Statement and End User License" shall survive termination of this Agreement.

Customer Records. Customer grants to Cisco and its independent accountants the right to examine Customer's books, records and accounts during Customer's normal business hours to verify compliance with this Agreement. In the event such audit discloses non-compliance with this Agreement, Customer shall promptly pay to Cisco the appropriate license fees, plus the reasonable cost of conducting the audit.

Export. Software and Documentation, including technical data, may be subject to U.S. export control laws, including the U.S. Export Administration Act and its associated regulations, and may be subject to export or import regulations in other countries. Customer agrees to comply strictly with all such regulations and acknowledges that it has the responsibility to obtain licenses to export, re-export, or import Software and Documentation. Customer's failure to comply with such restrictions shall constitute a material breach of the Agreement.

U.S. Government End User Purchasers. The Software and Documentation qualify as "commercial items," as that term is defined at Federal Acquisition Regulation ("FAR") (48 C.F.R.) 2.101, consisting of "commercial computer software" and "commercial computer software documentation" as such terms are used in FAR 12.212. Consistent with FAR 12.212 and DoD FAR Supp. 227.7202-1 through 227.7202-4, and notwithstanding any other FAR or other contractual clause to the contrary in any agreement into which this End User License Agreement may be incorporated, Customer may provide to Government end user or, if this Agreement is direct, Government end user will acquire, the Software and Documentation with only those rights set forth in this End User License Agreement. Use of either the Software or Documentation or both constitutes agreement by the Government that the Software and Documentation are "commercial computer software" and "commercial computer software documentation," and constitutes acceptance of the rights and restrictions herein.

Limited Warranty

Hardware for Cisco 2100 Series Wireless LAN Controllers, Cisco 4400 Series Wireless LAN Controllers, Cisco 5500 Series Wireless LAN Controllers, and Cisco Wireless Services Modules. Cisco Systems, Inc., or the Cisco Systems, Inc. subsidiary selling the Product ("Cisco") warrants that commencing from the date of shipment to Customer (and in case of resale by a Cisco reseller, commencing not more than ninety (90) days after original shipment by Cisco), and continuing for a period of ninety (90) days, the Hardware will be free from defects in material and workmanship under normal use. The date of shipment of a Product by Cisco is set forth on the packaging material in which the Product is shipped. This limited warranty extends only to the original user of the Product. Customer's sole and exclusive remedy and the entire liability of Cisco and its suppliers under this limited warranty will be, at Cisco's or its service center's option, shipment of a replacement within the warranty period and according to the replacement process described in the Warranty Card (if any), or if no Warranty Card, as described at http://www.cisco.com/c/en/us/products/warranty-listing.html or a refund of the purchase price if the Hardware is returned to the party supplying it to Customer, freight and insurance prepaid. Cisco replacement parts used in Hardware replacement may be new or equivalent to new. Cisco's obligations hereunder are conditioned upon the return of affected Hardware in accordance with Cisco's or its service center's then-current Return Material Authorization (RMA) procedures.

Software. Cisco warrants that commencing from the date of shipment to Customer (but in case of resale by an authorized Cisco reseller, commencing not more than ninety (90) days after original shipment by Cisco), and continuing for a period of the longer of (a) ninety (90) days or (b) the software warranty period (if any) set forth in the warranty card accompanying the Product (if any): (a) the media on which the Software is furnished will be free of defects in materials and workmanship under normal use; and (b) the Software substantially conforms to its published specifications. The date of shipment of a Product by Cisco is set forth on the packaging material in which the Product is shipped. Except for the foregoing, the Software is provided AS IS. This limited warranty extends only to the Customer who is the original licensee. Customer's sole and exclusive remedy and the entire liability of Cisco and its suppliers and licensors under this limited warranty will be, at Cisco's option, repair, replacement, or refund of the Software if reported (or, upon request, returned) to Cisco or the party supplying the Software to Customer. In no event does Cisco warrant that the Software is error free or that Customer will be able to operate the Software without problems or interruptions. In addition, due to the continual development of new techniques for intruding upon and attacking networks, Cisco does not warrant that the Software or any equipment, system or network on which the Software is used will be free of vulnerability to intrusion or attack.

Restrictions. This warranty does not apply if the Software, Product or any other equipment upon which the Software is authorized to be used (a) has been altered, except by Cisco or its authorized representative, (b) has not been installed, operated, repaired, or maintained in accordance with instructions supplied by Cisco, (c) has been subjected to abnormal physical or electrical stress, misuse, negligence, or accident; or (d) is licensed, for beta, evaluation, testing or demonstration purposes for which Cisco does not charge a purchase price or license fee.

Disclaimer of Warranty

EXCEPT AS SPECIFIED IN THIS WARRANTY, ALL EXPRESS OR IMPLIED CONDITIONS, REPRESENTATIONS, AND WARRANTIES INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT, SATISFACTORY QUALITY, NON-INTERFERENCE, ACCURACY OF INFORMATIONAL CONTENT, OR ARISING FROM A COURSE OF DEALING, LAW, USAGE, OR TRADE PRACTICE, ARE HEREBY EXCLUDED TO THE EXTENT ALLOWED BY APPLICABLE LAW AND ARE EXPRESSLY DISCLAIMED BY CISCO, ITS SUPPLIERS AND LICENSORS. TO THE EXTENT AN IMPLIED WARRANTY CANNOT BE EXCLUDED, SUCH WARRANTY IS LIMITED IN DURATION TO THE EXPRESS WARRANTY PERIOD. BECAUSE SOME STATES OR JURISDICTIONS DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, THE ABOVE LIMITATION MAY NOT APPLY. THIS WARRANTY GIVES CUSTOMER SPECIFIC LEGAL RIGHTS, AND CUSTOMER MAY ALSO HAVE OTHER RIGHTS WHICH VARY FROM JURISDICTION TO JURISDICTION. This disclaimer and exclusion shall apply even if the express warranty set forth above fails of its essential purpose.

General Terms Applicable to the Limited Warranty Statement and End User License Agreement

Disclaimer of Liabilities. REGARDLESS WHETHER ANY REMEDY SET FORTH HEREIN FAILS OF ITS ESSENTIAL PURPOSE OR OTHERWISE, IN NO EVENT WILL CISCO OR ITS SUPPLIERS BE LIABLE FOR ANY LOST REVENUE, PROFIT, OR LOST OR DAMAGED DATA, BUSINESS INTERRUPTION, LOSS OF CAPITAL, OR FOR SPECIAL, INDIRECT, CONSEQUENTIAL, INCIDENTAL, OR PUNITIVE DAMAGES HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY OR WHETHER ARISING OUT OF THE USE OF OR INABILITY TO USE SOFTWARE OR OTHERWISE AND EVEN IF CISCO OR ITS SUPPLIERS OR LICENSORS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. In no event shall Cisco's or its suppliers' or licensors' liability to Customer, whether in contract, tort (including negligence), breach of warranty, or otherwise, exceed the price paid by Customer for the Software that gave rise to the claim or if the Software is part of another Product, the price paid for such other Product. BECAUSE SOME STATES OR JURISDICTIONS DO NOT ALLOW LIMITATION OR EXCLUSION OF CONSEQUENTIAL OR INCIDENTAL DAMAGES, THE ABOVE LIMITATION MAY NOT APPLY TO YOU.

Customer agrees that the limitations of liability and disclaimers set forth herein will apply regardless of whether Customer has accepted the Software or any other product or service delivered by Cisco. Customer acknowledges and agrees that Cisco has set its prices and entered into this Agreement in reliance upon the disclaimers of warranty and the limitations of liability set forth herein, that the same reflect an allocation of risk between the parties (including the risk that a contract remedy may fail of its essential purpose and cause consequential loss), and that the same form an essential basis of the bargain between the parties.

The Warranty and the End User License shall be governed by and construed in accordance with the laws of the State of California, without reference to or application of choice of law rules or principles. The United Nations Convention on the International Sale of Goods shall not apply. If any portion hereof is found to be void or unenforceable, the remaining provisions of the Agreement shall remain in full force and effect. Except as expressly provided herein, this Agreement constitutes the entire agreement between the parties with respect to the license of the Software and Documentation and supersedes any conflicting or additional terms contained in any purchase order or elsewhere, all of which terms are excluded. This Agreement has been written in the English language, and the parties agree that the English version will govern. For warranty or license terms which may apply in particular countries and for translations of the above information please contact the Cisco Legal Department, 300 E. Tasman Drive, San Jose, California 95134.

Notices and Disclaimers

This section contains notices and disclaimers that pertain to Cisco controllers.

Notices

The following notices pertain to this software license.

OpenSSL/Open SSL Project

This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (http://www.openssl.org/).

This product includes cryptographic software written by Eric Young (eay@cryptsoft.com).

This product includes software written by Tim Hudson (tjh@cryptsoft.com).

License Issues

The OpenSSL toolkit stays under a dual license, i.e. both the conditions of the OpenSSL License and the original SSLeay license apply to the toolkit. See below for the actual license texts. Actually both licenses are BSD-style Open Source licenses. In case of any license issues related to OpenSSL please contact openssl-core@openssl.org.

OpenSSL License:

Copyright © 1998-2007 The OpenSSL Project. All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions, and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. All advertising materials mentioning features or use of this software must display the following acknowledgment: "This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (http://www.openssl.org/)".
4. The names "OpenSSL Toolkit" and "OpenSSL Project" must not be used to endorse or promote products derived from this software without prior written permission. For written permission, please contact openssl-core@openssl.org.
5. Products derived from this software may not be called "OpenSSL" nor may "OpenSSL" appear in their names without prior written permission of the OpenSSL Project.
6. Redistributions of any form whatsoever must retain the following acknowledgment:

   "This product includes software developed by the OpenSSL Project for use in the OpenSSL Toolkit (http://www.openssl.org/)".

THIS SOFTWARE IS PROVIDED BY THE OpenSSL PROJECT "AS IS"' AND ANY EXPRESSED OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE OpenSSL PROJECT OR ITS CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

This product includes cryptographic software written by Eric Young (eay@cryptsoft.com). This product includes software written by Tim Hudson (tjh@cryptsoft.com).

Original SSLeay License:

This package is an SSL implementation written by Eric Young (eay@cryptsoft.com).

The implementation was written so as to conform with Netscapes SSL.

This library is free for commercial and non-commercial use as long as the following conditions are adhered to. The following conditions apply to all code found in this distribution, be it the RC4, RSA, lhash, DES, etc., code; not just the SSL code. The SSL documentation included with this distribution is covered by the same copyright terms except that the holder is Tim Hudson (tjh@cryptsoft.com).

Copyright remains Eric Young's, and as such any Copyright notices in the code are not to be removed. If this package is used in a product, Eric Young should be given attribution as the author of the parts of the library used. This can be in the form of a textual message at program startup or in documentation (online or textual) provided with the package.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. All advertising materials mentioning features or use of this software must display the following acknowledgement:

   "This product includes cryptographic software written by Eric Young (eay@cryptsoft.com)".

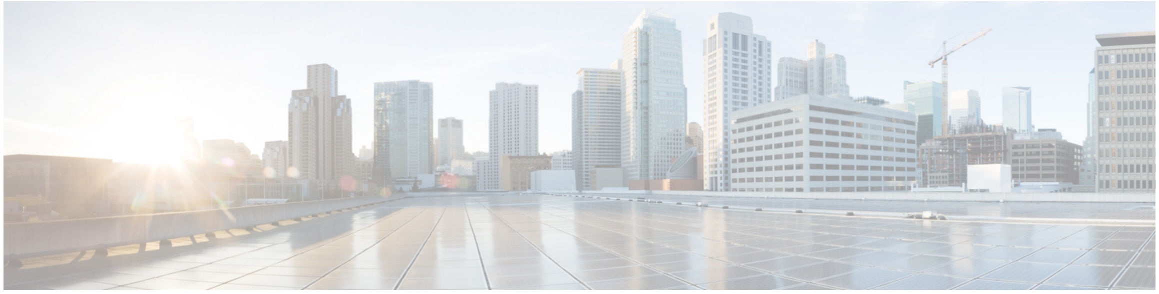
   The word 'cryptographic' can be left out if the routines from the library being used are not cryptography-related.
4. If you include any Windows specific code (or a derivative thereof) from the apps directory (application code) you must include an acknowledgement: "This product includes software written by Tim Hudson (tjh@cryptsoft.com)".

THIS SOFTWARE IS PROVIDED BY ERIC YOUNG "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE AUTHOR OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

The license and distribution terms for any publicly available version or derivative of this code cannot be changed. i.e. this code cannot simply be copied and put under another distribution license [including the GNU Public License].

Disclaimers

All third party trademarks are the property of their respective owners.



D

Troubleshooting

This appendix lists system messages that can appear on the Cisco UWN Solution interfaces, describes the LED patterns on controllers and lightweight access points, and provides CLI commands that can be used to troubleshoot problems on the controller. It contains these sections:

Americas Headquarters:
Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA

Interpreting LEDs

Interpreting Controller LEDs

Refer to the quick start guide for your specific controller for a description of the LED patterns.

Interpreting Lightweight Access Point LEDs

Refer to the quick start guide or hardware installation guide for your specific access point for a description of the LED patterns.

System Messages

Table 1 lists some common system messages and their descriptions. For a complete list of system messages, refer to the *Cisco Wireless LAN Controller System Message Guide, Release 6.0*.

Table 1 System Messages and Descriptions

Error Message	Description
apf_utils.c 680: Received a CIF field without the protected bit set from mobile xx:xx:xx:xx:xx:xx	A client is sending an association request on a security-enabled WLAN with the protected bit set to 0 (in the Capability field of the association request). As designed, the controller rejects the association request, and the client sees an association failure.
dtl_arp.c 480: Got an idle-timeout message from an unknown client xx:xx:xx:xx:xx:xx	The controller's network processing unit (NPU) sends a timeout message to the central processing unit (CPU) indicating that a particular client has timed out or aged out. This normally occurs when the CPU has removed a wireless client from its internal database but has not notified the NPU. Because the client remains in the NPU database, it ages out on the network processor and notifies the CPU. The CPU finds the client that is not present in its database and then sends this message.
STATION_DISASSOCIATE	Client may have intentionally terminated usage or may have experienced a service disruption.
STATION_DEAUTHENTICATE	Client may have intentionally terminated usage or it could indicate an authentication issue.
STATION_AUTHENTICATION_FAIL	Check disable, key mismatch or other configuration issues.
STATION_ASSOCIATE_FAIL	Check load on the Cisco radio or signal quality issues.
LRAD_ASSOCIATED	The associated lightweight access point is now managed by this controller.

Table 1 System Messages and Descriptions (continued)

Error Message	Description
LRAD_DISASSOCIATED	The lightweight access point may have associated to a different controller or may have become completely unreachable.
LRAD_UP	The lightweight access point is operational, no action required.
LRAD_DOWN	The lightweight access point may have a problem or is administratively disabled.
LRADIF_UP	Cisco radio is UP.
LRADIF_DOWN	Cisco radio may have a problem or is administratively disabled.
LRADIF_LOAD_PROFILE_FAILED	Client density may have exceeded system capacity.
LRADIF_NOISE_PROFILE_FAILED	The non-802.11 noise has exceed configured threshold.
LRADIF_INTERFERENCE_PROFILE_FAILED	802.11 interference has exceeded threshold on channel -- check channel assignments.
LRADIF_COVERAGE_PROFILE_FAILED	Possible coverage hole detected. Check the lightweight access point history to see if it is a common problem and add lightweight access points if necessary.
LRADIF_LOAD_PROFILE_PASSED	Load is now within threshold limits.
LRADIF_NOISE_PROFILE_PASSED	Detected noise is now less than threshold.
LRADIF_INTERFERENCE_PROFILE_PASSED	Detected interference is now less than threshold.
LRADIF_COVERAGE_PROFILE_PASSED	Number of clients receiving poor signal are within threshold.
LRADIF_CURRENT_TXPOWER_CHANGED	Informational message.
LRADIF_CURRENT_CHANNEL_CHANGED	Informational message.
LRADIF_RTS_THRESHOLD_CHANGED	Informational message.
LRADIF_ED_THRESHOLD_CHANGED	Informational message.
LRADIF_FRAGMENTATION_THRESHOLD_ CHANGED	Informational message.
RRM_DOT11_A_GROUPING_DONE	Informational message.
RRM_DOT11_B_GROUPING_DONE	Informational message.
ROGUE_AP_DETECTED	May be a security issue.Use maps and trends to investigate.
ROGUE_AP_REMOVED	Detected rogue access point has timed out. The unit might have shut down or moved out of the coverage area.
AP_MAX_ROGUE_COUNT_EXCEEDED	The current number of active rogue access points has exceeded system threshold.
LINK_UP	Positive confirmation message.

Table 1 System Messages and Descriptions (continued)

Error Message	Description
LINK_DOWN	Port may have a problem or is administratively disabled.
LINK_FAILURE	Port may have a problem or is administratively disabled.
AUTHENTICATION_FAILURE	Attempted security breech. Investigate.
STP_NEWROOT	Informational message.
STP_TOPOLOGY_CHANGE	Informational message.
IPSEC_ESP_AUTH_FAILURE	Check WLAN IPSec configuration.
IPSEC_ESP_REPLAY_FAILURE	Check for attempt to spoof IP Address.
IPSEC_ESP_POLICY_FAILURE	Check for IPSec configuration mismatch between WLAN and client.
IPSEC_ESP_INVALID_SPI	Informational message.
IPSEC_OTHER_POLICY_FAILURE	Check for IPSec configuration mismatch between WLAN and client.
IPSEC_IKE_NEG_FAILURE	Check for IPSec IKE configuration mismatch between WLAN and client.
IPSEC_SUITE_NEG_FAILURE	Check for IPSec IKE configuration mismatch between WLAN and client.
IPSEC_INVALID_COOKIE	Informational message.
RADIOS_EXCEEDED	Maximum number of supported Cisco radios exceeded. Check for controller failure in the same Layer 2 network or add another controller.
SENSED_TEMPERATURE_HIGH	Check fan, air conditioning and/or other cooling arrangements.
SENSED_TEMPERATURE_LOW	Check room temperature and/or other reasons for low temperature.
TEMPERATURE_SENSOR_FAILURE	Replace temperature sensor ASAP.
TEMPERATURE_SENSOR_CLEAR	Temperature sensor is operational.
POE_CONTROLLER_FAILURE	Check ports — possible serious failure detected.
MAX_ROGUE_COUNT_EXCEEDED	The current number of active rogue access points has exceeded system threshold.
SWITCH_UP	Controller is responding to SNMP polls.
SWITCH_DOWN	Controller is not responding to SNMP polls, check controller and SNMP settings.
RADIUS_SERVERS_FAILED	Check network connectivity between RADIUS and the controller.
CONFIG_SAVED	Running configuration has been saved to flash - will be active after reboot.
MULTIPLE_USERS	Another user with the same username has logged in.

