



## **Cisco Wireless ISR and HWIC Access Point Configuration Guide**

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## Preface

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The Preface provides information on the following topics:

- [Audience](#)
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## Audience

This guide is for the networking professional who installs and manages Cisco stationary routers with wireless capabilities. You should have experience working with the Cisco IOS software and be familiar with the concepts and terminology of wireless LANs.

This document provides information for the following interfaces:

- Access Point High-speed WAN Interface Card (AP HWIC)
- Cisco 800 series routers with wireless capabilities
- Cisco 1800 series routers with wireless capabilities.

## Purpose

This guide provides the information you need to install and configure your Cisco wireless device, for example, AP HWIC, Cisco 800 series and Cisco 1800 series routers. This guide provides procedures for using the Cisco IOS software commands that have been created or changed for use with the wireless device. It does not provide detailed information about these commands. For information about the standard Cisco IOS software commands, see the Cisco IOS software documentation set available from the Cisco.com home page at **Service and Support > Technical Documents**. On the Cisco Product Documentation home page, select **Release 12.4** from the Cisco IOS Software drop-down list.

# Organization

This guide consists of the following chapters:

[Chapter 1, “Overview,”](#) lists the software and hardware features of the wireless device and describes the role of the wireless device in your network.

[Chapter 2, “Configuring Radio Settings,”](#) describes how to configure settings for the wireless device radio such as the role in the radio network, data rates, transmit power, channel settings, and others.

[Chapter 3, “Configuring Multiple SSIDs,”](#) describes how to configure and manage multiple service set identifiers (SSIDs) and multiple basic SSIDs (BSSIDs) on your wireless device. You can configure up to 16 SSIDs and 16 BSSIDs on your wireless device and assign different configuration settings to each.

[Chapter 4, “Configuring an Access Point as a Local Authenticator,”](#) describes how to configure the wireless device to act as a local RADIUS server for your wireless LAN. If the WAN connection to your main RADIUS server fails, the wireless device acts as a backup server to authenticate wireless devices.

[Chapter 5, “Configuring Encryption Types,”](#) describes how to configure the cipher suites required to use authenticated key management, Wired Equivalent Privacy (WEP), and WEP features.

[Chapter 6, “Configuring Authentication Types,”](#) describes how to configure authentication types on the wireless device. Client devices use these authentication methods to join your network.

[Chapter 7, “Configuring RADIUS Servers,”](#) describes how to enable and configure the RADIUS, which provides detailed accounting information and flexible administrative control over authentication and authorization processes.

[Chapter 8, “Configuring VLANs,”](#) describes how to configure your wireless device to interoperate with the VLANs set up on your wired LAN.

[Chapter 9, “Configuring QoS,”](#) describes how to configure quality of service (QoS) on your wireless device. With this feature, you can provide preferential treatment to certain traffic at the expense of others.

[Appendix A, “Channel Settings,”](#) lists the wireless device radio channels and the maximum power levels supported by the world’s regulatory domains.

[Appendix B, “Protocol Filters,”](#) lists some of the protocols that you can filter on the wireless device.

[Appendix C, “Supported MIBs,”](#) lists the Simple Network Management Protocol (SNMP) Management Information Bases (MIBs) that the wireless device supports for this software release.

[Appendix D, “Error and Event Messages,”](#) lists the CLI error and event messages and provides an explanation and recommended action for each message.

# 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 screen** font.
- Nonprinting characters, such as passwords or tabs, are in angle brackets (< >).

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



**Tip**

Means the following will help you solve a problem. The tips information might not be troubleshooting or even an action, but could be useful information.



**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).**

<b>Warnung</b>	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).)
<b>Avvertenza</b>	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).
<b>Advarsel</b>	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].)
<b>Aviso</b>	Este símbolo de aviso indica perigo. Encontra-se numa situação que lhe poderá causar danos físicos. 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").
<b>¡Advertencia!</b>	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.")
<b>Varning!</b>	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

Related Cisco technical documentation include the following:

**Table 1** *Related and Referenced Documents*

Cisco Product	Document Title
Cisco Access Point High-Speed WAN Interface Card	<a href="#">Cisco Interface Cards Installation Guide</a>
	<a href="#">Quick Start Guide: Interface Cards for Cisco Access Routers</a>
	<a href="#">Installing, Replacing, and Upgrading Components in Cisco Modular Access Routers and Integrated Services Routers</a>

**Table 1** *Related and Referenced Documents (continued)*

<b>Cisco Product</b>	<b>Document Title</b>
Cisco 800 series routers	<i>Cisco 850 Series and Cisco 870 Series Routers Hardware Installation Guide</i>
	<i>Cisco 850 Series and Cisco 870 Series Access Routers Cabling and Setup Quick Start Guide</i>
	<i>Cisco 850 Series and Cisco 870 Series Access Routers Software Configuration Guide</i>
	<i>Regulatory Compliance and Safety Information for Cisco 800 Series and SOHO Series Routers</i>
	<i>Upgrading Memory in Cisco 800 Routers</i>
Cisco 1800 series routers	<i>Cisco 1800 Series Integrated Services Routers (Modular) Quick Start Guide</i>
	<i>Cisco 1800 Series Routers Hardware Installation Documents</i>
	<i>Cisco 1800 Series Software Configuration Guide</i>
	<i>Cisco 1800 Series Cards and Modules</i>
	<i>Regulatory Compliance and Safety Information for Cisco 1840 Routers</i>
	<i>Cisco Modular Access Router Cable Specifications</i>
Cisco IOS software	Cisco IOS software documentation, all releases. Refer to the documentation for the Cisco IOS software release installed on your router.
	Additional Documentation
	<i>Cisco AP HWIC and Access Router Wireless Configuration Guide</i>
	<i>Cisco Aironet 2.4-GHz Articulated Dipole Antenna (AIR-ANT4941)</i>
	<i>Cisco Aironet High Gain Omnidirectional Ceiling Mount Antenna (AIR-ANT1728)</i>
	<i>Cisco Aironet 2 dBi Diversity Omnidirectional Ceiling Mount Antenna (AIR-ANT5959)</i>
	<i>Antenna Cabling</i>
	<i>Declarations of Conformity and Regulatory Information for Cisco Access Products with 802.11a/b/g and 802.11b/g Radios</i>

## Obtaining Documentation

Cisco documentation and additional literature are available on Cisco.com. Cisco also provides several ways to obtain technical assistance and other technical resources. These sections explain how to obtain technical information from Cisco Systems.