Table 1 System Messages and Descriptions (continued)

Error Message	Description
FAN_FAILURE	Monitor controller temperature to avoid overheating.
POWER_SUPPLY_CHANGE	Check for power-supply malfunction.
COLD_START	The controller may have been rebooted.
WARM_START	The controller may have been rebooted.

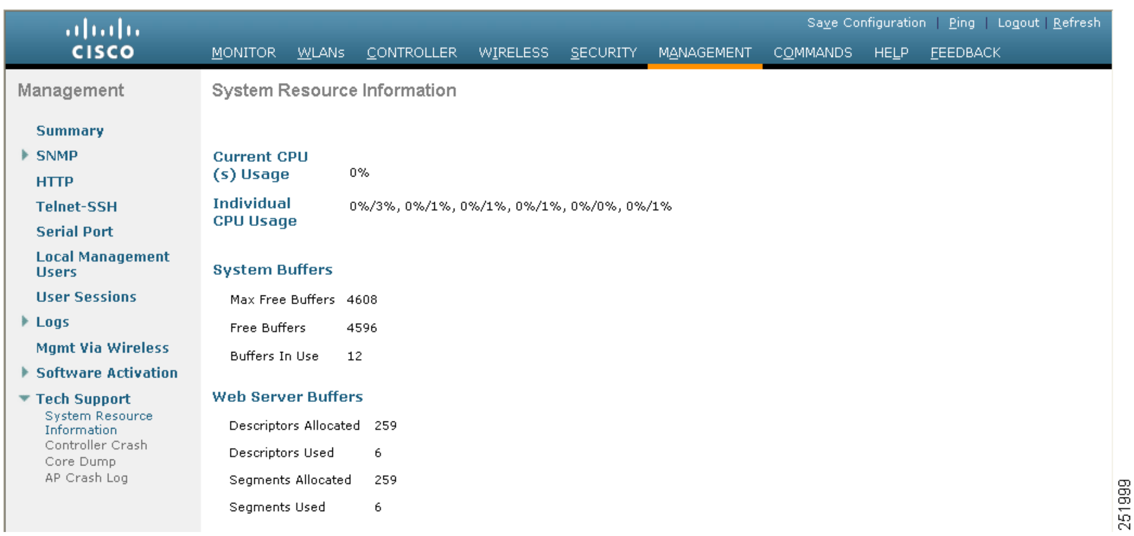
Viewing System Resources

You can use the GUI or CLI to determine the amount of system resources being used by the controller. Specifically, you can view the current controller CPU usage, system buffers, and web server buffers.

Note The 5500 series controllers have multiple CPUs, so you can view individual CPU usage. For each CPU, you can see the percentage of the CPU in use and the percentage of the CPU time spent at the interrupt level (for example, 0%/3%).

On the controller GUI, choose **Management** > **Tech Support** > **System Resource Information**. The System Resource Information page appears (see Figure 1).

Figure 1 System Resource Information Page



On the controller CLI, enter these commands:

- **show cpu**

  Information similar to the following appears:

```
Current CPU(s) load: 0%
Individual CPU load: 0%/3%, 0%/1%, 0%/1%, 0%/1%, 0%/0%, 0%/1%
```

- **show tech-support**

  Information similar to the following appears:

```
System Information
Manufacturer's Name............................. Cisco Systems Inc.
Product Name.................................... Cisco Controller
Product Version............................. 6.0.165.0
...
---------------Show cpu---------------
Current CPU(s) Load............................. 0%
Individual CPU Load............................. 0%/3%, 0%/1%, 0%/1%, 0%/1%, 0%/0%,
0%/1%

---------------Show system buffers---------------

System Buffers
   Max Free Buffers............................. 4608
   Free Buffers................................. 4596
   Buffers In Use............................... 12

Web Server Resources
   Descriptors Allocated........................ 259
   Descriptors Used............................. 4
   Segments Allocated........................... 259
   Segments Used................................ 4

System Resources
   Uptime....................................... 595748 Secs
   Total Ram................................. 907872 Kbytes
...
```

Using the CLI to Troubleshoot Problems

If you experience any problems with your controller, you can use the commands in this section to gather information and debug issues.

1. **show process cpu**—Shows how various tasks in the system are using the CPU at that instant in time. This command is helpful in understanding if any single task is monopolizing the CPU and preventing other tasks from being performed.

   Information similar to the following appears:

```
Name                Priority      CPU Use      Reaper
 reaperWatcher       ( 3/124)     0 %         (  0/  0)%   I
 osapiReaper          (10/121)    0 %         (  0/  0)%   I
 TempStatus          (255/  1)    0 %         (  0/  0)%   I
 emWeb               (255/  1)    0 %         (  0/  0)%   T 300
 cliWebTask          (255/  1)    0 %         (  0/  0)%   I
 UtilTask            (255/  1)    0 %         (  0/  0)%   T 300
```

In the example above, the following fields provide information:

- The Name field shows the tasks that the CPU is to perform.
- The Priority field shows two values: 1) the original priority of the task that was created by the actual function call and 2) the priority of the task divided by a range of system priorities.
- The CPU Use field shows the CPU usage of a particular task.
- The Reaper field shows three values: 1) the amount of time for which the task is scheduled in user mode operation, 2) the amount of time for which the task is scheduled in system mode operation, and 3) whether the task is being watched by the reaper task monitor (indicated by a "T"). If the task is being watched by the reaper task monitor, this field also shows the timeout value (in seconds) before which the task needs to alert the task monitor.

Note If you want to see the total CPU usage as a percentage, enter the **show cpu** command.

2. **show process memory**—Shows the allocation and deallocation of memory from various processes in the system at that instant in time.

   Information similar to the following appears:

```
Name                Priority     BytesInUse  BlocksInUse  Reaper
 reaperWatcher        ( 3/124)     0           0           (   0/   0)%    I
 osapiReaper          (10/121)     0           0           (   0/   0)%    I
 TempStatus          (255/   1)    308         1           (   0/   0)%    I
 emWeb               (255/   1)    294440      4910        (   0/   0)%  T 300
 cliWebTask          (255/   1)    738         2           (   0/   0)%    I
 UtilTask            (255/   1)    308         1           (   0/   0)%  T 300
```

   In the example above, the following fields provide information:

   - The Name field shows the tasks that the CPU is to perform.
   - The Priority field shows two values: 1) the original priority of the task that was created by the actual function call and 2) the priority of the task divided by a range of system priorities.
   - The BytesInUse field shows the actual number of bytes used by dynamic memory allocation for a particular task.
   - The BlocksInUse field shows the chunks of memory that are assigned to perform a particular task.
   - The Reaper field shows three values: 1) the amount of time for which the task is scheduled in user mode operation, 2) the amount of time for which the task is scheduled in system mode operation, and 3) whether the task is being watched by the reaper task monitor (indicated by a "T"). If the task is being watched by the reaper task monitor, this field also shows the timeout value (in seconds) before which the task needs to alert the task monitor.

3. **show tech-support**—Shows an array of information related to the state of the system, including the current configuration, last crash file, CPU utilization, and memory utilization.
4. **show run-config**—Shows the complete configuration of the controller. To exclude access point configuration settings, use the **show run-config no-ap** command.

Note If you want to see the passwords in clear text, enter **config passwd-cleartext enable**. To execute this command, you must enter an admin password. This command is valid only for this particular session. It is not saved following a reboot.

5. **show run-config commands**—Shows the list of configured commands on the controller. This command shows only values configured by the user. It does not show system-configured default values.

Configuring System and Message Logging

System logging allows controllers to log their system events to up to three remote syslog servers. The controller sends a copy of each syslog message as it is logged to each syslog server configured on the controller. Being able to send the syslog messages to multiple servers ensures that the messages are not lost due to the temporary unavailability of one syslog server. Message logging allows system messages to be logged to the controller buffer or console.

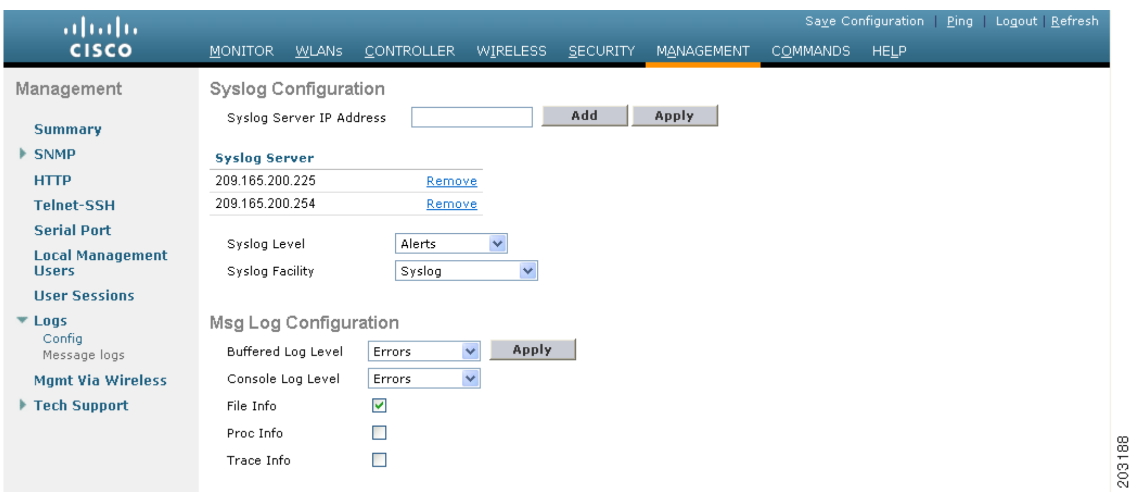
You can use the controller GUI or CLI to configure system and message logging.

Using the GUI to Configure System and Message Logging

Using the GUI, follow these steps to configure system and message logging.

Step 1 Choose **Management** > **Logs** > **Config**. The Syslog Configuration page appears (see Figure 2).

Figure 2 Syslog Configuration Page



Step 2 In the Syslog Server IP Address field, enter the IP address of the server to which to send the syslog messages and click **Add**. You can add up to three syslog servers to the controller. The list of syslog servers that have already been added to the controller appears below this field.

Note If you ever want to remove a syslog server from the controller, click **Remove** to the right of the desired server.

Step 3 To set the severity level for filtering syslog messages to the syslog servers, choose one of the following options from the Syslog Level drop-down box:

- **Emergencies** = Severity level 0
- **Alerts** = Severity level 1 (default value)
- **Critical** = Severity level 2
- **Errors** = Severity level 3
- **Warnings** = Severity level 4
- **Notifications** = Severity level 5
- **Informational** = Severity level 6
- **Debugging** = Severity level 7

If you set a syslog level, only those messages whose severity is equal to or less than that level are sent to the syslog servers. For example, if you set the syslog level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are sent to the syslog servers.

Step 4 To set the facility for outgoing syslog messages to the syslog servers, choose one of the following options from the Syslog Facility drop-down box:

- **Kernel** = Facility level 0
- **User Process** = Facility level 1
- **Mail** = Facility level 2
- **System Daemons** = Facility level 3
- **Authorization** = Facility level 4
- **Syslog** = Facility level 5 (default value)
- **Line Printer** = Facility level 6
- **USENET** = Facility level 7
- **Unix-to-Unix Cop**y = Facility level 8
- **Cron** = Facility level 9
- **FTP Daemon** = Facility level 11
- **System Use 1** = Facility level 12
- **System Use 2** = Facility level 13
- **System Use 3** = Facility level 14
- **System Use 4** = Facility level 15
- **Local Use 0** = Facility level 16
- **Local Use 1** = Facility level 17
- **Local Use 2** = Facility level 18
- **Local Use 3** = Facility level 19
- **Local Use 4** = Facility level 20
- **Local Use 5** = Facility level 21
- **Local Use 6** = Facility level 22
- **Local Use 7** = Facility level 23

Step 5 Click **Apply** to commit your changes.

Step 6 To set the severity level for logging messages to the controller buffer and console, choose one of the following options from both the Buffered Log Level and Console Log Level drop-down boxes:

- **Emergencies** = Severity level 0
- **Alerts** = Severity level 1
- **Critical** = Severity level 2
- **Errors** = Severity level 3 (default value)
- **Warnings** = Severity level 4
- **Notifications** = Severity level 5
- **Informational** = Severity level 6
- **Debugging** = Severity level 7

If you set a logging level, only those messages whose severity is equal to or less than that level are logged by the controller. For example, if you set the logging level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are logged.

Step 7 Check the **File Info** check box if you want the message logs to include information about the source file. The default value is enabled.

Step 8 Check the **Proc Info** check box if you want the message logs to include process information. The default value is disabled.

Step 9 Check the **Trace Info** check box if you want the message logs to include traceback information. The default value is disabled.

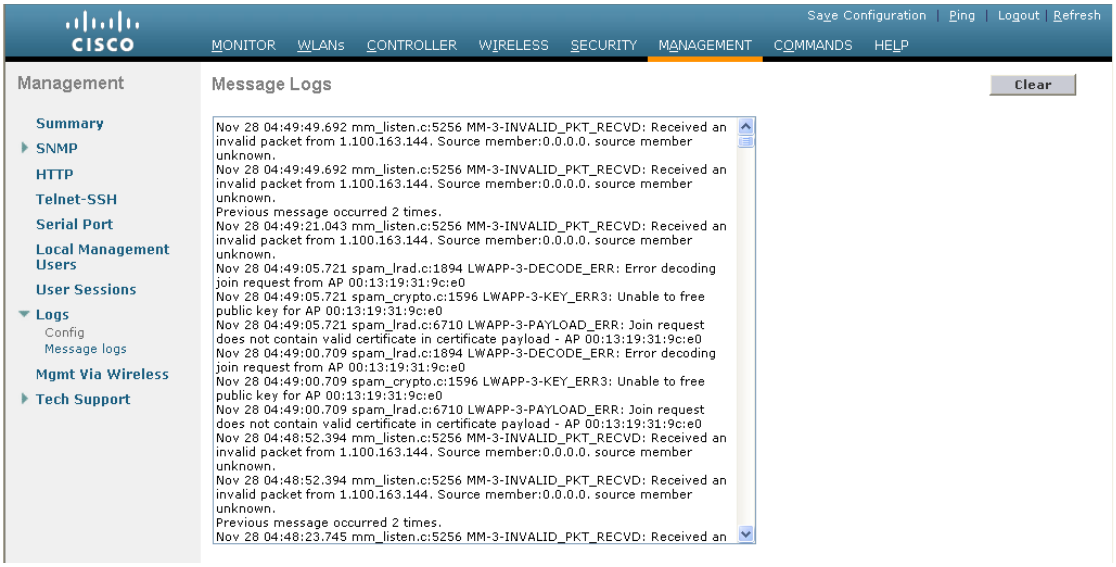
Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the GUI to View Message Logs

To view message logs using the controller GUI, choose **Management** > **Logs** > **Message Logs**. The Message Logs page appears (see Figure 3).

Figure 3 Message Logs Page



203166

Note To clear the current message logs from the controller, click **Clear**.

Using the CLI to Configure System and Message Logging

Using the CLI, follow these steps to configure system and message logging.

Step 1 To enable system logging and set the IP address of the syslog server to which to send the syslog messages, enter this command:

config logging syslog host *server_IP_address*

You can add up to three syslog servers to the controller.

Note To remove a syslog server from the controller, enter this command:
config logging syslog host *server_IP_address* **delete**

Step 2 To set the severity level for filtering syslog messages to the syslog server, enter this command:

config logging syslog level *severity_level*

where *severity_level* is one of the following:

- emergencies = Severity level 0
- alerts = Severity level 1
- critical = Severity level 2
- errors = Severity level 3
- warnings = Severity level 4
- notifications = Severity level 5

- informational = Severity level 6
- debugging = Severity level 7

Note As an alternative, you can enter a number from 0 through 7 for the *severity_level* parameter.

Note If you set a syslog level, only those messages whose severity is equal to or less than that level are sent to the syslog server. For example, if you set the syslog level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are sent to the syslog server.

Step 3 To set the severity level for filtering syslog messages for a particular access point or for all access points, enter this command:

config ap logging syslog level *severity_level* {*Cisco_AP* | **all**}

where *severity_level* is one of the following:

- emergencies = Severity level 0
- alerts = Severity level 1
- critical = Severity level 2
- errors = Severity level 3
- warnings = Severity level 4
- notifications = Severity level 5
- informational = Severity level 6
- debugging = Severity level 7

Note If you set a syslog level, only those messages whose severity is equal to or less than that level are sent to the access point. For example, if you set the syslog level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are sent to the access point.

Step 4 To set the facility for outgoing syslog messages to the syslog server, enter this command:

config logging syslog facility *facility_code*

where *facility_code* is one of the following:

- authorization = Authorization system. Facility level = 4.
- auth-private = Authorization system (private). Facility level = 10.
- cron = Cron/at facility. Facility level = 9.
- daemon = System daemons. Facility level = 3.
- ftp = FTP daemon. Facility level = 11.
- kern = Kernel. Facility level = 0.
- local0 = Local use. Facility level = 16.
- local1 = Local use. Facility level = 17.
- local2 = Local use. Facility level = 18.
- local3 = Local use. Facility level = 19.

- local4 = Local use. Facility level = 20.
- local5 = Local use. Facility level = 21.
- local6 = Local use. Facility level = 22.
- local7 = Local use. Facility level = 23.
- lpr = Line printer system. Facility level = 6.
- mail = Mail system. Facility level = 2.
- news = USENET news. Facility level = 7.
- sys12 = System use. Facility level = 12.
- sys13 = System use. Facility level = 13.
- sys14 = System use. Facility level = 14.
- sys15 = System use. Facility level = 15.
- syslog = The syslog itself. Facility level = 5.
- user = User process. Facility level = 1.
- uucp = Unix-to-Unix copy system. Facility level = 8.

Step 5 To set the severity level for logging messages to the controller buffer and console, enter these commands:

- **config logging buffered** *severity_level*
- **config logging console** *severity_level*

where *severity_level* is one of the following:

- emergencies = Severity level 0
- alerts = Severity level 1
- critical = Severity level 2
- errors = Severity level 3
- warnings = Severity level 4
- notifications = Severity level 5
- informational = Severity level 6
- debugging = Severity level 7

Note As an alternative, you can enter a number from 0 through 7 for the *severity_level* parameter.

Note If you set a logging level, only those messages whose severity is equal to or less than that level are logged by the controller. For example, if you set the logging level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are logged.

Step 6 To save debug messages to the controller buffer, the controller console, or a syslog server, enter these commands:

- **config logging debug buffered** {**enable** | **disable**}
- **config logging debug console** {**enable** | **disable**}
- **config logging debug syslog** {**enable** | **disable**}

By default, the console command is enabled, and the buffered and syslog commands are disabled.

Step 7 To cause the controller to include information about the source file in the message logs or to prevent the controller from displaying this information, enter this command:

config logging fileinfo {**enable** | **disable**}

The default value is enabled.

Step 8 To cause the controller to include process information in the message logs or to prevent the controller from displaying this information, enter this command:

config logging procinfo {**enable** | **disable**}

The default value is disabled.

Step 9 To cause the controller to include traceback information in the message logs or to prevent the controller from displaying this information, enter this command:

config logging traceinfo {**enable** | **disable**}

The default value is disabled.

Step 10 To enable or disable timestamps in log messages and debug messages, enter these commands:

- **config service timestamps log** {**datetime** | **disable**}
- **config service timestamps debug** {**datetime** | **disable**}

  where

  - **datetime** = Messages are timestamped with the standard date and time. This is the default value.
  - **disable** = Messages are not timestamped.

Step 11 To save your changes, enter this command:

save config

Using the CLI to View System and Message Logs

To see the logging parameters and buffer contents, enter this command:

show logging

Information similar to the following appears:

```
Logging to buffer :
- Logging of system messages to buffer :
 - Logging filter level.......................... errors
 - Number of system messages logged.............. 8716
 - Number of system messages dropped............. 2906
- Logging of debug messages to buffer ........... Disabled
 - Number of debug messages logged............... 0
 - Number of debug messages dropped.............. 0
```

```
Logging to console :
- Logging of system messages to console :
 - Logging filter level......................... errors
 - Number of system messages logged............. 0
 - Number of system messages dropped............ 11622
- Logging of debug messages to console .......... Enabled
 - Number of debug messages logged.............. 0
 - Number of debug messages dropped............. 0
Logging to syslog :
- Syslog facility................................ local0
- Logging of system messages to syslog :
 - Logging filter level......................... errors
 - Number of system messages logged............. 8716
- Number of debug messages dropped............... 0
- Number of remote syslog hosts.................. 0
  - Host 0....................................... Not Configured
  - Host 1....................................... Not Configured
  - Host 2....................................... Not Configured
Logging of traceback............................. Disabled
Logging of process information................... Disabled
Logging of source file informational............. Enabled
Timestamping of messages.........................
- Timestamping of system messages................ Enabled
 - Timestamp format............................. Date and Time
- Timestamping of debug messages................. Enabled
 - Timestamp format............................. Date and Time

Logging buffer (8722 logged, 2910 dropped)

*Mar 26 09:23:13.574: %MM-3-INVALID_PKT_RECVD: mm_listen.c:5508 Received an invalid packet
from 1.100.163.144. Source member:0.0.0.0. source member unknown.
*Mar 26 09:23:13.574: %MM-3-INVALID_PKT_RECVD: mm_listen.c:5508 Received an invalid packet
from 1.100.163.144. Source member:0.0.0.0. source member unknown.
Previous message occurred 2 times.
*Mar 26 09:22:44.925: %MM-3-INVALID_PKT_RECVD: mm_listen.c:5508 Received an invalid packet
from 1.100.163.144. Source member:0.0.0.0. source member unknown.
...
```

Viewing Access Point Event Logs

Access points log all system messages (with a severity level greater than or equal to notifications) to the access point event log. The event log can contain up to 1024 lines of messages, with up to 128 characters per line. When the event log becomes filled, the oldest message is removed to accommodate a new event message. The event log is saved in a file on the access point flash, which ensures that it is saved through a reboot cycle. To minimize the number of writes to the access point flash, the contents of the event log are written to the event log file during normal reload and crash scenarios only.

Use these CLI commands to view or clear the access point event log from the controller:

- To view the contents of the event log file for an access point that is joined to the controller, enter this command:

  show ap eventlog *Cisco_AP*

  Information similar to the following appears:

  ```
  AP event log download has been initiated
  Waiting for download to complete

  AP event log download completed.
  ```

```
 ====================== AP Event log Contents ====================
*Sep 22 11:44:00.573: %CAPWAP-5-CHANGED: CAPWAP changed state to IMAGE
*Sep 22 11:44:01.514: %LINEPROTO-5-UPDOWN: Line protocol on Interface Dot11Radio0,
changed state to down
*Sep 22 11:44:01.519: %LINEPROTO-5-UPDOWN: Line protocol on Interface Dot11Radio1,
changed state to down
*Sep 22 11:44:53.539: *** Access point reloading. Reason: NEW IMAGE DOWNLOAD ***
*Mar 1 00:00:39.078: %CAPWAP-3-ERRORLOG: Did not get log server settings from DHCP.
*Mar 1 00:00:42.142: %CDP_PD-4-POWER_OK: Full power - NEGOTIATED inline power source
*Mar 1 00:00:42.151: %LINK-3-UPDOWN: Interface Dot11Radio1, changed state to up
*Mar 1 00:00:42.158: %LINK-3-UPDOWN: Interface Dot11Radio0, changed state to up
*Mar 1 00:00:43.143: %LINEPROTO-5-UPDOWN: Line protocol on Interface Dot11Radio1,
changed state to up
*Mar 1 00:00:43.151: %LINEPROTO-5-UPDOWN: Line protocol on Interface Dot11Radio0,
changed state to up
*Mar 1 00:00:48.078: %CAPWAP-3-ERRORLOG: Could Not resolve CISCO-CAPWAP-CONTROLLER
*Mar 1 00:01:42.144: %CDP_PD-4-POWER_OK: Full power - NEGOTIATED inline power source
*Mar 1 00:01:48.121: %CAPWAP-3-CLIENTERRORLOG: Set Transport Address: no more AP
manager IP addresses remain
*Mar 1 00:01:48.122: %CAPWAP-5-CHANGED: CAPWAP changed state to JOIN
*Mar 1 00:01:48.122: %LINK-5-CHANGED: Interface Dot11Radio0, changed state to
administratively down
*Mar 1 00:01:48.122: %LINK-5-CHANGED: Interface Dot11Radio1, changed state to
administratively down
```

- To delete the existing event log and create an empty event log file for a specific access point or for all access points joined to the controller, enter this command:

  clear ap-eventlog {**specific** *Cisco_AP* | **all**}

Uploading Logs and Crash Files

Follow the instructions in this section to upload logs and crash files from the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the file upload. Keep these guidelines in mind when setting up a TFTP or FTP server:

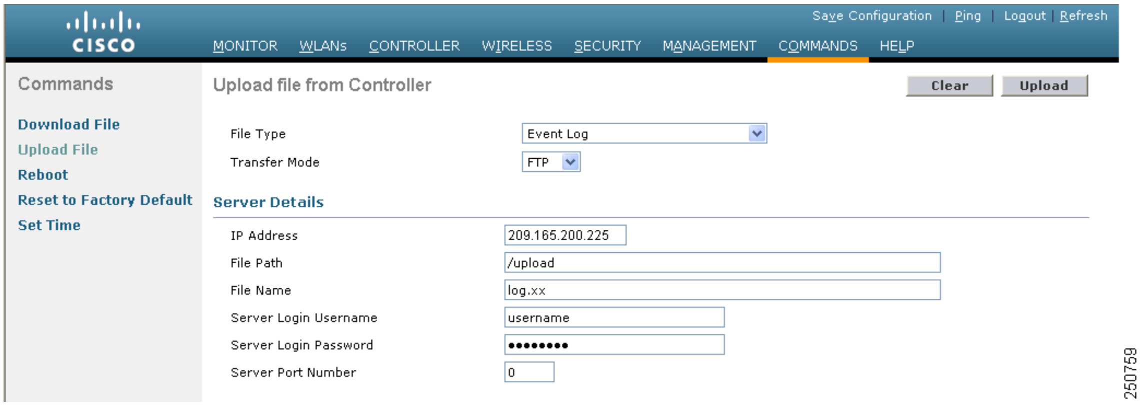
- If you are uploading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are uploading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Using the GUI to Upload Logs and Crash Files

Using the controller GUI, follow these steps to upload logs and crash files.

Step 1 Choose **Command** > **Upload File**. The Upload File from Controller page appears (see Figure 4).

Figure 4 Upload File from Controller Page



Step 2 From the File Type drop-down box, choose one of the following:

- **Event Log**
- **Message Log**
- **Trap Log**
- **Crash File**

Step 3 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 4 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 5 In the File Path field, enter the directory path of the log or crash file.

Step 6 In the File Name field, enter the name of the log or crash file.

Step 7 If you chose FTP as the Transfer Mode, follow these steps:

a. In the Server Login Username field, enter the FTP server login name.

b. In the Server Login Password field, enter the FTP server login password.

c. In the Server Port Number field, enter the port number of the FTP server. The default value for the server port is 21.

Step 8 Click **Upload** to upload the log or crash file from the controller. A message appears indicating the status of the upload.

Using the CLI to Upload Logs and Crash Files

Using the controller CLI, follow these steps to upload logs and crash files.

Step 1 To transfer the file from the controller to a TFTP or FTP server, enter this command:

transfer upload mode {**tftp** | **ftp**}

Step 2 To specify the type of file to be uploaded, enter this command:

transfer upload datatype *datatype*

where *datatype* is one of the following options:

- **crashfile**—Uploads the system's crash file.
- **errorlog**—Uploads the system's error log.
- **panic-crash-file**—Uploads the kernel panic information if a kernel panic occurs.
- **systemtrace**—Uploads the system's trace file.
- **traplog**—Uploads the system's trap log.
- **watchdog-crash-file**—Uploads the console dump resulting from a software-watchdog-initiated reboot of the controller following a crash. The software watchdog module periodically checks the integrity of the internal software and makes sure that the system does not stay in an inconsistent or non-operational state for a long period of time.

Step 3 To specify the path to the file, enter these commands:

- **transfer upload serverip** *server_ip_address*
- **transfer upload path** *server_path_to_file*
- **transfer upload filename** *filename*

Step 4 If you are using an FTP server, also enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 5 To view the updated settings, enter this command:

transfer upload start

Step 6 When prompted to confirm the current settings and start the software upload, answer **y**.

Uploading Core Dumps from the Controller

To help troubleshoot controller crashes, you can configure the controller to automatically upload its core dump file to an FTP server after experiencing a crash, or you can upload the core dump file from the flash memory of a 5500 series controller to a TFTP or FTP server. The 5500 series controllers save the core dump file to flash memory following a crash. Follow the instructions in this section to perform one of these functions.

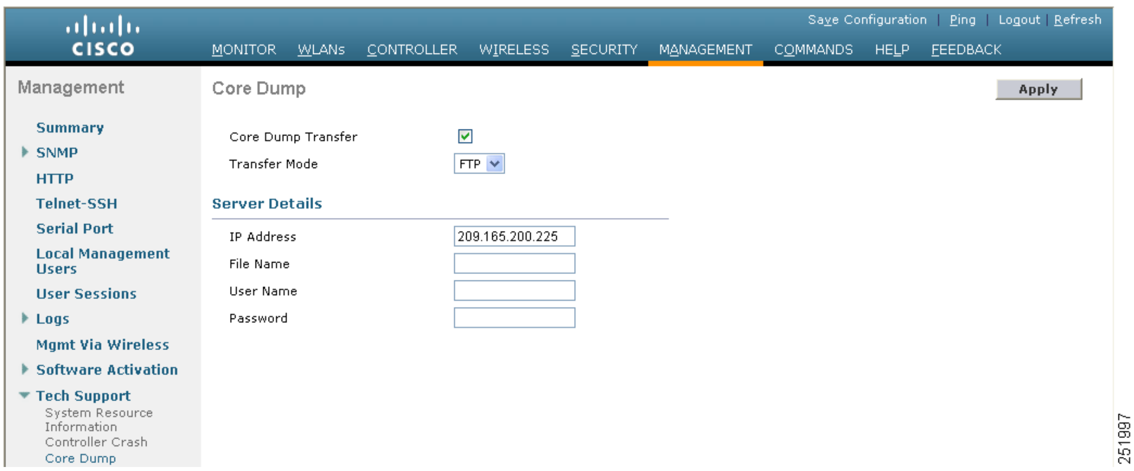
Configuring the Controller to Automatically Upload Core Dumps to an FTP Server

Using the GUI to Configure the Controller to Automatically Upload Core Dumps to an FTP Server

Using the controller GUI, follow these steps to enable the controller to automatically upload a core dump file to an FTP server.

Step 1 Choose **Management** > **Tech Support** > **Core Dump** to open the Core Dump page (see Figure 5).

Figure 5 Core Dump Page



Step 2 To enable the controller to generate a core dump file following a crash, check the **Core Dump Transfer** check box.

Step 3 To specify the type of server to which the core dump file is uploaded, choose **FTP** from the Transfer Mode drop-down box.

Step 4 In the IP Address field, enter the IP address of the FTP server.

Note The controller must be able to reach the FTP server.

Step 5 In the File Name field, enter the name that the controller uses to label the core dump file.

Step 6 In the User Name field, enter the username for FTP login.

Step 7 In the Password field, enter the password for FTP login.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure the Controller to Automatically Upload Core Dumps to an FTP Server

Using the controller CLI, follow these steps to enable the controller to automatically upload a core dump file to an FTP server.

Step 1 To enable or disable the controller to generate a core dump file following a crash, enter this command:

config coredump {enable | disable}

Step 2 To specify the FTP server to which the core dump file is uploaded, enter this command:

config coredump ftp *server_ip_address filename*

where

- *server_ip_address* is the IP address of the FTP server to which the controller sends its core dump file, and

  Note The controller must be able to reach the FTP server.

- *filename* is the name that the controller uses to label the core dump file.

Step 3 To specify the username and password for FTP login, enter this command:

config coredump username *ftp_username* **password** *ftp_password*

Step 4 To save your changes, enter this command:

save config

Step 5 To see a summary of the controller's core dump file, enter this command:

show coredump summary

Information similar to the following appears:

```
Core Dump is enabled

FTP Server IP.................................. 10.10.10.17
FTP Filename................................... file1
FTP Username................................... ftpuser
FTP Password................................. *********
```

Uploading Core Dumps from a 5500 Series Controller to a TFTP or FTP Server

Using the controller CLI, follow these steps to upload the core dump file from the flash memory of a 5500 series controller to a TFTP or FTP server.

Step 1 To see information about the core dump file in flash memory, enter this command:

show coredump summary

Information similar to the following appears:

```
Core Dump is disabled

Core Dump file is saved on flash

Sw Version.................................. 6.0.83.0
Time Stamp.................................. Wed Feb  4 13:23:11 2009
File Size................................... 9081788
File Name Suffix........................... filename.gz
```

Step 2 To transfer the file from the controller to a TFTP or FTP server, enter these commands:

- **transfer upload mode** {**tftp** | **ftp**}
- **transfer upload datatype coredump**
- **transfer upload serverip** *server_ip_address*
- **transfer upload path** *server_path_to_file*
- **transfer upload filename** *filename*

Note After the file is uploaded, it ends with a .gz suffix. If desired, you can upload the same core dump file multiple times with different names to different servers.

Step 3 If you are using an FTP server, also enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 4 To view the updated settings, enter this command:

transfer upload start

Step 5 When prompted to confirm the current settings and start the software upload, answer **y**.

Uploading Packet Capture Files

When a 5500 series controller's data plane crashes, it stores the last 50 packets that the controller received in flash memory. This information can be useful in troubleshooting the crash.

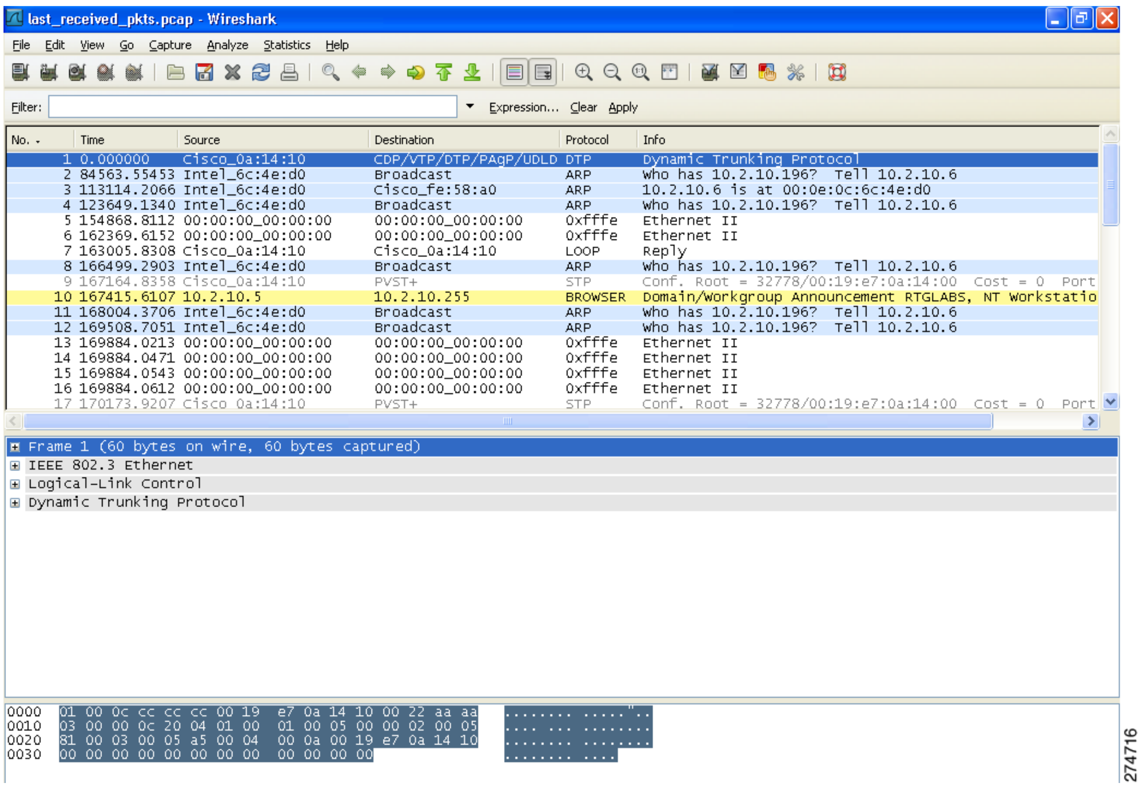
When a crash occurs, the controller generates a new packet capture file (*.pcap) file, and a message similar to the following appears in the controller crash file:

```
Last 5 packets processed at each core are stored in
 "last_received_pkts.pcap" captured file.
   - Frame 36,38,43,47,49, processed at core #0.
   - Frame 14,27,30,42,45, processed at core #1.
   - Frame 15,18,20,32,48, processed at core #2.
   - Frame 11,29,34,37,46, processed at core #3.
   - Frame 7,8,12,31,35, processed at core #4.
   - Frame 21,25,39,41,50, processed at core #5.
```

```
- Frame 16,17,19,22,33, processed at core #6.
- Frame 6,10,13,23,26, processed at core #7.
- Frame 9,24,28,40,44, processed at core #8.
- Frame 1,2,3,4,5, processed at core #9.
```

You can use the controller GUI or CLI to upload the packet capture file from the controller. You can then use Wireshark or another standard packet capture tool to view and analyze the contents of the file. Figure 6 shows a sample output of a packet capture file in Wireshark.