### Cisco.com

You can access the most current Cisco documentation at this URL:

<http://www.cisco.com/techsupport>

You can access the Cisco website at this URL:

<http://www.cisco.com>

You can access international Cisco websites at this URL:

[http://www.cisco.com/public/countries\\_languages.shtml](http://www.cisco.com/public/countries_languages.shtml)

## Product Documentation DVD

Cisco documentation and additional literature are available in the Product Documentation DVD package, which may have shipped with your product. The Product Documentation DVD is updated regularly and may be more current than printed documentation.

The Product Documentation DVD is a comprehensive library of technical product documentation on portable media. The DVD enables you to access multiple versions of hardware and software installation, configuration, and command guides for Cisco products and to view technical documentation in HTML. With the DVD, you have access to the same documentation that is found on the Cisco website without being connected to the Internet. Certain products also have .pdf versions of the documentation available.

The Product Documentation DVD is available as a single unit or as a subscription. Registered Cisco.com users (Cisco direct customers) can order a Product Documentation DVD (product number DOC-DOCDVD=) from the Ordering tool or Cisco Marketplace.

Cisco Ordering tool:

<http://www.cisco.com/en/US/partner/ordering/>

Cisco Marketplace:

<http://www.cisco.com/go/marketplace/>

## Ordering Documentation

Beginning June 30, 2005, registered Cisco.com users may order Cisco documentation at the Product Documentation Store in the Cisco Marketplace at this URL:

<http://www.cisco.com/go/marketplace/>

Cisco will continue to support documentation orders using the Ordering tool:

- Registered Cisco.com users (Cisco direct customers) can order documentation from the Ordering tool:  
<http://www.cisco.com/en/US/partner/ordering/>
- Instructions for ordering documentation using the Ordering tool are at this URL:  
[http://www.cisco.com/univercd/cc/td/doc/es\\_inpk/pdi.htm](http://www.cisco.com/univercd/cc/td/doc/es_inpk/pdi.htm)
- Nonregistered Cisco.com users can order documentation through a local account representative by calling Cisco Systems Corporate Headquarters (California, USA) at 408 526-7208 or, elsewhere in North America, by calling 1 800 553-NETS (6387).

## Documentation Feedback

You can rate and provide feedback about Cisco technical documents by completing the online feedback form that appears with the technical documents on Cisco.com.

You can send comments about Cisco documentation to [bug-doc@cisco.com](mailto:bug-doc@cisco.com).

You can submit comments by using the response card (if present) behind the front cover of your document or by writing to the following address:

Cisco Systems  
Attn: Customer Document Ordering  
170 West Tasman Drive  
San Jose, CA 95134-9883

We appreciate your comments.

## Cisco Product Security Overview

Cisco provides a free online Security Vulnerability Policy portal at this URL:

[http://www.cisco.com/en/US/products/products\\_security\\_vulnerability\\_policy.html](http://www.cisco.com/en/US/products/products_security_vulnerability_policy.html)

From this site, you can perform these tasks:

- Report security vulnerabilities in Cisco products.
- Obtain assistance with security incidents that involve Cisco products.
- Register to receive security information from Cisco.

A current list of security advisories and notices for Cisco products is available at this URL:

<http://www.cisco.com/go/psirt>

If you prefer to see advisories and notices as they are updated in real time, you can access a Product Security Incident Response Team Really Simple Syndication (PSIRT RSS) feed from this URL:

[http://www.cisco.com/en/US/products/products\\_psirt\\_rss\\_feed.html](http://www.cisco.com/en/US/products/products_psirt_rss_feed.html)

## Reporting Security Problems in Cisco Products

Cisco is committed to delivering secure products. We test our products internally before we release them, and we strive to correct all vulnerabilities quickly. If you think that you might have identified a vulnerability in a Cisco product, contact PSIRT:

- Emergencies—[security-alert@cisco.com](mailto:security-alert@cisco.com)

An emergency is either a condition in which a system is under active attack or a condition for which a severe and urgent security vulnerability should be reported. All other conditions are considered non emergencies.

- Non emergencies—[psirt@cisco.com](mailto:psirt@cisco.com)

In an emergency, you can also reach PSIRT by telephone:

- 1 877 228-7302
- 1 408 525-6532



Tip

We encourage you to use Pretty Good Privacy (PGP) or a compatible product to encrypt any sensitive information that you send to Cisco. PSIRT can work from encrypted information that is compatible with PGP versions 2.x through 8.x.

Never use a revoked or an expired encryption key. The correct public key to use in your correspondence with PSIRT is the one linked in the Contact Summary section of the Security Vulnerability Policy page at this URL:

[http://www.cisco.com/en/US/products/products\\_security\\_vulnerability\\_policy.htm](http://www.cisco.com/en/US/products/products_security_vulnerability_policy.htm)

The link on this page has the current PGP key ID in use.

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## Obtaining Technical Assistance

Cisco Technical Support provides 24-hour-a-day award-winning technical assistance. The Cisco Technical Support & Documentation website on Cisco.com features extensive online support resources. In addition, if you have a valid Cisco service contract, Cisco Technical Assistance Center (TAC) engineers provide telephone support. If you do not have a valid Cisco service contract, contact your reseller.

### Cisco Technical Support & Documentation Website

The Cisco Technical Support & Documentation website provides online documents and tools for troubleshooting and resolving technical issues with Cisco products and technologies. The website is available 24 hours a day, at this URL:

<http://www.cisco.com/techsupport>

Access to all tools on the Cisco Technical Support & Documentation website requires a Cisco.com user ID and password. If you have a valid service contract but do not have a user ID or password, you can register at this URL:

<http://tools.cisco.com/RPF/register/register.do>



#### Note

Use the Cisco Product Identification (CPI) tool to locate your product serial number before submitting a web or phone request for service. You can access the CPI tool from the Cisco Technical Support & Documentation website by clicking the **Tools & Resources** link under Documentation & Tools. Choose **Cisco Product Identification Tool** from the Alphabetical Index drop-down list, or click the **Cisco Product Identification Tool** link under Alerts & RMAs. The CPI tool offers three search options: by product ID or model name; by tree view; or for certain products, by copying and pasting **show** command output. Search results show an illustration of your product with the serial number label location highlighted. Locate the serial number label on your product and record the information before placing a service call.

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### Submitting a Service Request

Using the online TAC Service Request Tool is the fastest way to open S3 and S4 service requests. (S3 and S4 service requests are those in which your network is minimally impaired or for which you require product information.) After you describe your situation, the TAC Service Request Tool provides recommended solutions. If your issue is not resolved using the recommended resources, your service request is assigned to a Cisco engineer. The TAC Service Request Tool is located at this URL:

<http://www.cisco.com/techsupport/servicerequest>

For S1 or S2 service requests or if you do not have Internet access, contact the Cisco TAC by telephone. (S1 or S2 service requests are those in which your production network is down or severely degraded.) Cisco engineers are assigned immediately to S1 and S2 service requests to help keep your business operations running smoothly.

To open a service request by telephone, use one of the following numbers:

Asia-Pacific: +61 2 8446 7411 (Australia: 1 800 805 227)

EMEA: +32 2 704 55 55

USA: 1 800 553-2447

For a complete list of Cisco TAC contacts, go to this URL:

<http://www.cisco.com/techsupport/contacts>

## Definitions of Service Request Severity

To ensure that all service requests are reported in a standard format, Cisco has established severity definitions.

**Severity 1 (S1)**—Your network is “down,” or there is a critical impact to your business operations. You and Cisco will commit all necessary resources around the clock to resolve the situation.

**Severity 2 (S2)**—Operation of an existing network is severely degraded, or significant aspects of your business operation are negatively affected by inadequate performance of Cisco products. You and Cisco will commit full-time resources during normal business hours to resolve the situation.

**Severity 3 (S3)**—Operational performance of your network is impaired, but most business operations remain functional. You and Cisco will commit resources during normal business hours to restore service to satisfactory levels.

**Severity 4 (S4)**—You require information or assistance with Cisco product capabilities, installation, or configuration. There is little or no effect on your business operations.

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# Overview

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Cisco wireless devices provide a secure, affordable, and easy-to-use wireless LAN solution that combines mobility and flexibility with the enterprise-class features required by networking professionals. With a management system based on Cisco IOS software, Cisco wireless devices are Wi-Fi certified, 802.11b-compliant, 802.11g-compliant, or 802.11a-compliant wireless LAN transceivers.

This document provides information for the following devices:

- Access Point High-speed WAN Interface Card (AP HWIC)
- Cisco 800 Series routers with wireless capabilities
- Cisco 1800 Series routers with wireless capabilities

This chapter provides information on the following topics:

- [Wireless Device Management](#)
- [Network Configuration Example](#)
- [Features](#)

## Wireless Device Management

You can use the wireless device management system through the following interfaces:

- The Cisco IOS command-line interface (CLI), that can be used through a console port or a Telnet session. Use the interface `dot11radio` configuration command in global mode to place the wireless device into radio configuration mode.
- Simple Network Management Protocol (SNMP).

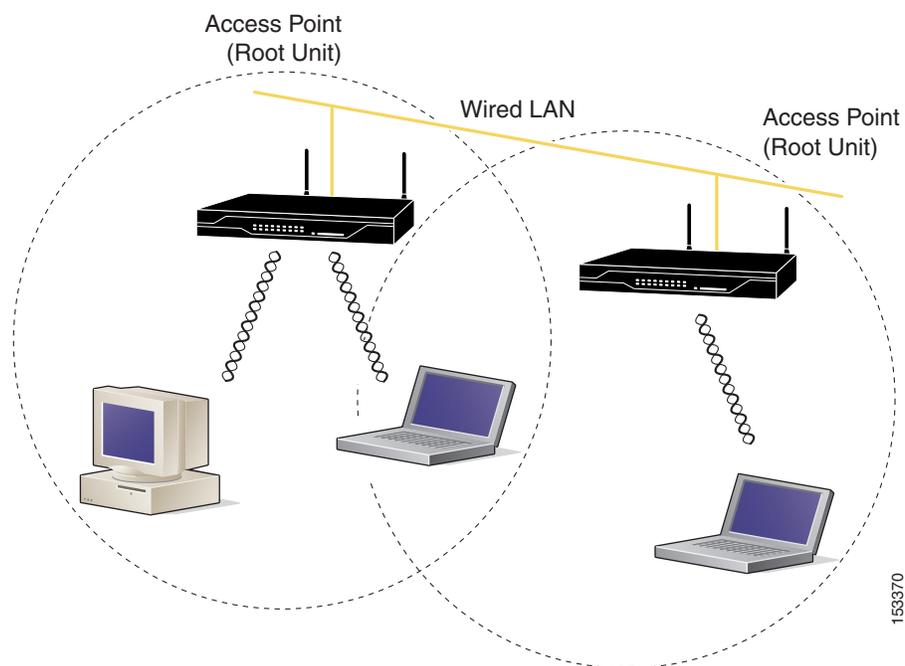
# Network Configuration Example

This section describes the wireless device role in common wireless network configurations. The access point default configuration is as a root unit connected to a wired LAN or as the central unit in an all-wireless network.

## Root Unit on a Wired LAN

An access point connected directly to a wired LAN provides a connection point for wireless users. [Figure 1-1](#) shows access points acting as root units on a wired LAN.

**Figure 1-1** Access Points as Root Units on a Wired LAN



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# Features

This section lists features supported on access points running Cisco IOS software.