Figure 6 Sample Output of Packet Capture File in Wireshark



> **Note** Only 5500 series controllers generate packet capture files. This feature is not available on other controller platforms.

Follow the instructions in this section to upload packet capture files from the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the file upload. Keep these guidelines in mind when setting up a TFTP or FTP server:

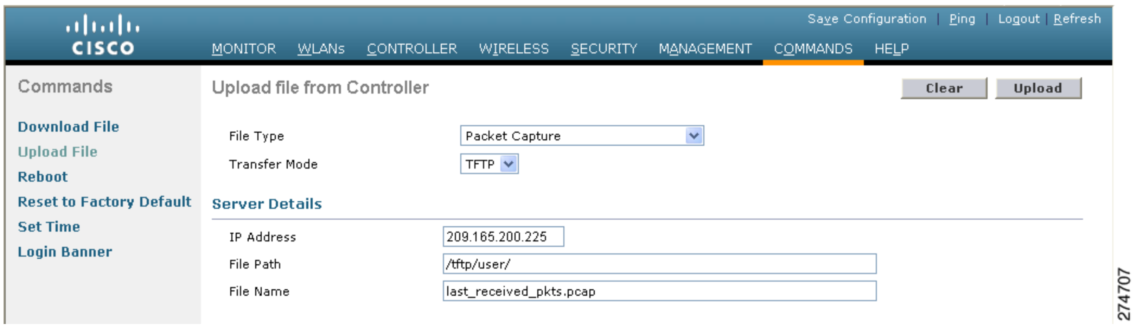
- If you are uploading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are uploading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Using the GUI to Upload Packet Capture Files

Using the controller GUI, follow these steps to upload a packet capture file from the controller.

Step 1 Choose **Commands** > **Upload File** to open the Upload File from Controller page (see Figure 7).

Figure 7 Upload File from Controller Page



Step 2 From the File Type drop-down box, choose **Packet Capture**.

Step 3 From the Transfer Mode drop-down box, choose **TFTP** or **FTP**.

Step 4 In the IP Address field, enter the IP address of the TFTP or FTP server.

Step 5 In the File Path field, enter the directory path of the packet capture file.

Step 6 In the File Name field, enter the name of the packet capture file. These files have a .pcap extension.

Step 7 If you are using an FTP server, follow these steps:

a. In the Server Login Username field, enter the username to log into the FTP server.

b. In the Server Login Password field, enter the password to log into the FTP server.

c. In the Server Port Number field, enter the port number on the FTP server through which the upload occurs. The default value is 21.

Step 8 Click **Upload** to upload the packet capture file from the controller. A message appears indicating the status of the upload.

Step 9 Use Wireshark or another standard packet capture tool to open the packet capture file and see the last 50 packets that were received by the controller.

Using the CLI to Upload Packet Capture Files

Using the controller CLI, follow these steps to upload a packet capture file from the controller.

Step 1 Log into the controller CLI.

Step 2 Enter **transfer upload mode** {**tftp** | **ftp**}.

Step 3 Enter **transfer upload datatype packet-capture**.

Step 4 Enter **transfer upload serverip** *server-ip-address*.

Step 5 Enter **transfer upload path** *server-path-to-file*.

Step 6 Enter **transfer upload filename** *last_received_pkts*.pcap.

Step 7 If you are using an FTP server, enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 8 Enter **transfer upload start** to view the updated settings; then answer **y** when prompted to confirm the current settings and start the upload process. This example shows the upload command output:

```
Mode........................................... TFTP
TFTP Server IP................................. 10.10.10.10
TFTP Path...................................... /tftp/user/
TFTP Filename...................................... last_received_pkts.pcap
Data Type...................................... Packet capture

Are you sure you want to start? (y/N) y

TFTP Packet Capture Dump starting.

File transfer operation completed successfully.
```

Step 9 Use Wireshark or another standard packet capture tool to open the packet capture file and see the last 50 packets that were received by the controller.

Monitoring Memory Leaks

This section provides instructions for troubleshooting hard-to-solve or hard-to-reproduce memory problems.

Caution The commands in this section can be disruptive to your system and should be run only when you are advised to do so by the Cisco Technical Assistance Center (TAC).

Using the controller CLI, follow these steps to monitor the controller for memory leaks.

Step 1 To enable or disable monitoring for memory errors and leaks, enter this command:

config memory monitor errors {**enable** | **disable**}

The default value is disabled.

Note Your changes are not saved across reboots. After the controller reboots, it uses the default setting for this feature.

Step 2 If you suspect that a memory leak has occurred, enter this command to configure the controller to perform an auto-leak analysis between two memory thresholds (in kilobytes):

config memory monitor leaks *low_thresh high_thresh*

If the free memory is lower than the *low_thresh* threshold, the system crashes, generating a crash file. The default value for this parameter is 10000 kilobytes, and you cannot set it below this value.

Set the *high_thresh* threshold to the current free memory level or higher so that the system enters auto-leak-analysis mode. After the free memory reaches a level lower than the specified *high_thresh* threshold, the process of tracking and freeing memory allocation begins. As a result, the **debug memory events enable** command shows all allocations and frees, and the **show memory monitor detail** command starts to detect any suspected memory leaks. The default value for this parameter is 30000 kilobytes.

Step 3 To view a summary of any discovered memory issues, enter this command:

show memory monitor

Information similar to the following appears:

```
Memory Leak Monitor Status:
low_threshold(10000), high_threshold(30000), current status(disabled)

-------------------------------------------

Memory Error Monitor Status:
Crash-on-error flag currently set to (disabled)
No memory error detected.
```

Step 4 To view the details of any memory leaks or corruption, enter this command:

show memory monitor detail

Information similar to the following appears:

```
Memory error detected. Details:
------------------------------------------------
-  Corruption detected at pmalloc entry address:        (0x179a7ec0)
-  Corrupt entry:headerMagic(0xdeadf00d),trailer(0xabcd),poison(0xreadceef),
entrysize(128),bytes(100),thread(Unknown task name, task id = (332096592)),
file(pmalloc.c),line(1736),time(1027)

Previous 1K memory dump from error location.
------------------------------------------------
(179a7ac0): 00000000 00000000 00000000 ceeff00d readf00d 00000080 00000000 00000000
(179a7ae0): 17958b20 00000000 1175608c 00000078 00000000 readceef 179a7afc 00000001
(179a7b00): 00000003 00000006 00000001 00000004 00000001 00000009 00000009 0000020d
(179a7b20): 00000001 00000002 00000002 00000001 00000004 00000000 00000000 5d7b9aba
(179a7b40): cbddf004 192f465e 7791acc8 e5032242 5365788c a1b7cee6 00000000 00000000
(179a7b60): 00000000 00000000 00000000 00000000 00000000 ceeff00d readf00d 00000080
(179a7b80): 00000000 00000000 17958dc0 00000000 1175608c 00000078 00000000 readceef
(179a7ba0): 179a7ba4 00000001 00000003 00000006 00000001 00000004 00000001 00003763
(179a7bc0): 00000002 00000002 00000010 00000001 00000002 00000000 0000001e 00000013
(179a7be0): 0000001a 00000089 00000000 00000000 000000d8 00000000 00000000 17222194
(179a7c00): 1722246c 1722246c 00000000 00000000 00000000 00000000 00000000 ceeff00d
(179a7c20): readf00d 00000080 00000000 00000000 179a7b78 00000000 1175608c 00000078
```

Step 5 If a memory leak occurs, enter this command to enable debugging of errors or events during memory allocation:

debug memory {**errors** | **events**} {**enable** | **disable**}

Troubleshooting CCXv5 Client Devices

The controller supports three features designed to help troubleshoot communication problems with CCXv5 clients: diagnostic channel, client reporting, and roaming and real-time diagnostics. See the "Configuring Cisco Client Extensions" section on page 49 for more information on CCX.

Note These features are supported only on CCXv5 clients. They are not supported for use with non-CCX clients or with clients running an earlier version of CCX.

Diagnostic Channel

The diagnostic channel feature enables you to troubleshoot problems regarding client communication with a WLAN. The client and access points can be put through a defined set of tests in an attempt to identify the cause of communication difficulties the client is experiencing and then allow corrective measures to be taken to make the client operational on the network. You can use the controller GUI or CLI to enable the diagnostic channel, and you can use the controller CLI or WCS to run the diagnostic tests.

Note Cisco recommends that you enable the diagnostic channel feature only for non-anchored SSIDs that use the management interface.

Client Reporting

The client reporting protocol is used by the client and the access point to exchange client information. Client reports are collected automatically when the client associates. You can use the controller GUI or CLI to send a client report request to any CCXv5 client any time after the client associates. There are four types of client reports:

- Client profile—Provides information about the configuration of the client.
- Operating parameters—Provides the details of the client's current operational modes.
- Manufacturers' information—Provides data about the wireless LAN client adapter in use.
- Client capabilities—Provides information about the client's capabilities.

Roaming and Real-Time Diagnostics

You can use roaming and real-time logs and statistics to solve system problems. The event log enables you to identify and track the behavior of a client device. It is especially useful when attempting to diagnose difficulties that a user may be having on a WLAN. The event log provides a log of events and reports them to the access point. There are three categories of event logs:

- Roaming log—This log provides a historical view of the roaming events for a given client. The client maintains a minimum of five previous roaming events including failed attempts and successful roams.
- Robust Security Network Association (RSNA) log—This log provides a historical view of the authentication events for a given client. The client maintains a minimum of five previous authentication attempts including failed attempts and successful ones.

- Syslog—This log provides internal system information from the client. For example, it may indicate problems with 802.11 operation, system operation, and so on.

The statistics report provides 802.1X and security information for the client. You can use the controller CLI to send the event log and statistics request to any CCXv5 client any time after the client associates.

Using the GUI to Configure the Diagnostic Channel

Follow these steps to configure the diagnostic channel using the controller GUI.

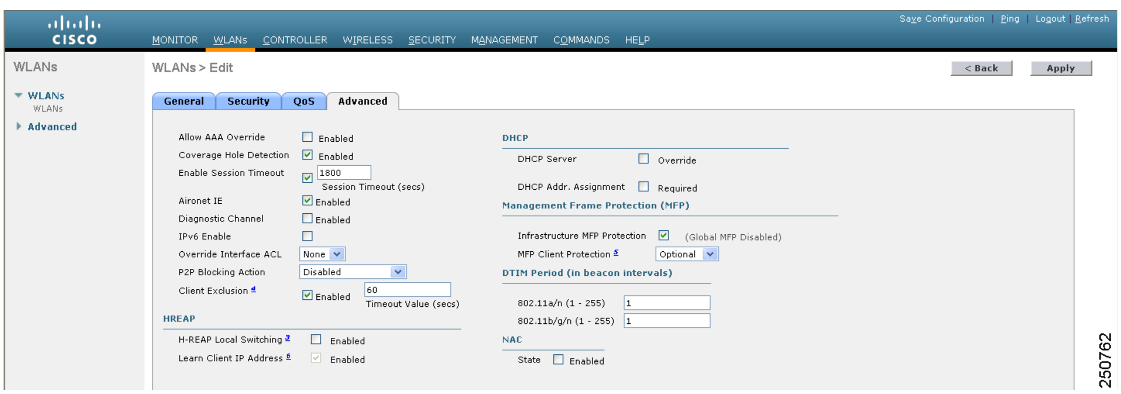
Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Create a new WLAN or click the ID number of an existing WLAN.

Note Cisco recommends that you create a new WLAN on which to run the diagnostic tests.

Step 3 When the WLANs > Edit page appears, choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 8).

Figure 8 WLANs > Edit (Advanced) Page



Step 4 If you want to enable diagnostic channel troubleshooting on this WLAN, check the **Diagnostic Channel** check box. Otherwise, leave this check box unchecked, which is the default value.

Note You can use the CLI to initiate diagnostic tests on the client. See the "Using the CLI to Configure the Diagnostic Channel" section on page 28 for details.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure the Diagnostic Channel

Using the controller CLI, follow these steps to configure the diagnostic channel.

Step 1 To enable diagnostic channel troubleshooting on a particular WLAN, enter this command:

config wlan diag-channel {**enable** | **disable**} *wlan_id*

Step 2 To verify that your change has been made, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... employee1
Network Name (SSID).............................. employee
Status........................................... Disabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Number of Active Clients......................... 0
Exclusionlist Timeout............................ 60 seconds
Session Timeout.................................. Infinity
Interface........................................ management
WLAN ACL......................................... unconfigured
DHCP Server...................................... Default
DHCP Address Assignment Required................. Disabled
Quality of Service............................... Silver (best effort)
WMM.............................................. Disabled
CCX - AironetIe Support.......................... Enabled
CCX - Gratuitous ProbeResponse (GPR)............. Disabled
CCX - Diagnostics Channel Capability............. Enabled
...
```

Step 3 To send a request to the client to perform the DHCP test, enter this command:

config client ccx dhcp-test *client_mac_address*

Note This test does not require the client to use the diagnostic channel.

Step 4 To send a request to the client to perform the default gateway ping test, enter this command:

config client ccx default-gw-ping *client_mac_address*

Note This test does not require the client to use the diagnostic channel.

Step 5 To send a request to the client to perform the DNS server IP address ping test, enter this command:

config client ccx dns-ping *client_mac_address*

Note This test does not require the client to use the diagnostic channel.

Step 6 To send a request to the client to perform the DNS name resolution test to the specified host name, enter this command:

config client ccx dns-resolve *client_mac_address host_name*

> **Note** This test does not require the client to use the diagnostic channel.

Step 7 To send a request to the client to perform the association test, enter this command:

config client ccx test-association *client_mac_address ssid bssid* {**802.11a | 802.11b | 802.11g**} *channel*

Step 8 To send a request to the client to perform the 802.1X test, enter this command:

config client ccx test-dot1x *client_mac_address profile_id bssid* {**802.11a | 802.11b | 802.11g**} *channel*

Step 9 To send a request to the client to perform the profile redirect test, enter this command:

config client ccx test-profile *client_mac_address profile_id*

The *profile_id* should be from one of the client profiles for which client reporting is enabled.

> **Note** Users are redirected back to the parent WLAN, not to any other profile. The only profile shown is the user's parent profile. Note however that parent WLAN profiles can have one child diagnostic WLAN.

Step 10 Use these commands if necessary to abort or clear a test:

- To send a request to the client to abort the current test, enter this command:

  config client ccx test-abort *client_mac_address*

  Only one test can be pending at a time, so this command aborts the current pending test.

- To clear the test results on the controller, enter this command:

  config client ccx clear-results *client_mac_address*

Step 11 To send a message to the client, enter this command:

config client ccx send-message *client_mac_address message_id*

where *message_id* is one of the following:

- 1 = The SSID is invalid.
- 2 = The network settings are invalid.
- 3 = There is a WLAN credibility mismatch.
- 4 = The user credentials are incorrect.
- 5 = Please call support.
- 6 = The problem is resolved.
- 7 = The problem has not been resolved.
- 8 = Please try again later.
- 9 = Please correct the indicated problem.
- 10 = Troubleshooting is refused by the network.
- 11 = Retrieving client reports.
- 12 = Retrieving client logs.

- 13 = Retrieval complete.
- 14 = Beginning association test.
- 15 = Beginning DHCP test.
- 16 = Beginning network connectivity test.
- 17 = Beginning DNS ping test.
- 18 = Beginning name resolution test.
- 19 = Beginning 802.1X authentication test.
- 20 = Redirecting client to a specific profile.
- 21 = Test complete.
- 22 = Test passed.
- 23 = Test failed.
- 24 = Cancel diagnostic channel operation or select a WLAN profile to resume normal operation.
- 25 = Log retrieval refused by the client.
- 26 = Client report retrieval refused by the client.
- 27 = Test request refused by the client.
- 28 = Invalid network (IP) setting.
- 29 = There is a known outage or problem with the network.
- 30 = Scheduled maintenance period.
- 31 = The WLAN security method is not correct.
- 32 = The WLAN encryption method is not correct.
- 33 = The WLAN authentication method is not correct.

Step 12 To see the status of the last test, enter this command:

show client ccx last-test-status *client_mac_address*

Information similar to the following appears for the default gateway ping test:

```
Test Type........................................ Gateway Ping Test
Test Status...................................... Pending/Success/Timeout

Dialog Token..................................... 15
Timeout.......................................... 15000 ms
Request Time..................................... 1329 seconds since system boot
```

Step 13 To see the status of the last test response, enter this command:

show client ccx last-response-status *client_mac_address*

Information similar to the following appears for the 802.1X authentication test:

```
Test Status...................................... Success

Response Dialog Token............................ 87
Response Status.................................. Successful
Response Test Type............................... 802.1x Authentication Test
Response Time.................................... 3476 seconds since system boot
```

Step 14 To see the results from the last successful diagnostics test, enter this command:

show client ccx results *client_mac_address*

Information similar to the following appears for the 802.1X authentication test:

```
dot1x Complete.................................. Success
EAP Method...................................... *1,Host OS Login Credentials
dot1x Status................................ 255
```

Step 15 To see the relevant data frames captured by the client during the previous test, enter this command:

show client ccx frame-data *client_mac_address*

Information similar to the following appears:

```
LOG Frames:

Frame Number:................................... 1
Last Frame Number:.............................. 1120
Direction:...................................... 1
Timestamp:...................................... 0d 00h 50m 39s 863954us
Frame Length:................................... 197
Frame Data:
00000000: 80 00 00 00 ff ff ff ff  ff ff 00 12 44 bd bd b0  ............D...
00000010: 00 12 44 bd bd b0 f0 af  43 70 00 f2 82 01 00 00  ..D.....Cp......
00000020: 64 00 11 08 00 01 00 01  08 8c 12 98 24 b0 48 60  d...........$.H`
00000030: 6c 05 04 01 02 00 00 85  1e 00 00 89 00 0f 00 ff  l...............
00000040: 03 19 00 41 50 32 33 2d  31 30 00 00 00 00 00 00  ...AP23-10......
00000050: 00 00 00 00 00 00 26 96  06 00 40 96 00 ff ff dd  ......&...@.....
00000060: 18 00 50 f2 01 01 00 00  50 f2 05 01 00 00 50 f2  ..P.....P.....P.
00000070: 05 01 00 00 40 96 00 28  00 dd 06 00 40 96 01 01  ....@..(....@...