- Access Point Link Role Flexibility—This feature allows the user to configure root and non-root bridging mode functionality, universal client mode, and support of a WGB client device, in addition to a root access point on the radio interface.



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**Note** Root/Non-Root bridging mode is supported only on modular ISR platforms, such as Cisco 3800 series, Cisco 2800 and Cisco 1841 series. Fixed ISR platforms, such as the Cisco 800 and Cisco 1800 do not support this feature.

---

- QoS Basic Service Set (QBSS) support—This feature aligns Cisco QBSS implementation with the evolving 802.11e standard. The QBSS element of the access point's beacon advertises channel load instead of traffic load. A new configuration command, **dot11 phone dot11e** has been added in Release 12.4 that allows the standard QBSS Load element to be sent in the beacon. This command should be used when compatible phones are employed in the network.
- Secure Shell version 2 (SSHv2) support—SSH v2 is a standards-based protocol to provide secure Telnet capability for router configuration and administration.
- Support for Multiple BSSIDs—This feature permits a single access point to appear to the WLAN as multiple virtual access points. It does this by assigning an access point with multiple Basic Service Set IDs (MBSSIDs) or MAC addresses.

To determine whether a radio supports multiple basic SSIDs, enter the **show controllers** command for the radio interface. The radio supports multiple basic SSIDs if the results include this line:

```
Number of supported simultaneous BSSID on radio_interface: 8
```

- Support for Wi-Fi 802.11h and Dynamic Frequency Selection (DFS)—This feature allows access points configured at the factory for use in Europe to detect radar signals such as military and weather sources and switch channels on the access points.
- SNMPv3—This feature enables SNMPv3 support on Cisco wireless devices to provide an additional level of security.
- World mode—Use this feature to communicate the access point's regulatory setting information, including maximum transmit power and available channels, to world mode-enabled clients. Clients using world mode can be used in countries with different regulatory settings and automatically conform to local regulations. World mode is supported only on the 2.4-GHz radio.
- Multiple SSIDs—Create up to 16 SSIDs on the wireless device and assign any combination of these settings to each SSID:
  - Broadcast SSID mode for guests on your network
  - Client authentication methods
  - Maximum number of client associations
  - VLAN identifier
  - RADIUS accounting list identifier
  - A separate SSID for infrastructure devices such as repeaters and workgroup bridges



**Note**

---

Only 10 SSIDs are supported on the Cisco 800 series platforms.

---

- VLANs—Assign VLANs to the SSIDs on the wireless device (one VLAN per SSID) to differentiate policies and services among users.
- QoS—Use this feature to support quality of service for prioritizing traffic from the Ethernet to the access point. The access point also supports the voice-prioritization schemes used by 802.11b wireless phones such as the Cisco 7920 and Spectralink's Netlink™.
- RADIUS Accounting—Enable accounting on the access point to send accounting data about wireless client devices to a RADIUS server on your network.
- Enhanced security—Enable three advanced security features to protect against sophisticated attacks on your wireless network's WEP keys: Message Integrity Check (MIC), WEP key hashing, and broadcast WEP key rotation.
- Enhanced authentication services—Set up repeater access points to authenticate to your network like other wireless client devices. After you provide a network username and password for the repeater, it authenticates to your network using Light Extensible Authentication Protocol (LEAP), Cisco's wireless authentication method, and receives and uses dynamic WEP keys.
- Wi-Fi Protected Access (WPA)—Wi-Fi Protected Access is a standards-based, interoperable security enhancement that strongly increases the level of data protection and access control for existing and future wireless LAN systems. It is derived from and will be forward-compatible with the upcoming IEEE 802.11i standard. WPA leverages Temporal Key Integrity Protocol (TKIP) for data protection and 802.1X for authenticated key management.
- Access point as backup or stand-alone authentication server—You can configure an access point to act as a local authentication server to provide authentication service for small wireless LANs without a RADIUS server or to provide backup authentication service in case of a WAN link or a server failure. The number of clients supported varies based on platform, with up to 1000 user accounts supported on the higher end platforms.
- Support for 802.11g radios—Cisco IOS Releases 12.4(2)T or later support the standard 802.11g, 2.4-GHz radio.
- Support for Cisco 802.11a Radios—The 802.11a radios support all access point features introduced in Cisco IOS Release 12.4 and later.
- AES-CCMP—This feature supports Advanced Encryption Standard-Counter Mode with Cipher Block Chaining Message Authentication Code Protocol (AES-CCMP). AES-CCMP is required for Wi-Fi Protected Access 2 (WPA2) and IEEE 802.11i wireless LAN security.
- IEEE 802.1X Local Authentication Service for EAP-FAST—This feature expands wireless domain services (WDS) IEEE 802.1X local authentication to include support for Extensible Authentication Protocol-Flexible Authentication via Secure Tunneling (EAP-FAST).
- Wi-Fi Multimedia (WMM) Required Elements—This feature supports the required elements of WMM. WMM is designed to improve the user experience for audio, video, and voice applications over a Wi-Fi wireless connection. WMM is a subset of the IEEE 802.11e Quality of Service (QoS) draft standard. WMM supports QoS prioritized media access via the Enhanced Distributed Channel Access (EDCA) method. Optional elements of the WMM specification including call admission control using traffic specifications (TSPEC) are not supported in this release.
- VLAN Assignment By Name—This feature allows the RADIUS server to assign a client to a virtual LAN (VLAN) identified by its VLAN name. In releases before Cisco IOS Release 12.4(5)T, the RADIUS server identified the VLAN by ID. This feature is important for deployments where VLAN IDs are not used consistently throughout the network.

- Microsoft WPS IE SSIDL—This feature allows the access point to broadcast a list of configured SSIDs (the SSIDL) in the Microsoft Wireless Provisioning Services Information Element (WPS IE). A client with the ability to read the SSIDL can alert the user to the availability of the SSIDs. This feature provides a bandwidth-efficient, software-upgradeable alternative to multiple broadcast SSIDs (MB/SSIDs).
- HTTP Web Server v1.1—This feature provides a consistent interface for users and applications by implementing the HTTP 1.1 standard (see RFC 2616). In previous releases, Cisco software supported only a partial implementation of HTTP 1.0. The integrated HTTP Server API supports server application interfaces. When combined with the HTTPS and HTTP 1.1 Client features, provides a complete, secure solution for HTTP services to and from Cisco devices.





## Configuring Radio Settings

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This chapter describes how to configure radio settings for the wireless device. This chapter includes these sections:

- [Enabling the Radio Interface, page 2-2](#)
- [Roles in Radio Network, page 2-2](#)
- [Configuring Network or Fallback Role, page 2-3](#)
- [Sample Bridging Configuration, page 2-4](#)
- [Universal Client Mode, page 2-7](#)
- [Configuring Universal Client Mode, page 2-7](#)
- [Configuring Radio Data Rates, page 2-10](#)
- [Configuring Radio Transmit Power, page 2-12](#)
- [Configuring Radio Channel Settings, page 2-14](#)
- [Enabling and Disabling World Mode, page 2-20](#)
- [Enabling and Disabling Short Radio Preambles, page 2-21](#)
- [Configuring Transmit and Receive Antennas, page 2-22](#)
- [Disabling and Enabling Access Point Extensions, page 2-23](#)
- [Configuring the Ethernet Encapsulation Transformation Method, page 2-23](#)
- [Enabling and Disabling Reliable Multicast to Workgroup Bridges, page 2-24](#)
- [Enabling and Disabling Public Secure Packet Forwarding, page 2-25](#)
- [Configuring Beacon Period and DTIM, page 2-26](#)
- [Configuring RTS Threshold and Retries, page 2-27](#)
- [Configuring Maximum Data Retries, page 2-27](#)
- [Configuring Fragmentation Threshold, page 2-28](#)
- [Enabling Short Slot Time for 802.11g Radios, page 2-28](#)
- [Performing a Carrier Busy Test, page 2-29](#)

## Enabling the Radio Interface

The wireless device radios are disabled by default.



### Note

In Cisco IOS Release 12.4 there is no default SSID. You must create a Radio Service Set Identifier (SSID) before you can enable the radio interface.

Beginning in privileged EXEC mode, follow these steps to enable the wireless device radio:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<b>ssid</b>	Enter the SSID. The SSID can consist of up to 32 alphanumeric characters. SSIDs are case sensitive.
Step 4	<b>no shutdown</b>	Enable the radio port.
Step 5	<b>end</b>	Return to privileged EXEC mode.
Step 6	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **shutdown** command to disable the radio port.

## Roles in Radio Network

You can configure the following roles in a radio network:

- Network or Fallback Role
- Universal Client Mode

Table 2-1 shows the role in the radio network for each device.

**Table 2-1** Device Role in Radio Network Configuration

Role in Radio Network	Cisco 800 series ISRs	Cisco 1800 series ISRs	Cisco 1841 series	Cisco 2800 series ISRs	Cisco 3800 series ISRs
Root access point	X	X	X	X	X
Root bridge with or without clients	–	–	X	X	X
Non-root bridge without clients	–	–	X	X	X
Universal client mode	X	X	X	X	X
Support of Workgroup bridge clients	X	X	X	X	X

## Configuring Network or Fallback Role

You can also configure a fallback role for root access points. The wireless device automatically assumes the fallback role when its Ethernet port is disabled or disconnected from the wired LAN. The fallback role is Shutdown—the wireless device shuts down its radio and disassociates all client devices.

Beginning in privileged EXEC mode, follow these steps to set the wireless device's radio network role and fallback role:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<b>station-role</b>  <b>non-root {bridge   return}</b>  <b>root {fallback   repeater   wireless clients   shutdown}}</b>	<p>Sets the wireless device role to universal client mode.</p> <ul style="list-style-type: none"> <li>Set the role to non-root bridge with or without wireless clients, repeater access point, root access point or bridge, scanner, or workgroup bridge.</li> <li>The bridge mode radio supports point-to-point configuration only.</li> <li>The Ethernet port is shut down when any one of the radios is configured as a repeater. Only one radio per access point may be configured as a workgroup bridge or repeater.</li> <li>The <b>dot11radio 0 1 antenna-alignment</b> command is available when the access point is configured as a repeater.</li> <li>Spanning Tree Protocol (STP) is configurable on Cisco ISR series access points in bridge modes.</li> <li>(Optional) Select the root access point's fallback role. If the wireless device's Ethernet port is disabled or disconnected from the wired LAN, the wireless device can either shut down its radio port or become a repeater access point associated to any nearby root access point.</li> </ul>
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Bridge Features Not Supported

The following features are not supported when a Cisco ISR series access point is configured as a bridge:

- Clear Channel Assessment (CCA)
- Interoperability with 1400 series bridge
- Concatenation
- Install mode
- EtherChannel and PageP configuration on switch

For root and non-root bridging mode operations, only bridge-group mode using BVI interface is supported. Routing mode is not supported for root and non-root bridging operations.

## Sample Bridging Configuration

The following is a sample of a Root Bridge Configuration:

```

!
aaa new-model
!
!
aaa group server radius rad_eap
  server 20.0.0.1 auth-port 1812 acct-port 1813
!
aaa authentication login eap_methods group rad_eap
!
aaa session-id common
!
resource policy
!
mmi polling-interval 60
no mmi auto-configure
no mmi pvc
mmi snmp-timeout 180
!
dot11 ssid airlink2-bridge
  vlan 1
  authentication open
  authentication key-management wpa
  wpa-psk ascii 0 12345678
!
dot11 priority-map avvid
ip cef
!
!
no ip domain lookup
!
!
bridge irb
!
!
interface FastEthernet0/0
  no ip address
  shutdown
  duplex auto
  speed auto
!
interface FastEthernet0/1