00000080: 00 dd 05 00 40 96 03 04  dd 16 00 40 96 04 00 02  ....@......@....
00000090: 07 a4 00 00 23 a4 00 00  42 43 00 00 62 32 00 00  ....#...BC..b2..
000000a0: dd 05 00 40 96 0b 01 dd  18 00 50 f2 02 01 01 82  ...@......P.....
000000b0: 00 03 a4 00 00 27 a4 00  00 42 43 5e 00 62 32 2f  .....'...BC^.b2/

LOG Frames:

Frame Number:................................... 2
Last Frame Number:.............................. 1120
Direction:...................................... 1
Timestamp:...................................... 0d 00h 50m 39s 878289us
Frame Length:................................... 147
Frame Data:
00000000: 80 00 00 00 ff ff ff ff  ff ff 00 0d ed c3 a0 22  ..............."
00000010: 00 0d ed c3 a0 22 00 bd  4d 50 a5 f7 78 08 00 00  ....."..MP..x...
00000020: 64 00 01 00 00 01 00 01  08 8c 12 98 24 b0 48 60  d...........$.H`
00000030: 6c 05 04 01 02 00 00 85  1e 00 00 84 00 0f 00 ff  l...............
00000040: 03 19 00 72 6f 67 75 65  2d 74 65 73 74 31 00 00  ...rogue-test1..
00000050: 00 00 00 00 00 00 23 96  06 00 40 96 00 10 00 dd  ......#...@.....
00000060: 06 00 40 96 01 01 00 dd  05 00 40 96 03 04 dd 05  ..@.......@.....
00000070: 00 40 96 0b 01 dd 18 00  50 f2 02 01 01 81 00 03  .@......P.......

00000080: a4 00 00 27 a4 00 00 42  43 5e 00 62 32 2f 00 d2  ...'...BC^.b2/..
00000090: b4 ab 84                                         ...

LOG Frames:

Frame Number:................................... 3
Last Frame Number:.............................. 1120
Direction:...................................... 1
Timestamp:...................................... 0d 00h 50m 39s 881513us
Frame Length:................................... 189
```

```
Frame Data:
00000000: 80 00 00 00 ff ff ff ff  ff ff 00 12 44 bd 80 30  ............D..0
00000010: 00 12 44 bd 80 30 60 f7  46 c0 8b 4b d1 05 00 00  ..D..0`.F..K....
00000020: 64 00 11 08 00 01 00 01  08 8c 12 98 24 b0 48 60  d...........$.H`
00000030: 6c 05 04 00 02 00 00 85  1e 00 00 89 00 0f 00 ff  l...............
00000040: 03 19 00 41 50 34 30 2d  31 37 00 00 00 00 00 00  ...AP40-17......
00000050: 00 00 00 00 00 00 26 dd  18 00 50 f2 01 01 00 00  ......&...P.....
00000060: 50 f2 05 01 00 00 50 f2  05 01 00 00 40 96 00 28  P.....P.....@..(
00000070: 00 dd 06 00 40 96 01 01  00 dd 05 00 40 96 03 04  ....@.......@...

00000080: dd 16 00 40 96 04 00 05  07 a4 00 00 23 a4 00 00  ...@........#...
00000090: 42 43 00 00 62 32 00 00  dd 05 00 40 96 0b 01 dd  BC..b2.....@....
000000a0: 18 00 50 f2 02 01 01 85  00 03 a4 00 00 27 a4 00  ..P..........'..
000000b0: 00 42 43 5e 00 62 32 2f  00 0b 9a 1d 6f           .BC^.b2/....o
...
```

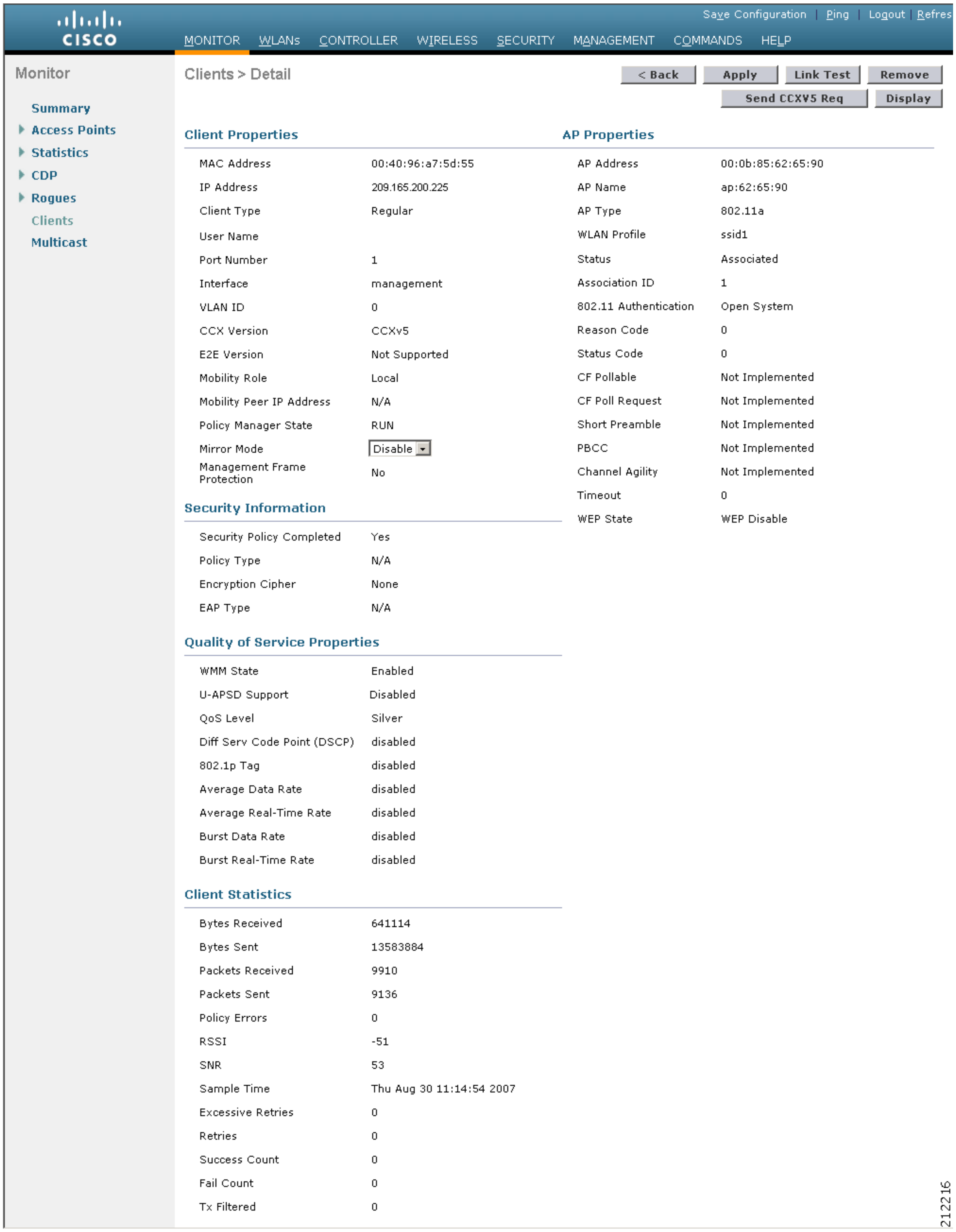
Using the GUI to Configure Client Reporting

Follow these steps to configure client reporting using the controller GUI.

Step 1 Choose **Monitor** > **Clients** to open the Clients page.

Step 2 Click the MAC address of the desired client. The Clients > Detail page appears (see Figure 9).

Figure 9 Clients > Detail Page

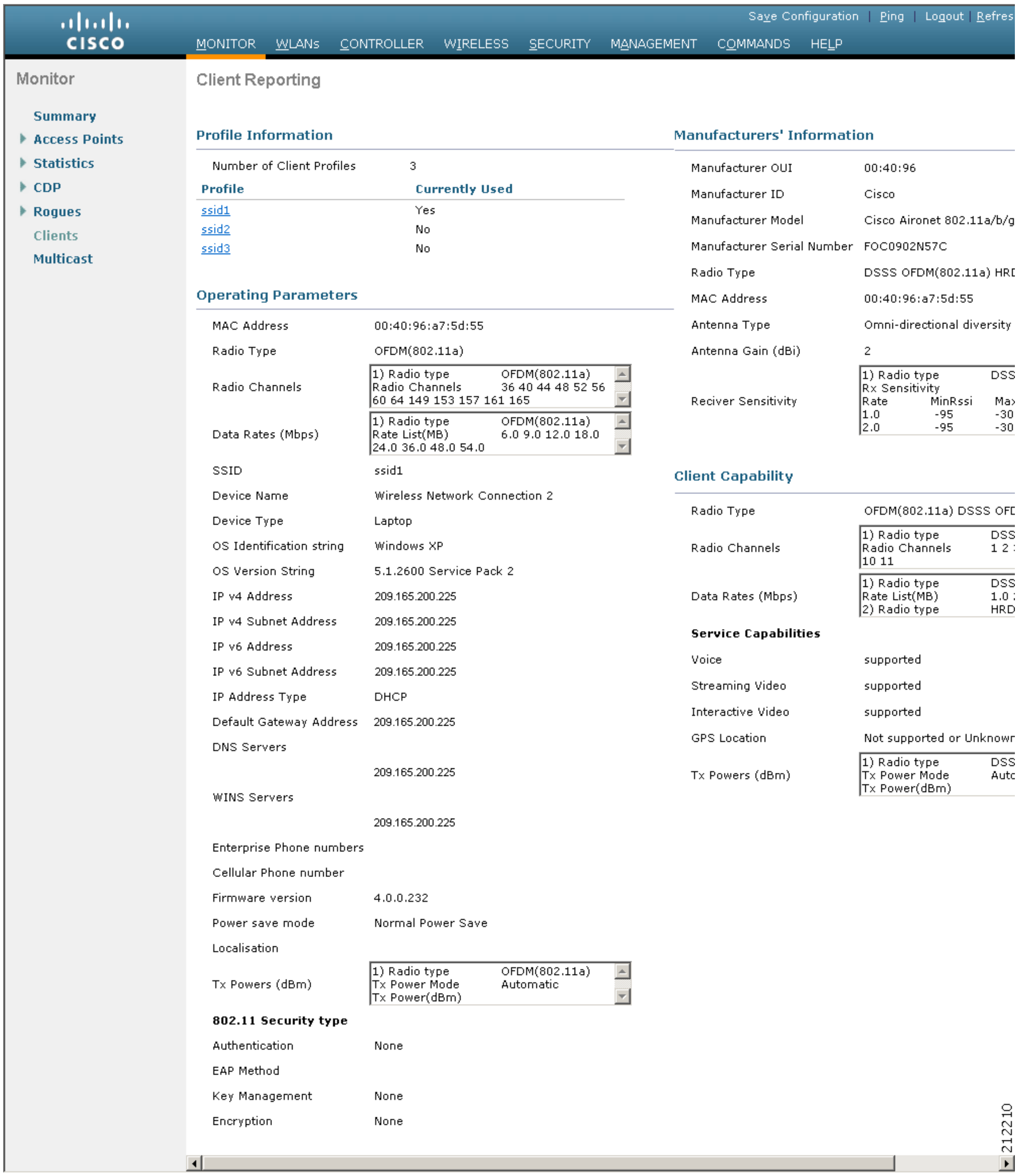


Step 3 To send a report request to the client, click the **CCXv5 Req** button.

> **Note** You must create a Trusted Profile using ACAU for Cisco CB21AG or equivalent software from your CCXv5 vendor.

Step 4 To view the parameters from the client, click **Display**. The Client Reporting page appears (see Figure 10).

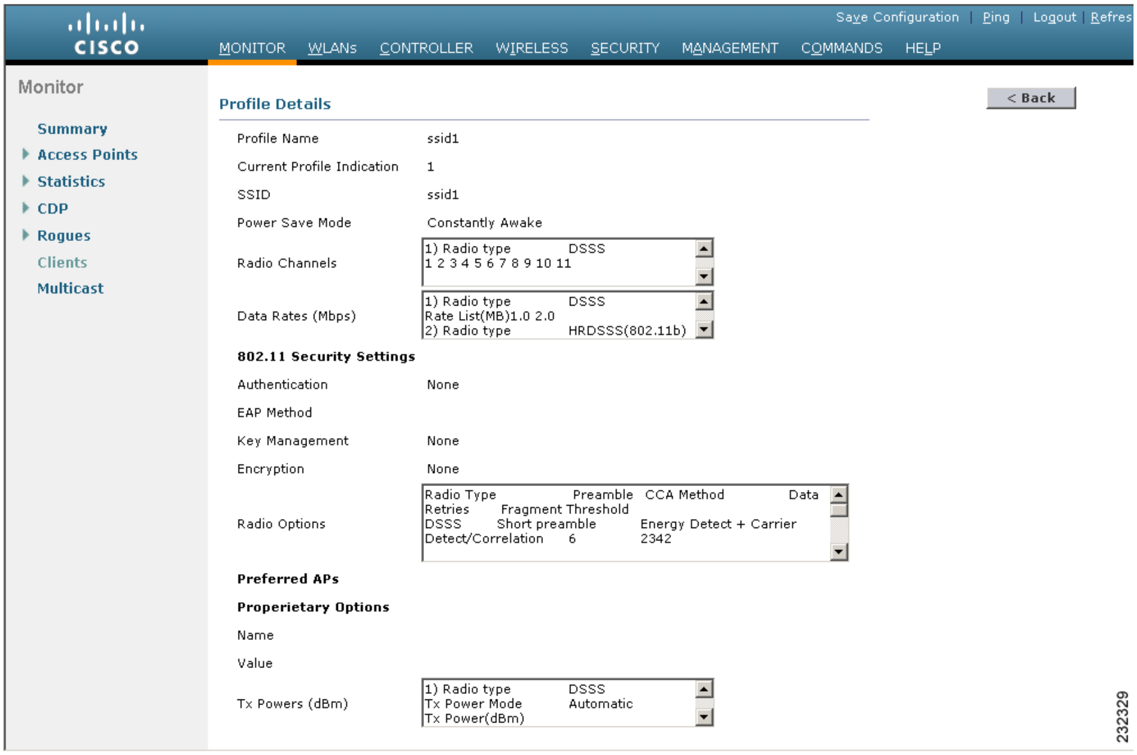
Figure 10 Client Reporting Page



This page lists the client profiles and indicates if they are currently in use. It also provides information on the client's operating parameters, manufacturer, and capabilities.

Step 5 Click the link for the desired client profile. The Profile Details page appears (see Figure 11).

Figure 11 Profile Details Page



This page shows the client profile details, including the SSID, power save mode, radio channel, data rates, and 802.11 security settings.

Using the CLI to Configure Client Reporting

Using the controller CLI, follow these steps to configure client reporting.

Step 1 To send a request to the client to send its profiles, enter this command:

config client ccx get-profiles *client_mac_address*

Step 2 To send a request to the client to send its current operating parameters, enter this command:

config client ccx get-operating-parameters *client_mac_address*

Step 3 To send a request to the client to send the manufacturer's information, enter this command:

config client ccx get-manufacturer-info *client_mac_address*

Step 4 To send a request to the client to send its capability information, enter this command:

config client ccx get-client-capability *client_mac_address*

Step 5 To clear the client reporting information, enter this command:

config client ccx clear-reports *client_mac_address*

Step 6 To see the client profiles, enter this command:

show client ccx profiles *client_mac_address*

Information similar to the following appears:

```
Number of Profiles.............................. 1
Current Profile................................. 1

Profile ID...................................... 1
Profile Name.................................... wifiEAP
SSID............................................ wifiEAP
Security Parameters[EAP Method,Credential]....... EAP-TLS,Host OS Login Credentials
Auth Method..................................... EAP
Key Management.................................. WPA2+CCKM
Encryption...................................... AES-CCMP
Power Save Mode................................. Constantly Awake
Radio Configuration:
Radio Type...................................... DSSS
  Preamble Type................................. Long preamble
  CCA Method.................................... Energy Detect + Carrier
Detect/Correlation
  Data Retries.................................. 6
  Fragment Threshold............................ 2342
  Radio Channels................................ 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................. Automatic
  Rate List(MB)................................. 1.0 2.0

Radio Type...................................... HRDSSS(802.11b)
  Preamble Type................................. Long preamble
  CCA Method.................................... Energy Detect + Carrier
Detect/Correlation
  Data Retries.................................. 6
  Fragment Threshold............................ 2342
  Radio Channels................................ 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................. Automatic
  Rate List(MB)................................. 5.5 11.0

Radio Type...................................... ERP(802.11g)
  Preamble Type................................. Long preamble
  CCA Method.................................... Energy Detect + Carrier
Detect/Correlation
  Data Retries.................................. 6
  Fragment Threshold............................ 2342
  Radio Channels................................ 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................. Automatic
  Rate List(MB)................................. 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0

Radio Type...................................... OFDM(802.11a)
  Preamble Type................................. Long preamble
  CCA Method.................................... Energy Detect + Carrier
Detect/Correlation
  Data Retries.................................. 6
  Fragment Threshold............................ 2342
Radio Channels................................ 36 40 44 48 52 56 60 64 149 153 157 161
165
  Tx Power Mode................................. Automatic
  Rate List(MB)................................. 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0
```

Step 7 To see the client operating parameters, enter this command:

show client ccx operating-parameters *client_mac_address*

Information similar to the following appears:

```
Client Mac..................................... 00:40:96:b2:8d:5e
Radio Type..................................... OFDM(802.11a)

Radio Type..................................... OFDM(802.11a)
  Radio Channels............................... 36 40 44 48 52 56 60 64 100 104 108 112
116 120 124 128 132 136 140 149 153 157 161 165
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0