```

```

ip address 30.0.0.1 255.0.0.0
duplex auto
speed auto
!
interface Dot11Radio0/0/0
no ip address
!
encryption vlan 1 mode ciphers tkip
!
ssid airlink2-bridge
!
speed basic-1.0 basic-2.0 basic-5.5 6.0 9.0 basic-11.0 12.0 18.0 24.0 36.0 48.0 54.0
station-role root bridge
!
interface Dot11Radio0/0/0.1
encapsulation dot1Q 1 native
no snmp trap link-status
bridge-group 1
bridge-group 1 spanning-disabled
!
interface Dot11Radio0/0/1
no ip address
speed basic-6.0 9.0 basic-12.0 18.0 basic-24.0 36.0 48.0 54.0
station-role root
!
interface BVI1
ip address 20.0.0.1 255.0.0.0
!
ip route 0.0.0.0 0.0.0.0 20.0.0.5
!
!
ip http server
no ip http secure-server
!
!
radius-server local
nas 20.0.0.1 key 0 wireless
user non-root nhash 0 3741A4EE66E1AA56CD8B3A9038580DC9
!
radius-server host 20.0.0.1 auth-port 1812 acct-port 1813 key wireless
!
control-plane
!
bridge 1 route ip
!
!
line con 0
exec-timeout 0 0
line aux 0
line vty 0 4
!
!
webvpn context Default_context
ssl authenticate verify all
!
no inservice
!
end

```

The following is a sample of Non-Root Bridge Configuration:

```
no aaa new-model
```

```

!
resource policy
!
mmi polling-interval 60
no mmi auto-configure
no mmi pvc
mmi snmp-timeout 180
!
dot11 ssid airlink2-bridge
    vlan 1
    authentication open
    authentication key-management wpa
    wpa-psk ascii 0 12345678
!
dot11 priority-map avvid
ip cef
!
!
bridge irb
!
!
interface FastEthernet0/0
no ip address
duplex auto
speed auto
!
interface FastEthernet0/1
no ip address
duplex auto
speed auto
bridge-group 1
bridge-group 1 spanning-disabled
!
interface Dot11Radio0/1/0
no ip address
!
encryption vlan 1 mode ciphers tkip
!
ssid airlink2-bridge
!
speed basic-1.0 basic-2.0 basic-5.5 6.0 9.0 basic-11.0 12.0 18.0 24.0 36.0 48.0 54.0
station-role non-root bridge
!
interface Dot11Radio0/1/0.1
encapsulation dot1Q 1 native
no snmp trap link-status
bridge-group 1
bridge-group 1 spanning-disabled
!
interface BVI1
ip address 20.0.0.5 255.0.0.0
!
ip route 0.0.0.0 0.0.0.0 20.0.0.1
!
!
ip http server
no ip http secure-server
!
!
control-plane
!
bridge 1 route ip
!
!

```

```

line con 0
  exec-timeout 0 0
line aux 0
line vty 0 4
  login
!
!
webvpn context Default_context
  ssl authenticate verify all
!
no inservice
!
end

```

## Universal Client Mode

Universal client mode is a wireless radio station role that allows the radio to act as a wireless client to another access point or repeater. This feature is exclusive to the integrated radio running in the Cisco 870, 1800, 2800, and 3800 Integrated Services Routers. It operates differently from the workgroup bridge and non-root bridge modes that are supported on other Cisco wireless devices such as the Cisco AP 1200.

Universal client mode has the following features and limitations:

- You can configure universal client mode on the main **dot11radio** interface only, sub-interfaces are not supported.
- Universal client can associate to access points with radio VLANs.
- Layer-3 routing is supported over the radio interface. However, there is no support for L2-bridging. The user cannot configure a dot11radio interface with a bridge-group when in universal client mode.
- SSIDs are required to be configured on the dot11 interface operating as a universal client; association to an access point running in guest-mode is not supported.
- The universal client can associate to Cisco access points, 3rd party access points, and repeaters. It cannot associate to Cisco root bridges or Cisco workgroup bridges.

## Configuring Universal Client Mode

You can configure universal client mode in Cisco ISR series by setting the radio interface station-role to non-root. This is different from configuring the **dot11radio** interface to operate in non-root bridge mode, which requires specifying the word bridge at the end of the command, ex: "**station-role non-root bridge**".



### Note

In other Cisco wireless products such as the Cisco AP1232, **station-role non-root** operates the same as **station-role non-root bridge**. On the ISRs, the two commands are different: **station-role non-root** is considered the universal client mode and **station-role non-root bridge** is considered the non-root bridge mode.

Example using Cisco 2801 series router:

```

c2801#conf t
Enter configuration commands, one per line. End with CNTL/Z.
c2801(config)#interface Dot11Radio0/1/0

```

```

c2801(config-if)#station-role ?
  non-root  Non-root (bridge)
  root      Root access point or bridge

c2801(config-if)#station-role non-root ?
  bridge    Bridge non-root This CLI enables non-root bridge mode.
  <cr>      This CLI enables universal client mode

```

## DHCP

IP DHCP addressing is supported in the Dot11Radio interface configured in universal client mode. The following is an example of Dot11Radio configured with "ip address dhcp":

```

dot11 ssid test10
  authentication open
!
interface Dot11Radio0/1/0
  ip address dhcp
  !
  ssid test10
  !
  speed basic-1.0 basic-2.0 basic-5.5 6.0 9.0 basic-11.0 12.0 18.0 24.0 36.0 48.0 54.0
  station-role non-root

```

Issuing a "show ip interface brief" will show the Virtual-Dot11Radio interface getting the IP address from the DHCP server.

```

c2801_uc#sh ip int brief
Interface                IP-Address      OK? Method Status          Protocol
FastEthernet0/0          unassigned      YES NVRAM    administratively down down
FastEthernet0/1          unassigned      YES NVRAM    administratively down down
Dot11Radio0/1/0          unassigned      YES DHCP    up              up
Dot11Radio0/1/1          unassigned      YES NVRAM    administratively down down
Virtual-Dot11Radio0      200.1.1.2       YES DHCP    up              up
c2801_uc#

```

## NAT (Network Address Translation):

NAT translation takes place if you overload the interface which has an ip address. In the case of universal client, the virtual-interface has the ip address obtained from the DHCP. Hence we require to overload the virtual interface to aid NAT translation.



### Note

NAT fails to translate with a DHCP address on the **dot11** interface running in universal client mode.

The following configuration is supported on NAT:

```
ip nat inside source list 1 interface Virtual-Dot11Radio0 overload
```

The following is an example of a NAT configuration on a Cisco 1803 ISR:

```

C1803W_UC#
C1803W_UC#sh run
Building configuration...

Current configuration : 2189 bytes
!
version 12.4
service timestamps debug datetime msec
service timestamps log datetime msec

```

```
no service password-encryption
!
hostname C1803W_UC
!
boot-start-marker
boot-end-marker
!
logging buffered 4096 debugging
no logging console
!
no aaa new-model
!
resource policy
!
!
dot11 ssid hurricane
    authentication open
    authentication key-management wpa
    wpa-psk ascii 0 allyouneedislove
!
dot11 ssid tsunami
    authentication open
    guest-mode
!
dot11 priority-map avvid
!
!
ip cef
no ip dhcp use vrf connected
ip dhcp excluded-address 100.1.1.1
!
ip dhcp pool jimmy
    network 100.1.1.0 255.255.255.0
    default-router 100.1.1.1
!
!
!
!
!
!
controller DSL 0
    line-term cpe
!
!
bridge irb
!
interface Dot11Radio0
    ip address 100.1.1.1 255.255.255.0
    ip nat inside
    ip virtual-reassembly
    no ip route-cache cef
    no ip route-cache
    !
    ssid tsunami
    !
    speed basic-1.0 basic-2.0 basic-5.5 6.0 9.0 basic-11.0 12.0 18.0 24.0 36.0 48.0 54.0
    station-role root
    rts threshold 2312
    no cdp enable
    !
interface Dot11Radio1
    ip address dhcp
    ip nat outside
    ip virtual-reassembly
```

```

!
encryption mode ciphers tkip
!
ssid hurricane
!
speed basic-6.0 9.0 basic-12.0 18.0 basic-24.0 36.0 48.0 54.0
station-role non-root
!
End

```

## Configuring Radio Data Rates

You use the data rate settings to choose the data rates the wireless device uses for data transmission. The rates are expressed in megabits per second. The wireless device always attempts to transmit at the highest data rate set to **Basic**, also called **Require** on the browser-based interface. If there are obstacles or interference, the wireless device steps down to the highest rate that allows data transmission. You can set each data rate to one of three states:

- **Basic** (the GUI labels Basic rates as Required)—Allows transmission at this rate for all packets, both unicast and multicast. At least one of the wireless device's data rates must be set to Basic.
- **Enabled**—The wireless device transmits only unicast packets at this rate; multicast packets are sent at one of the data rates set to Basic.
- **Disabled**—The wireless device does not transmit data at this rate.



### Note

At least one data rate must be set to **basic**.

You can use the Data Rate settings to set an access point to serve client devices operating at specific data rates. For example, to set the 2.4-GHz radio for 11 megabits per second (Mbps) service only, set the 11-Mbps rate to **Basic** and set the other data rates to **Disabled**. To set the wireless device to serve only client devices operating at 1 and 2 Mbps, set 1 and 2 to **Basic** and set the rest of the data rates to **Disabled**. To set the 2.4-GHz, 802.11g radio to serve only 802.11g client devices, set any Orthogonal Frequency Division Multiplexing (OFDM) data rate (6, 9, 12, 18, 24, 36, 48, 54) to **Basic**. To set the 5-GHz radio for 54 Mbps service only, set the 54-Mbps rate to **Basic** and set the other data rates to **Disabled**.

You can configure the wireless device to set the data rates automatically to optimize either the range or the throughput. When you enter **range** for the data rate setting, the wireless device sets the 1 Mbps rate to basic and the other rates to **enabled**. When you enter **throughput** for the data rate setting, the wireless device sets all four data rates to **basic**.

Beginning in privileged EXEC mode, follow these steps to configure the radio data rates:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.