Power Save Mode................................ Normal Power Save
SSID........................................... wifi
Security Parameters[EAP Method,Credential]....... None
Auth Method.................................... None
Key Management................................. None
Encryption..................................... None
Device Name.................................... Wireless Network Connection 15
Device Type.................................... 0
OS Id.......................................... Windows XP
OS Version..................................... 5.1.2600 Service Pack 2
IP Type........................................ DHCP address
IPv4 Address................................... Available
IP Address..................................... 70.0.4.66
Subnet Mask.................................... 255.0.0.0
Default Gateway................................ 70.1.0.1
IPv6 Address................................... Not Available
IPv6 Address...................................  0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0:
0: 0: 0:
IPv6 Subnet Mask...............................  0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0:
0: 0: 0:
DNS Servers.................................... 103.0.48.0
WINS Servers...................................
System Name.................................... URAVAL3777
Firmware Version............................... 4.0.0.187
Driver Version................................. 4.0.0.187
```

Step 8 To see the client manufacturer information, enter this command:

show client ccx manufacturer-info *client_mac_address*

Information similar to the following appears:

```
Manufacturer OUI............................... 00:40:96
Manufacturer ID................................ Cisco
Manufacturer Model............................. Cisco Aironet 802.11a/b/g Wireless
Adapter
Manufacturer Serial............................ FOC1046N3SX
Mac Address.................................... 00:40:96:b2:8d:5e
Radio Type..................................... DSSS OFDM(802.11a) HRDSSS(802.11b)
ERP(802.11g)
Antenna Type................................... Omni-directional diversity
Antenna Gain................................... 2 dBi

Rx Sensitivity:
Radio Type..................................... DSSS
Rx Sensitivity ................................ Rate:1.0 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:2.0 Mbps, MinRssi:-95, MaxRssi:-30
Radio Type..................................... HRDSSS(802.11b)
Rx Sensitivity ................................ Rate:5.5 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:11.0 Mbps, MinRssi:-95, MaxRssi:-30
```

```
Radio Type..................................... ERP(802.11g)
Rx Sensitivity ................................ Rate:6.0 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:9.0 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:12.0 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:18.0 Mbps, MinRssi:-95, MaxRssi:-30
```

Step 9 To see the client's capability information, enter this command:

show client ccx client-capability *client_mac_address*

Note This command displays the client's available capabilities, not current settings for the capabilities.

Information similar to the following appears:

```
Service Capability.............................. Voice, Streaming(uni-directional) Video,
Interactive(bi-directional) Video
Radio Type..................................... DSSS OFDM(802.11a) HRDSSS(802.11b)
ERP(802.11g)

Radio Type..................................... DSSS
  Radio Channels............................... 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 1.0 2.0

Radio Type..................................... HRDSSS(802.11b)
  Radio Channels............................... 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 5.5 11.0

Radio Type..................................... ERP(802.11g)
  Radio Channels............................... 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0

Radio Type..................................... OFDM(802.11a)
  Radio Channels............................... 36 40 44 48 52 56 60 64 100 104 108 112
116 120 124 128 132 136 140 149 153 157 161 165
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0
```

Using the CLI to Configure Roaming and Real-Time Diagnostics

Using the controller CLI, follow these steps to configure roaming and real-time diagnostics.

Step 1 To send a log request, enter this command:

config client ccx log-request *log_type client_mac_address*

where *log_type* is roam, rsna, or syslog.

Step 2 To view a log response, enter this command:

show client ccx log-response *log_type client_mac_address*

where *log_type* is roam, rsna, or syslog.

Information similar to the following appears for a log response with a *log_type* of roam:

```
Tue Jun 26 18:28:48 2007  Roaming Response LogID=133: Status=Successful
                          Event Timestamp=0d 00h 00m 13s 322396us
                          Source BSSID=00:0b:85:81:06:c2, Target BSSID=00:0b:85:81:06:c2,
Transition Time=3125(ms)
                          Transition Reason: Normal roam, poor link
                          Transition Result: Success
Tue Jun 26 18:28:48 2007  Roaming Response LogID=133: Status=Successful
                          Event Timestamp=0d 00h 00m 16s 599006us
                          Source BSSID=00:0b:85:81:06:c2, Target BSSID=00:0b:85:81:06:c2,
Transition Time=3235(ms)
                          Transition Reason: Normal roam, poor link
                          Transition Result: Success
                          Event Timestamp=0d 00h 00m 19s 882921us
                          Source BSSID=00:0b:85:81:06:c2, Target BSSID=00:0b:85:81:06:c2,
Transition Time=3234(ms)
                          Transition Reason: Normal roam, poor link
                          Transition Result: Success
Tue Jun 26 18:28:48 2007  Roaming Response LogID=133: Status=Successful
                          Event Timestamp=0d 00h 00m 08s 815477us
                          Source BSSID=00:0b:85:81:06:c2, Target BSSID=00:0b:85:81:06:d2,
Transition Time=3281(ms)
                          Transition Reason: First association to WLAN
                          Transition Result: Success
                          Event Timestamp=0d 00h 00m 26s 637084us
                          Source BSSID=00:0b:85:81:06:d2, Target BSSID=00:0b:85:81:06:c2,
Transition Time=3313(ms)
```

Information similar to the following appears for a log response with a *log_type* of rsna:

```
Tue Jun 26 18:24:09 2007  RSNA Response LogID=132: Status=Successful
                          Event Timestamp=0d 00h 00m 00s 246578us
                          Target BSSID=00:14:1b:58:86:cd
                          RSNA Version=1
                          Group Cipher Suite=00-0f-ac-02
                          Pairwise Cipher Suite Count = 1
                              Pairwise Cipher Suite 0 = 00-0f-ac-04
                          AKM Suite Count = 1
                              AKM Suite 0 = 00-0f-ac-01
                          RSN Capability = 0x0
                          RSNA Result: Success
Tue Jun 26 18:24:09 2007  RSNA Response LogID=132: Status=Successful
                          Event Timestamp=0d 00h 00m 00s 246625us
                          Target BSSID=00:14:1b:58:86:cd
                          RSNA Version=1
                          Group Cipher Suite=00-0f-ac-02
                          Pairwise Cipher Suite Count = 1
                              Pairwise Cipher Suite 0 = 00-0f-ac-04
                          AKM Suite Count = 1
                              AKM Suite 0 = 00-0f-ac-01
                          RSN Capability = 0x0
                          RSNA Result: Success
```

```
Tue Jun 26 18:24:09 2007  RSNA Response LogID=132: Status=Successful
                          Event Timestamp=0d 00h 00m 01s 624375us
                          Target BSSID=00:14:1b:58:86:cd
                          RSNA Version=1
                          Group Cipher Suite=00-0f-ac-02
                          Pairwise Cipher Suite Count = 1
                              Pairwise Cipher Suite 0 = 00-0f-ac-04
                          AKM Suite Count = 1
                              AKM Suite 0 = 00-0f-ac-01
                          RSN Capability = 0x0
                        RSNA Result: Success
```

Information similar to the following appears for a log response with a *log_type* of syslog:

```
Tue Jun 26 18:07:48 2007  SysLog Response LogID=131: Status=Successful
                          Event Timestamp=0d 00h 19m 42s 278987us
                          Client SysLog = '<11> Jun 19 11:49:47 uraval3777 Mandatory
elements missing in the OID response'
                          Event Timestamp=0d 00h 19m 42s 278990us
                          Client SysLog = '<11> Jun 19 11:49:50 uraval3777 Mandatory
elements missing in the OID response'
Tue Jun 26 18:07:48 2007  SysLog Response LogID=131: Status=Successful
                          Event Timestamp=0d 00h 19m 42s 278993us
                          Client SysLog = '<11> Jun 19 11:49:53 uraval3777 Mandatory
elements missing in the OID response'
                          Event Timestamp=0d 00h 19m 42s 278996us
                          Client SysLog = '<11> Jun 19 11:49:56 uraval3777 Mandatory
elements missing in the OID response'
Tue Jun 26 18:07:48 2007  SysLog Response LogID=131: Status=Successful
                          Event Timestamp=0d 00h 19m 42s 279000us
                          Client SysLog = '<11> Jun 19 11:50:00 uraval3777 Mandatory
elements missing in the OID response'
                          Event Timestamp=0d 00h 19m 42s 279003us
                          Client SysLog = '<11> Jun 19 11:50:03 uraval3777 Mandatory
elements missing in the OID response'
Tue Jun 26 18:07:48 2007  SysLog Response LogID=131: Status=Successful
                          Event Timestamp=0d 00h 19m 42s 279009us
                          Client SysLog = '<11> Jun 19 11:50:09 uraval3777 Mandatory
elements missing in the OID response'
                          Event Timestamp=0d 00h 19m 42s 279012us
                          Client SysLog = '<11> Jun 19 11:50:12 uraval3777 Mandatory
elements missing in the OID response'
```

Step 3 To send a request for statistics, enter this command:

config client ccx stats-request *measurement_duration stats_name client_mac_address*

where *stats_name* is dot11 or security.

Step 4 To view the statistics response, enter this command:

show client ccx stats-report *client_mac_address*

Information similar to the following appears:

```
Measurement duration = 1

     dot11TransmittedFragmentCount       = 1
     dot11MulticastTransmittedFrameCount = 2
     dot11FailedCount                    = 3
     dot11RetryCount                     = 4
     dot11MultipleRetryCount             = 5
     dot11FrameDuplicateCount            = 6
     dot11RTSSuccessCount                = 7
     dot11RTSFailureCount                = 8
     dot11ACKFailureCount                = 9
```

```
dot11ReceivedFragmentCount           = 10
dot11MulticastReceivedFrameCount     = 11
dot11FCSErrorCount                   = 12
dot11TransmittedFrameCount         = 13
```

Using the Debug Facility

The debug facility enables you to display all packets going to and from the controller CPU. You can enable it for received packets, transmitted packets, or both. By default, all packets received by the debug facility are displayed. However, you can define access control lists (ACLs) to filter packets before they are displayed. Packets not passing the ACLs are discarded without being displayed.

Each ACL includes an action (permit, deny, or disable) and one or more fields that can be used to match the packet. The debug facility provides ACLs that operate at the following levels and on the following values:

- Driver ACL
  - NPU encapsulation type
  - Port
- Ethernet header ACL
  - Destination address
  - Source address
  - Ethernet type
  - VLAN ID
- IP header ACL
  - Source address
  - Destination address
  - Protocol
  - Source port (if applicable)
  - Destination port (if applicable)
- EoIP payload Ethernet header ACL
  - Destination address
  - Source address
  - Ethernet type
  - VLAN ID
- EoIP payload IP header ACL
  - Source address
  - Destination address
  - Protocol
  - Source port (if applicable)
  - Destination port (if applicable)

- CAPWAP payload 802.11 header ACL
  - Destination address
  - Source address
  - BSSID
  - SNAP header type
- CAPWAP payload IP header ACL
  - Source address
  - Destination address
  - Protocol
  - Source port (if applicable)
  - Destination port (if applicable)

At each level, you can define multiple ACLs. The first ACL that matches the packet is the one that is selected.

Follow these steps to use the debug facility.

Step 1 To enable the debug facility, enter this command:

debug packet logging enable {**rx** | **tx** | **all**} *packet_count display_size*

where

- **rx** displays all received packets, **tx** displays all transmitted packets, and **all** displays both transmitted and received packets.
- *packet_count* is the maximum number of packets to log. You can enter a value between 1 and 65535 packets, and the default value is 25 packets.
- *display_size* is the number of bytes to display when printing a packet. By default, the entire packet is displayed.

Note To disable the debug facility, enter this command: **debug packet logging disable**.

Step 2 Use these commands to configure packet-logging ACLs:

- **debug packet logging acl driver** *rule_index action npu_encap port*

  where
  - *rule_index* is a value between 1 and 6 (inclusive).
  - *action* is permit, deny, or disable.
  - *npu_encap* specifies the NPU encapsulation type, which determines how packets are filtered. The possible values include dhcp, dot11-mgmt, dot11-probe, dot1x, eoip-ping, iapp, ip, lwapp, multicast, orphan-from-sta, orphan-to-sta, rbcp, wired-guest, or any.
  - *port* is the physical port for packet transmission or reception.

- **debug packet logging acl eth** *rule_index action dst src type vlan*

  where

  - *rule_index* is a value between 1 and 6 (inclusive).
  - *action* is permit, deny, or disable.
  - *dst* is the destination MAC address.
  - *src* is the source MAC address.
  - *type* is the two-byte type code (such as 0x800 for IP, 0x806 for ARP). This parameter also accepts a few common string values such as “ip” (for 0x800) or “arp” (for 0x806).
  - *vlan* is the two-byte VLAN ID.

- **debug packet logging acl ip** *rule_index action src dst proto src_port dst_port*

  where

  - *proto* is a numeric or any string recognized by getprotobyname(). The controller supports the following strings: ip, icmp, igmp, ggp, ipencap, st, tcp, egp, pup, udp, hmp, xns-idp, rdp, iso-tp4, xtp, ddp, idpr-cmtp, rspf, vmtp, ospf, ipip, and encap.
  - *src_port* is the UDP/TCP two-byte source port (for example, telnet, 23) or “any.” The controller accepts a numeric or any string recognized by getservbyname(). The controller supports the following strings: tcpmux, echo, discard, systat, daytime, netstat, qotd, msp, chargen, ftp-data, ftp, fsp, ssh, telnet, smtp, time, rlp, nameserver, whois, re-mail-ck, domain, mtp, bootps, bootpc, tftp, gopher, rje, finger, www, link, kerberos, supdup, hostnames, iso-tsap, csnet-ns, 3com-tsmux, rtelnet, pop-2, pop-3, sunrpc, auth, sftp, uucp-path, nntp, ntp, netbios-ns, netbios-dgm, netbios-ssn, imap2, snmp, snmp-trap, cmip-man, cmip-agent, xdmcp, nextstep, bgp, prospero, irc, smux, at-rtmp, at-nbp, at-echo, at-zis, qmtp, z3950, ipx, imap3, ulistserv, https, snpp, saft, npmp-local, npmp-gui, and hmmp-ind.
  - *dst_port* is the UDP/TCP two-byte destination port (for example, telnet, 23) or “any.” The controller accepts a numeric or any string recognized by getservbyname(). The controller supports the same strings as those for the *src_port*.

- **debug packet logging acl eoip-eth** *rule_index action dst src type vlan*
- **debug packet logging acl eoip-ip** *rule_index action src dst proto src_port dst_port*
- **debug packet logging acl lwapp-dot11** *rule_index action dst src bssid snap_type*

  where

  - *bssid* is the Basic Service Set Identifier.
  - *snap_type* is the Ethernet type.

- **debug packet logging acl lwapp-ip** *rule_index action src dst proto src_port dst_port*

Note To remove all configured ACLs, enter this command: **debug packet logging acl clear-all**.

Step 3 To configure the format of the debug output, enter this command:

debug packet logging format {**hex2pcap | text2pcap**}

The debug facility supports two output formats: hex2pcap and text2pcap. The standard format used by IOS supports the use of hex2pcap and can be decoded using an HTML front end. The text2pcap option is provided as an alternative so that a sequence of packets can be decoded from the same console log file. Figure 12 shows an example of hex2pcap output, and Figure 13 shows an example of text2pcap output.

Figure 12 ***Sample Hex2pcap Output***

```
tx len=118, encap=n/a, port=1
[0000]: 000C316E 7F80000B 854008c0 08004500 ..1n.....@.@..E.
[0010]: 00680000 40004001 5FBE0164 6C0E0164 .h..@.@._>.dl..d
[0020]: 6C010800 08D9E500 00000000 00000000 l....Ye.........
[0030]: 00000000 00000000 00000000 00001C1D ................
[0040]: 1E1F2021 22232425 26272829 2A2B2C2D ...!"#$%&'()*+,-
[0050]: 2E2F3031 32333435 36373839 3A3B3C3D ./0123456789:;<=
[0060]: 3E3F4041 42434445 46474849 4A4B4C4D >?@ABCDEFGHIJKLM
[0070]: 4E4F5051 5253                       NOPQRS
rx len=118, encap=ip, port=1
[0000]: 000B8540 08C0000C 316E7F80 08004500 ...@.@..1n....E.
[0010]: 00680000 4000FF01 A0BD0164 6C010164 .h..@....=.dl..d
[0020]: 6C0E0000 10D9E500 00000000 00000000 l....Ye.........
[0030]: 00000000 00000000 00000000 00001C1D ................
[0040]: 1E1F2021 22232425 26272829 2A2B2C2D ...!"#$%&'()*+,-
[0050]: 2E2F3031 32333435 36373839 3A3B3C3D ./0123456789:;<=
[0060]: 3E3F4041 42434445 46474849 4A4B4C4D >?@ABCDEFGHIJKLM
[0070]: 4E4F5051 5253                       NOPQRS
```

212235

Figure 13 ***Sample Text2pcap Output***

```
tx len=118, encap=n/a, port=1
0000 00 0C 31 6E 7F 80 00 0B 85 40 08 c0 08 00 45 00 ..1n.....@.@..E.
0010 00 68 00 00 40 00 40 01 5F BE 01 64 6C 0E 01 64 .h..@.@._>.dl..d
0020 6C 01 08 00 08 D9 E5 00 00 00 00 00 00 00 00 00 l....Ye.........
0030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 1C 1D ................
0040 1E 1F 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D ...!"#$%&'()*+,-
0050 2E 2F 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D ./0123456789:;<=
0060 3E 3F 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D >?@ABCDEFGHIJKLM
0070 4E 4F 50 51 52 53                               NOPQRS
rx len=118, encap=ip, port=1
0000 00 0B 85 40 08 C0 00 0C 31 6E 7F 80 08 00 45 00 ...@.@..1n....E.
0010 00 68 00 00 40 00 FF 01 A0 BD 01 64 6C 01 01 64 .h..@....=.dl..d
0020 6C 0E 00 00 10 D9 E5 00 00 00 00 00 00 00 00 00 l....Ye.........
0030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 1C 1D ................
0040 1E 1F 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D ...!"#$%&'()*+,-
0050 2E 2F 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D ./0123456789:;<=
0060 3E 3F 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D >?@ABCDEFGHIJKLM
0070 4E 4F 50 51 52 53                               NOPQRS
```

232343

Step 4 To determine why packets might not be displayed, enter this command:

debug packet error {**enable** | **disable**}

Step 5 To display the status of packet debugging, enter this command:

show debug packet

Information similar to the following appears:

```
Status........................................... disabled
Number of packets to display..................... 25
Bytes/packet to display.......................... 0
Packet display format............................ text2pcap
```

```
Driver ACL:
      [1]: disabled
      [2]: disabled
      [3]: disabled
      [4]: disabled
      [5]: disabled
      [6]: disabled
   Ethernet ACL:
      [1]: disabled
      [2]: disabled
      [3]: disabled
      [4]: disabled
      [5]: disabled
      [6]: disabled
   IP ACL:
      [1]: disabled
      [2]: disabled
      [3]: disabled
      [4]: disabled
      [5]: disabled
      [6]: disabled
   EoIP-Ethernet ACL:
      [1]: disabled
      [2]: disabled
      [3]: disabled
      [4]: disabled
      [5]: disabled
      [6]: disabled
   EoIP-IP ACL:
      [1]: disabled
      [2]: disabled
      [3]: disabled
      [4]: disabled
      [5]: disabled
      [6]: disabled
   LWAPP-Dot11 ACL:
      [1]: disabled
      [2]: disabled
      [3]: disabled
      [4]: disabled
      [5]: disabled
      [6]: disabled
   LWAPP-IP ACL:
      [1]: disabled
      [2]: disabled
      [3]: disabled
      [4]: disabled
      [5]: disabled
      [6]: disabled
```

Configuring Wireless Sniffing

The controller enables you to configure an access point as a network “sniffer,” which captures and forwards all the packets on a particular channel to a remote machine that runs packet analyzer software. These packets contain information on timestamp, signal strength, packet size, and so on. Sniffers allow you to monitor and record network activity and to detect problems.

Supported third-party network analyzer software applications include:

- Wildpackets Omnipeek or Airopeek
- AirMagnet Enterprise Analyzer
- Wireshark

Note The latest version of Wireshark can decode the packets by going to the ‘Anaylze’ mode. select ‘decode as’, and switch UDP5555 to decode as "AIROPEEK".

Note You must disable IP-MAC address binding in order to use an access point in sniffer mode if the access point is joined to a 5500 series controller, a 2100 series controller, or a controller network module running software release 6.0. To disable IP-MAC address binding, enter this command using the controller CLI: **config network ip-mac-binding disable**. Refer to the “Configuring IP-MAC Address Binding” section on page 66 for more information.

Note WLAN 1 must be enabled in order to use an access point in sniffer mode if the access point is joined to a 5500 series controller, a 2100 series controller, or a controller network module running software release 6.0. If WLAN 1 is disabled, the access point cannot send packets.

Prerequisites for Wireless Sniffing

To perform wireless sniffing, you need the following hardware and software:

- **A dedicated access point**—An access point configured as a sniffer cannot simultaneously provide wireless access service on the network. To avoid disrupting coverage, use an access point that is not part of your existing wireless network.
- **A remote monitoring device**—A computer capable of running the analyzer software.
- **Windows XP or Linux operating system**—The controller supports sniffing on both Windows XP and Linux machines.
- **Software and supporting files, plug-ins, or adapters**—Your analyzer software may require specialized files before you can successfully enable sniffing:
  - **Omnipeek or Airopeek**—Go to WildPackets’ website and follow the instructions to purchase, install, and configure the software.
  - **AirMagnet**—Go to Fluke Networks’ website and follow the instructions to purchase, install, and configure the software.
  - **Wireshark**—Go to http://www.wireshark.org/download.html and follow the instructions to download Wireshark and the correct installation wizard for your operating system.

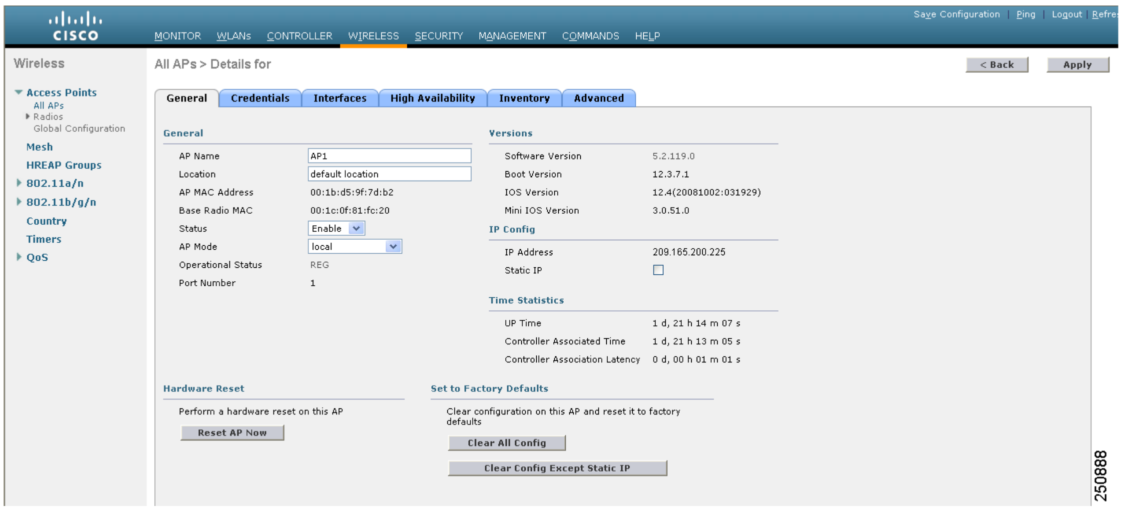
Using the GUI to Configure Sniffing on an Access Point

Using the controller GUI, follow these steps to configure sniffing on an access point.

Step 1 Choose **Wireless > Access Points > All APs** to open the All APs page.

Step 2 Click the name of the access point that you want to configure as the sniffer. The All APs > Details for page appears (see Figure 14).

Figure 14 All APs > Details for Page



Step 3 From the AP Mode drop-down box, choose **Sniffer**.

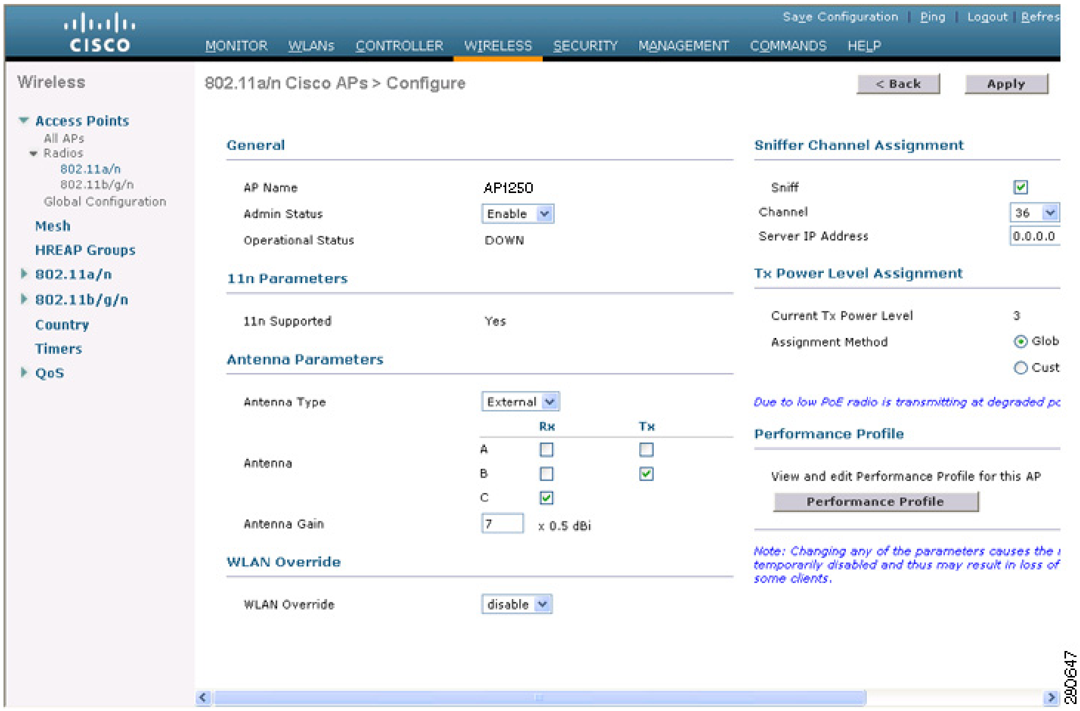
Step 4 Click **Apply** to commit your changes.

Step 5 Click **OK** when warned that the access point will be rebooted.

Step 6 Choose **Wireless > Access Points > Radios > 802.11a/n** (or **802.11b/g/n**) to open the 802.11a/n (or 802.11b/g/n) Radios page.

Step 7 Hover your cursor over the blue drop-down arrow for the desired access point and choose **Configure**. The 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page appears (see Figure 15).

Figure 15 802.11b/g/n Cisco APs > Configure Page



Step 8 Check the **Sniff** check box to enable sniffing on this access point, or leave it unchecked to disable sniffing. The default value is unchecked.

Step 9 If you enabled sniffing in Step 8, follow these steps:

a. From the Channel drop-down box, choose the channel on which the access point sniffs for packets.

b. In the Server IP Address field, enter the IP address of the remote machine running Omnipeek, Airopeek, AirMagnet, or Wireshark.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Configure Sniffing on an Access Point

Using the controller CLI, follow these steps to configure sniffing on an access point.

Step 1 To configure the access point as a sniffer, enter this command:

config ap mode sniffer *Cisco_AP*

where *Cisco_AP* is the access point configured as the sniffer.

Step 2 When warned that the access point will be rebooted and asked if you want to continue, enter **Y**. The access point reboots in sniffer mode.

Step 3 To enable sniffing on the access point, enter this command:

config ap sniff {802.11a | 802.11b} enable *channel server_IP_address Cisco_AP*

where

- *channel* is the radio channel on which the access point sniffs for packets. The default values are 36 (802.11a/n) and 1 (802.11b/g/n).
- *server_IP_address* is the IP address of the remote machine running Omnipeek, Airopeek, AirMagnet, or Wireshark.
- *Cisco_AP* is the access point configured as the sniffer.

Note To disable sniffing on the access point, enter this command:
config ap sniff {802.11a | 802.11b} disable *Cisco_AP*

Step 4 To save your changes, enter this command:

save config

Step 5 To view the sniffer configuration settings for an access point, enter this command:

show ap config {802.11a | 802.11b} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 17
Cisco AP Name.......................................... AP1131:46f2.98ac
...
AP Mode ........................................... Sniffer
Public Safety ..................................... Global: Disabled, Local: Disabled
Sniffing ............................................. No
...
```

Troubleshooting Access Points Using Telnet or SSH

The controller supports the use of the Telnet and Secure Shell (SSH) protocols to troubleshoot lightweight access points. Using these protocols makes debugging easier, especially when the access point is unable to connect to the controller.

- To avoid potential conflicts and security threats to the network, the following commands are unavailable while a Telnet or SSH session is enabled: **config terminal**, **telnet**, **ssh**, **rsh**, **ping**, **traceroute**, **clear**, **clock**, **crypto**, **delete**, **fsck**, **lwapp**, **mkdir**, **radius**, **release**, **reload**, **rename,** **renew**, **rmdir**, **save**, **set**, **test**, **upgrade**.
- Commands available during a Telnet or SSH session include: **debug**, **disable**, **enable**, **help**, **led**, **login**, **logout**, **more**, **no debug**, **show**, **systat**, **undebug**, **where**.

You can configure Telnet or SSH using the controller CLI in software release 5.0 or later or using the controller GUI in software release 6.0.

Note Refer to the "Configuring Telnet and SSH Sessions" section on page 34 for instructions on configuring Telnet or SSH sessions on the controller.

Using the GUI to Troubleshoot Access Points Using Telnet or SSH

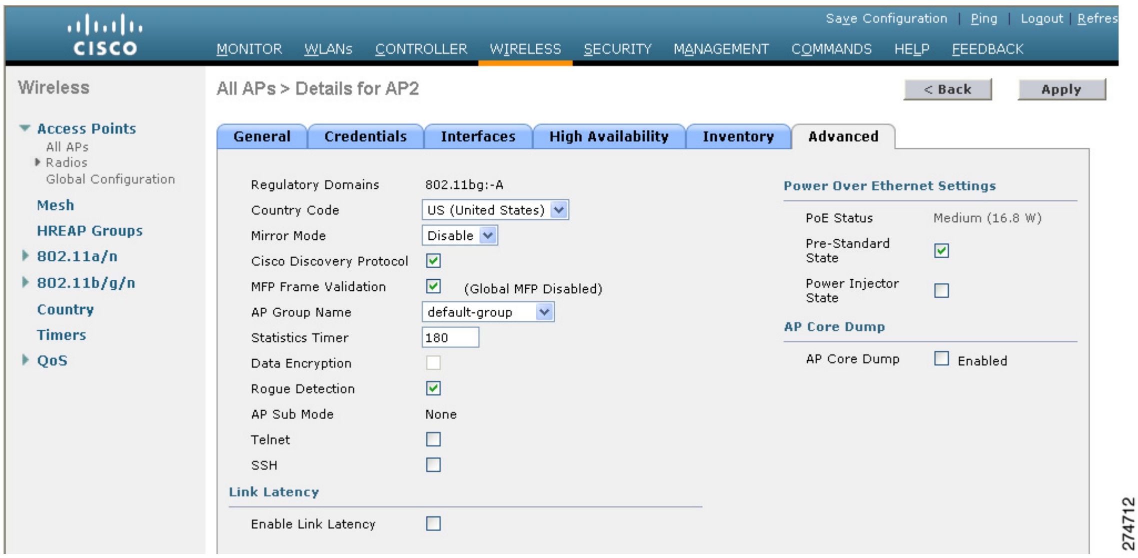
Using the controller GUI, follow these steps to enable Telnet or SSH access (or both) on lightweight access points.

Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to enable Telnet or SSH.

Step 3 Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 16).

Figure 16 All APs > Details for (Advanced) Page



Step 4 To enable Telnet connectivity on this access point, check the **Telnet** check box. The default value is unchecked.

Step 5 To enable SSH connectivity on this access point, check the **SSH** check box. The default value is unchecked.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Troubleshoot Access Points Using Telnet or SSH

Using the controller CLI, follow these steps to enable Telnet or SSH access (or both) on lightweight access points.

Step 1 To enable Telnet or SSH connectivity on an access point, enter this command:

config ap {**telnet** | **ssh**} **enable** *Cisco_AP*

The default value is disabled.

Note To disable Telnet or SSH connectivity on an access point, enter this command:
config ap {**telnet** | **ssh**} **disable** *Cisco_AP*

Step 2 To save your changes, enter this command:

save config

Step 3 To see whether Telnet or SSH is enabled on an access point, enter this command:

show ap config general *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier............................ 5
Cisco AP Name.................................. AP33
Country code................................... Multiple Countries:US,AE,AR,AT,AU,BH
Reg. Domain allowed by Country................. 802.11bg:-ABCENR 802.11a:-ABCEN
AP Country code................................ US - United States
AP Regulatory Domain........................... 802.11bg:-A 802.11a:-A
Switch Port Number ............................ 2
MAC Address.................................... 00:19:2f:11:16:7a
IP Address Configuration....................... Static IP assigned
IP Address..................................... 10.22.8.133
IP NetMask..................................... 255.255.248.0
Gateway IP Addr................................ 10.22.8.1
Domain.........................................
Name Server....................................
Telnet State................................... Enabled
Ssh State...................................... Enabled
...
```

Debugging the Access Point Monitor Service

The controller sends access point status information to the Cisco 3300 Series Mobility Services Engine (MSE) using the access point monitor service.

The MSE sends a service subscription and an access point monitor service request to get the status of all access points currently known to the controller. When any change is made in the status of an access point, a notification is sent to the MSE.

Using the CLI to Debug Access Point Monitor Service Issues

If you experience any problems with the access point monitor service, enter this command:

debug service ap-monitor {**all** | **error** | **event** | **nmsp** | **packet**} {**enable** | **disable**}

where

- **all** configures debugging of all access point status messages,
- **error** configures debugging of access point monitor error events,
- **event** configures debugging of access point monitor events,
- **nmsp** configures debugging of access point monitor NMSP events, and
- **packet** configures debugging of access point monitor packets.

Troubleshooting OfficeExtend Access Points

This section provides troubleshooting information if you experience any problems with your OfficeExtend access points.

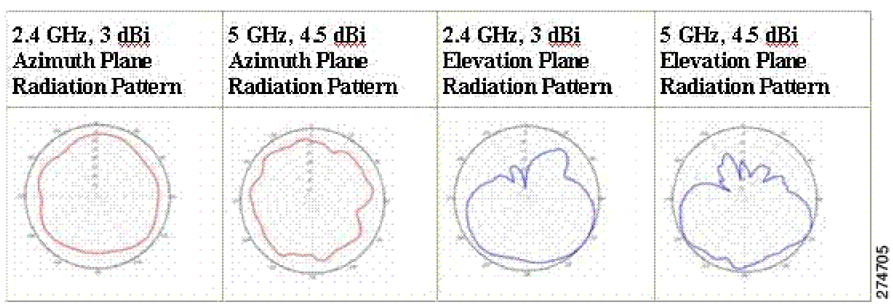
Interpreting OfficeExtend LEDs

The LED patterns are different for 1130 series and 1140 series OfficeExtend access points. Refer to the *Cisco OfficeExtend Access Point Quick Start Guide* for a description of the LED patterns.

Positioning OfficeExtend Access Points for Optimal RF Coverage

When positioning your OfficeExtend access point, consider that its RF signals are emitted in a cone shape spreading outward from the LED side of the access point (see Figure 17). Be sure to mount the access point so that air can flow behind the metal back plate and prevent the access point from over heating.

Figure 17 OfficeExtend Access Point Radiation Patterns



Troubleshooting Common Problems

Most of the problems experienced with OfficeExtend access points are one of the following:

- The access point cannot join the controller because of network or firewall issues.

  Resolution: Follow the instructions in the "Viewing Access Point Join Information" section on page 38 to view join statistics for the OfficeExtend access point, or find the access point's public IP address and perform pings of different packet sizes from inside the company.

- The access point joins but keeps dropping off. This behavior usually occurs because of network problems or when the network address translation (NAT) or firewall ports close because of short timeouts.

  Resolution: Ask the teleworker for the LED status.

- Clients cannot associate because of NAT issues.

  Resolution: Ask the teleworker to perform a speed test and a ping test in DSL Reports website. Some servers do not return big packet pings, so use the www.dslreports.com server to do pings such as ping -l 1500 -n 10 www.dslreports.com.

- Clients keep dropping data. This behavior usually occurs because the home router closes the port because of short timeouts.

  Resolution: Perform client troubleshooting in WCS to determine if the problem is related to the OfficeExtend access point or the client.

- The access point is not broadcasting the enterprise WLAN.

  Resolution: Ask the teleworker to check the cables, power supply, and LED status. If you still cannot identify the problem, ask the teleworker to try the following:

  – Connect to the home router directly and see if the PC is able to connect to an Internet website such as http://www.cisco.com/. If the PC cannot connect to the Internet, check the router or modem. If the PC can connect to the Internet, check the home router configuration to see if a firewall or MAC-based filter is enabled that is blocking the access point from reaching the Internet.

  – Log into the home router and check to see if the access point has obtained an IP address. If it has, the access point's LED normally blinks orange.

- The access point cannot join the controller, and you cannot identify the problem.

  Resolution: A problem could exist with the home router. Ask the teleworker to check the router manual and try the following:

  – Assign the access point a static IP address based on the access point's MAC address.

  – Put the access point in a demilitarized zone (DMZ), which is a small network inserted as a neutral zone between a company's private network and the outside public network. It prevents outside users from getting direct access to a server that has company data.

  – If problems still occur, contact your company's IT department for assistance.

- The teleworker experiences problems while configuring a personal SSID on the access point.

  Resolution: Clear the access point configuration and return it to factory default settings by clicking **Clear Config** on the access point GUI or by entering this command on the controller CLI: **clear ap config** *Cisco_AP*, and then follow the steps in the "Configuring a Personal SSID on an OfficeExtend Access Point" section on page 58 to try again. If problems still occur, contact your company's IT department for assistance.

- The home network needs to be rebooted.

  Resolution: Ask the teleworker to follow these steps:

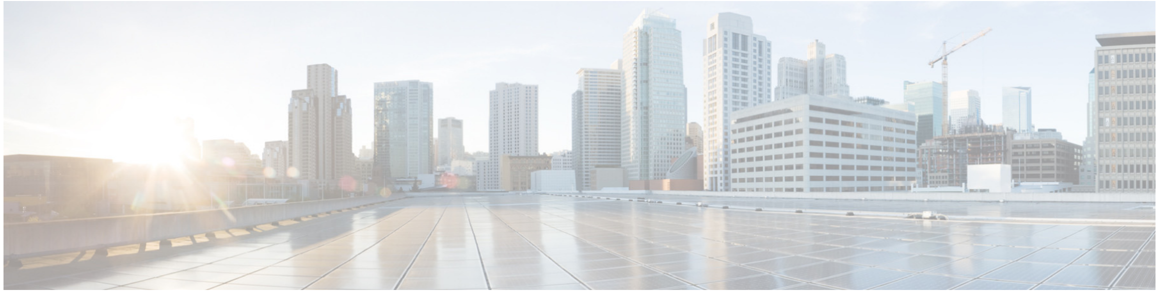
  a. Leave all devices networked and connected; then power down all the devices.

  b. Turn on the cable or DSL modem; then wait for 2 minutes. (Check the LED status.)

  c. Turn on the home router; then wait for 2 minutes. (Check the LED status.)

  d. Turn on the access point; then wait for 5 minutes. (Check the LED status.)

  e. Turn on the client.



E

Logical Connectivity Diagrams

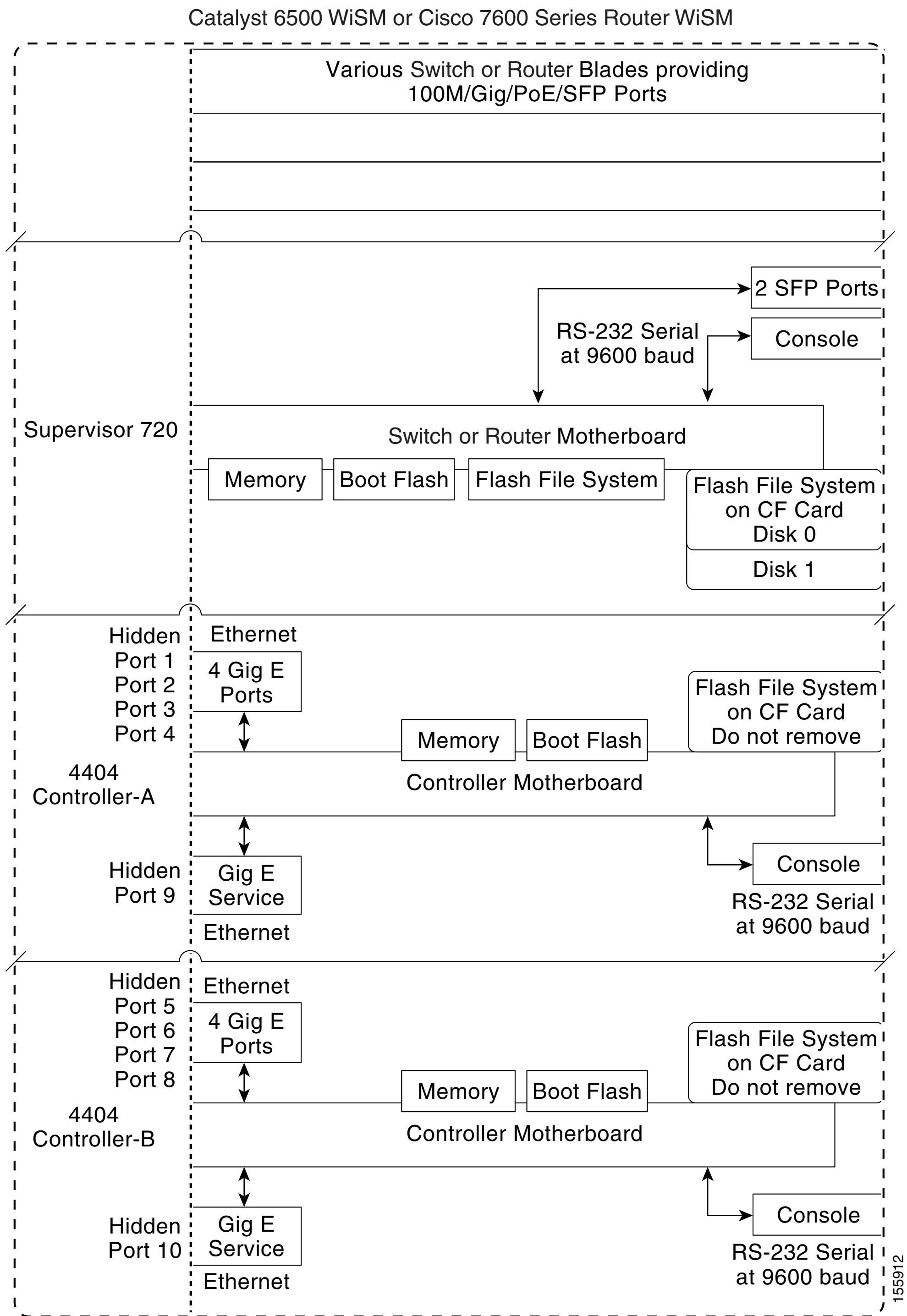
This appendix provides logical connectivity diagrams and related software commands for integrated controllers. It contains these sections:

This section provides logical connectivity diagrams for the controllers integrated into other Cisco products, specifically the Catalyst 3750G Integrated Wireless LAN Controller Switch, the Cisco WiSM, and the Cisco 28/37/38xx Series Integrated Services Router. These diagrams show the internal connections between the switch or router and the controller. The software commands used for communication between the devices are also provided.

Americas Headquarters:
Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA

Cisco WiSM

Figure 1 Logical Connectivity Diagram for the Cisco WiSM

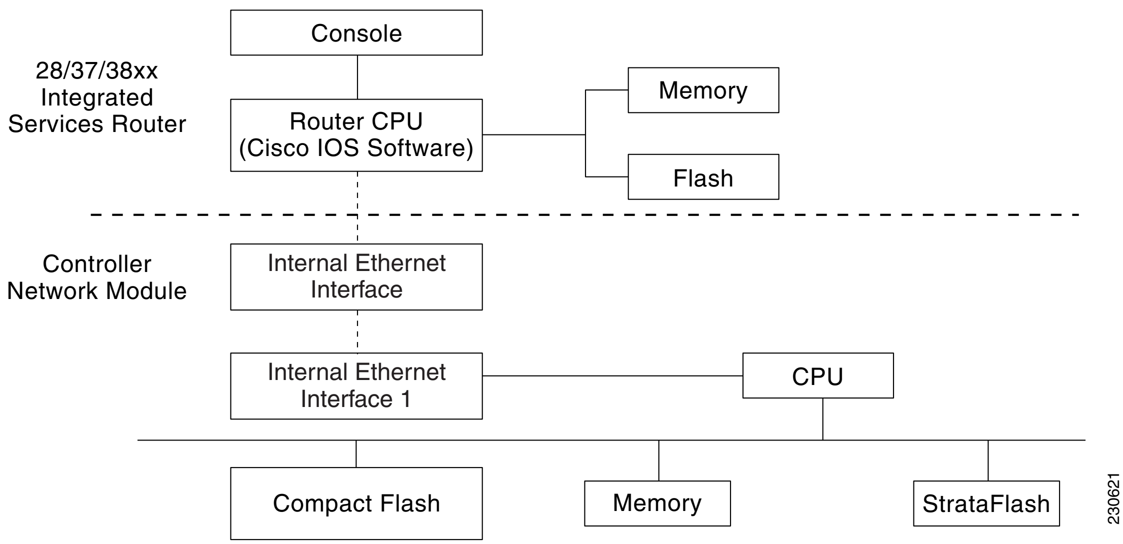


The commands used for communication between the Cisco WiSM, the Supervisor 720, and the 4404 controllers are documented in *Configuring a Cisco Wireless Services Module and Wireless Control System* at this URL:

http://www.cisco.com/c/en/us/td/docs/wireless/technology/wism/technical/reference/appnote.html#wp39498

Cisco 28/37/38xx Integrated Services Router

Figure 2 Logical Connectivity Diagram for the Cisco 28/37/38xx Integrated Services Router



These commands are used for communication between the 28/37/38xx Integrated Services Router and the controller network module. They are initiated from the router. The commands vary depending on the version of the network module.

These commands are used for communication between the router and Fast Ethernet versions of the controller network module:

- **interface wlan-controller** *slot/unit* (and support for subinterfaces with **dot1q encap**)
- **show interfaces wlan-controller** *slot/unit*
- **show controllers wlan-controller** *slot/unit*
- **test service-module wlan-controller** *slot/unit*
- **test HW-module wlan-controller** *slot/unit* **reset** {**enable** | **disable**}
- **service-module wlan-controller** *slot/port* {**reload** | **reset** | **session** [**clear**] | **shutdown** | **status**}

These commands are used for communication between the router and Gigabit Ethernet versions of the controller network module:

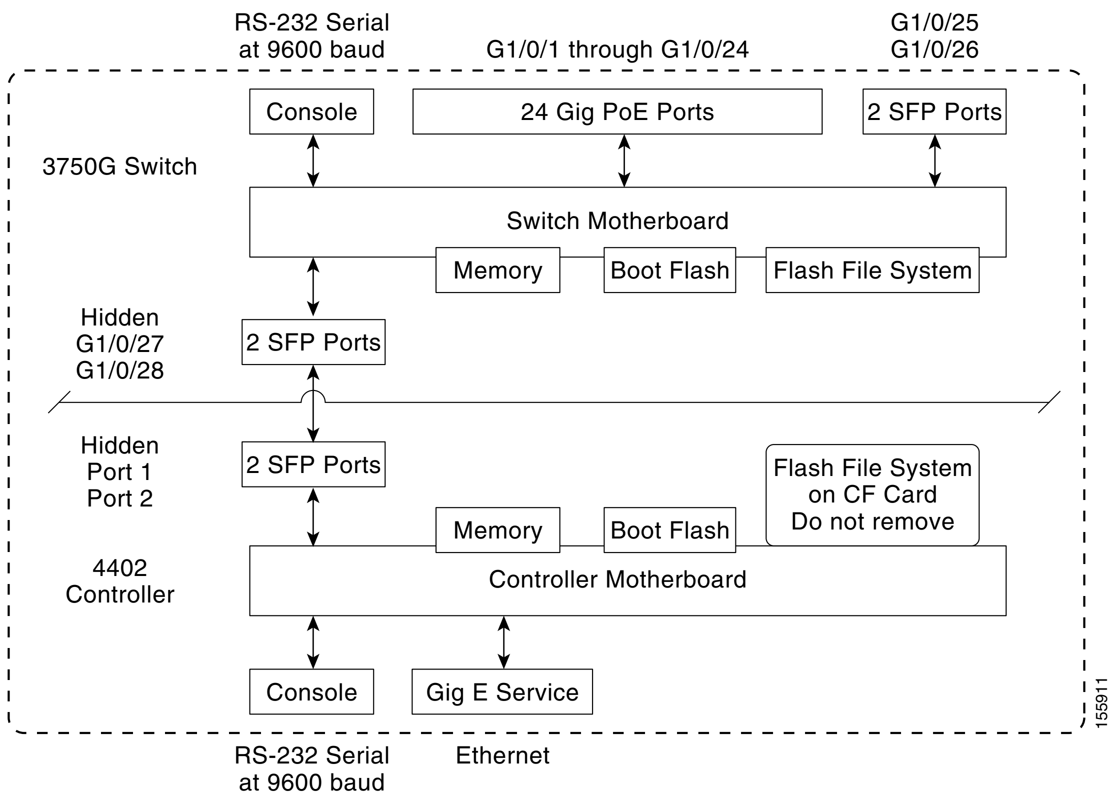
- **interface integrated-service-engine** *slot/unit* (and support for subinterfaces with **dot1q encap**)
- **show interfaces integrated-service-engine** *slot/unit*
- **show controllers integrated-service-engine** *slot/unit*
- **test service-module integrated-service-engine** *slot/unit*

- **test HW-module integrated-service-engine** *slot/unit* **reset** {**enable** | **disable**}
- **service-module integrated-service engine** *slot/port* {**reload** | **reset** | **session** [**clear**] | **shutdown** | **status**}

Note Refer to the *Cisco Wireless LAN Controller Network Module Feature Guide* for more information. You can find this document at this URL: http://www.cisco.com/c/en/us/products/hw/tsd_products_support_end-of-sale_and_end-of-life_products_list.html

Catalyst 3750G Integrated Wireless LAN Controller Switch

Figure 3 Logical Connectivity Diagram for the Catalyst 3750G Integrated Wireless LAN Controller Switch



These commands are used for communication between the Catalyst 3750G switch and the 4402 controller.

Login Command

This command is used to initiate a telnet session from the switch to the controller:

session *switch_number* **processor 1**

Because there can be several switches in a stack, the *switch_number* parameter is used to indicate to which controller in the stack this session should be directed. Once a session is established, the user interacts with the controller CLI. Entering **exit** terminates the session and returns the user to the switch CLI.

Show Commands

These commands are used to view the status of the internal controller. They are initiated from the switch.

- **show platform wireless-controller** *switch_number* **summary**

  Information similar to the following appears:

```
Switch  Status  State
1       up      operational
2       up      operational
```

- **show platform wireless-controller** *switch_number* **status**

  Information similar to the following appears:

```
Switch  Service IP      Management IP   SW Version      Status
------+---------------+---------------+---------------+-------
 1      127.0.1.1       70.1.30.1       4.0.52.0        operational
 2      127.0.1.2       70.1.31.1       4.0.45.0        operational
```

- **show platform wireless-controller** *switch_number* **management-info**

```
sw vlan ip                 gateway         http https mac            version
1  0    70.1.30.1/16       70.1.1.1        1    1     0016.9dca.d963 4.0.52.0
2  0    70.1.31.1/16       70.1.1.1        0    1     0016.9dca.dba3 4.0.45.0
```

Debug Commands

The Wireless Control Protocol (WCP) is an internal keep-alive protocol that runs between the switch and the controller. It enables the switch to monitor the health of the controller and to report any problems. It uses UDP and runs over the two internal Gigabit ports, but it creates an internal VLAN 4095 to separate control traffic from data traffic. Every 20 seconds the switch sends a keep-alive message to the controller. If the controller does not acknowledge 16 consecutive keep-alive messages, the switch declares the controller dead and sends a reset signal to reboot the controller.

These commands are used to monitor the health of the internal controller.

This command is initiated from the controller.

- **debug wcp** *?*

  where *?* is one of the following:

  packet—Debugs WCP packets.

  events—Debugs WCP events.

  Information similar to the following appears:

```
Tue Feb  7 23:30:31 2006: Received WCP_MSG_TYPE_REQUEST
Tue Feb  7 23:30:31 2006: Received WCP_MSG_TYPE_REQUEST,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:30:31 2006: Sent WCP_MSG_TYPE_RESPONSE,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:30:51 2006: Received WCP_MSG_TYPE_REQUEST
Tue Feb  7 23:30:51 2006: Received WCP_MSG_TYPE_REQUEST,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:30:51 2006: Sent WCP_MSG_TYPE_RESPONSE,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:31:11 2006: Received WCP_MSG_TYPE_REQUEST
Tue Feb  7 23:31:11 2006: Received WCP_MSG_TYPE_REQUEST,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:31:11 2006: Sent WCP_MSG_TYPE_RESPONSE,of type WCP_TLV_KEEP_ALIVE
```

This command is initiated from the switch.

- **debug platform wireless-controller** *switch_number ?*

  where *?* is one of the following:

  all—All

  errors—Errors

  packets—WCP packets

  sm—State machine

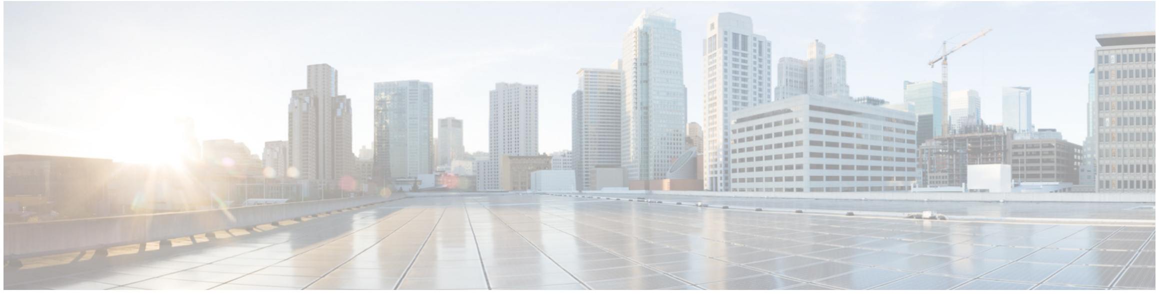
  wcp—WCP protocol

<u>Reset Commands</u>

These two commands (in this order) are used to reset the controller from the switch. They are not yet available but will be supported in a future release.

- **test wireless-controller stop** *switch_number*
- **test wireless-controller start** *switch_number*

Note A direct console connection to the controller does not operate when hardware flow control is enabled on the PC. However, the switch console port operates with hardware flow control enabled.



INDEX

Numerics

Americas Headquarters:
Cisco Systems, Inc., 170 West Tasman Drive, San Jose, CA 95134-1706 USA

A

B

C

D

E

F

G

H

I

M

N

O

P

Q

R

S

T

U

V

W