	Command	Purpose
<p><b>Step 3</b></p> <p><b>speed</b></p> <p>These options are available for the 802.11b, 2.4-GHz radio:</p> <pre>{ [1.0] [11.0] [2.0] [5.5] [basic-1.0] [basic-11.0] [basic-2.0] [basic-5.5]   range   throughput }</pre> <p>These options are available for the 802.11g, 2.4-GHz radio:</p> <pre>{ [1.0] [2.0] [5.5] [6.0] [9.0] [11.0] [12.0] [18.0] [24.0] [36.0] [48.0] [54.0] [basic-1.0] [basic-2.0] [basic-5.5] [basic-6.0] [basic-9.0] [basic-11.0] [basic-12.0] [basic-18.0] [basic-24.0] [basic-36.0] [basic-48.0] [basic-54.0]   range   throughput [ofdm]   default }</pre> <p>These options are available for the 5-GHz radio:</p> <pre>{ [6.0] [9.0] [12.0] [18.0] [24.0] [36.0] [48.0] [54.0] [basic-6.0] [basic-9.0] [basic-12.0] [basic-18.0] [basic-24.0] [basic-36.0] [basic-48.0] [basic-54.0]   range   throughput   default }</pre>	<p>Set each data rate to <b>basic</b> or <b>enabled</b>, or enter <b>range</b> to optimize range or <b>throughput</b> to optimize throughput.</p> <ul style="list-style-type: none"> <li>(Optional) Enter <b>1.0</b>, <b>2.0</b>, <b>5.5</b>, and <b>11.0</b> to set these data rates to <b>enabled</b> on the 802.11b, 2.4-GHz radio.</li> </ul> <p>Enter <b>1.0</b>, <b>2.0</b>, <b>5.5</b>, <b>6.0</b>, <b>9.0</b>, <b>11.0</b>, <b>12.0</b>, <b>18.0</b>, <b>24.0</b>, <b>36.0</b>, <b>48.0</b>, and <b>54.0</b> to set these data rates to <b>enabled</b> on the 802.11g, 2.4-GHz radio.</p> <p>Enter <b>6.0</b>, <b>9.0</b>, <b>12.0</b>, <b>18.0</b>, <b>24.0</b>, <b>36.0</b>, <b>48.0</b>, and <b>54.0</b> to set these data rates to <b>enabled</b> on the 5-GHz radio.</p> <ul style="list-style-type: none"> <li>(Optional) Enter <b>basic-1.0</b>, <b>basic-2.0</b>, <b>basic-5.5</b>, and <b>basic-11.0</b> to set these data rates to <b>basic</b> on the 802.11b, 2.4-GHz radio.</li> </ul> <p>Enter <b>basic-1.0</b>, <b>basic-2.0</b>, <b>basic-5.5</b>, <b>basic-6.0</b>, <b>basic-9.0</b>, <b>basic-11.0</b>, <b>basic-12.0</b>, <b>basic-18.0</b>, <b>basic-24.0</b>, <b>basic-36.0</b>, <b>basic-48.0</b>, and <b>basic-54.0</b> to set these data rates to <b>basic</b> on the 802.11g, 2.4-GHz radio.</p> <p><b>Note</b> The client must support the basic rate that you select or it cannot associate to the wireless device. If you select 12 Mbps or higher for the basic data rate on the 802.11g radio, 802.11b client devices cannot associate to the wireless device's 802.11g radio.</p> <p>Enter <b>basic-6.0</b>, <b>basic-9.0</b>, <b>basic-12.0</b>, <b>basic-18.0</b>, <b>basic-24.0</b>, <b>basic-36.0</b>, <b>basic-48.0</b>, and <b>basic-54.0</b> to set these data rates to <b>basic</b> on the 5-GHz radio.</p> <ul style="list-style-type: none"> <li>(Optional) Enter <b>range</b> or <b>throughput</b> to automatically optimize radio range or throughput. When you enter <b>range</b>, the wireless device sets the lowest data rate to basic and the other rates to <b>enabled</b>. When you enter <b>throughput</b>, the wireless device sets all data rates to <b>basic</b>.</li> </ul> <p>(Optional) On the 802.11g radio, enter <b>speed throughput ofdm</b> to set all OFDM rates (6, 9, 12, 18, 24, 36, and 48) to basic (required) and set all the CCK rates (1, 2, 5.5, and 11) to disabled. This setting disables 802.11b protection mechanisms and provides maximum throughput for 802.11g clients. However, it prevents 802.11b clients from associating to the access point.</p> <ul style="list-style-type: none"> <li>(Optional) Enter <b>default</b> to set the data rates to factory default settings (not supported on 802.11b radios).</li> </ul> <p>On the 802.11g radio, the <b>default</b> option sets rates 1, 2, 5.5, and 11 to basic, and rates 6, 9, 12, 18, 24, 36, 48, and 54 to enabled. These rate settings allow both 802.11b and 802.11g client devices to associate to the wireless device's 802.11g radio.</p> <p>On the 5-GHz radio, the <b>default</b> option sets rates 6.0, 12.0, and 24.0 to basic, and rates 9.0, 18.0, 36.0, 48.0, and 54.0 to enabled.</p>	

	Command	Purpose
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the **speed** command to remove one or more data rates from the configuration. This example shows how to remove data rates basic-2.0 and basic-5.5 from the configuration:

```
router# configure terminal
router(config)# interface dot11radio 0
router(config-if)# no speed basic-2.0 basic-5.5
router(config-if)# end
```

## Configuring Radio Transmit Power

Radio transmit power is based on the type of radio or radios installed in your access point and the regulatory domain in which it operates. To determine what transmit power is available for your access point and which regulatory domain it operates in, refer to the hardware installation guide for that device. hardware installation guides are available at [cisco.com](http://cisco.com). Follow these steps to view and download them:

- 
- Step 1** Browse to <http://www.cisco.com>.
  - Step 2** Click **Technical Support & Documentation**. A small window appears containing a list of technical support links.
  - Step 3** Click **Technical Support & Documentation**. The Technical Support and Documentation page appears.
  - Step 4** In the Documentation & Tools section, choose **Wireless**. The Wireless Support Resources page appears.
  - Step 5** In the Wireless LAN Access section, choose the device you are working with. An introduction page for the device appears.
  - Step 6** In the Install and Upgrade section, choose **Install and Upgrade Guides**. The Install and Upgrade Guides page for the device appears.
  - Step 7** Choose the hardware installation guide for the device. The home page for the guide appears.
  - Step 8** In the left frame, click **Channels and Antenna Settings**.
- 

Table 2-2 shows the relationship between mW and dBm.

**Table 2-2** Translation between mW and dBm

<b>dBm</b>	-1	2	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
<b>mW</b>	1	2	3	4	5	6	8	10	12	15	20	25	30	40	50	60	80	100	125	150	200	250

Beginning in privileged EXEC mode, follow these steps to set the transmit power on access point radios:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<code>power local</code> power settings should be: { 3   4   5   6   7   10   13   15   17   18   20   maximum }	Set the transmit power for the 802.11g, 2.4-GHz radio to one of the power levels allowed in your regulatory domain. All settings are in mW.  On the 2.4-GHz, 802.11g radio, you can set Orthogonal Frequency Division Multiplexing (OFDM) power levels and Complementary Code Keying (CCK) power levels. CCK modulation is supported by 802.11b and 802.11g devices. OFDM modulation is supported by 802.11g and 802.11a devices.  <b>Note</b> See the hardware installation guide for your access point to determine the power settings for your regulatory domain.  <b>Note</b> The 802.11g radio transmits at up to 100 mW for the 1, 2, 5.5, and 11Mbps data rates. However, for the 6, 9, 12, 18, 24, 36, 48, and 54Mbps data rates, the maximum transmit power for the 802.11g radio is 30 mW.
Step 4	<code>end</code>	Return to privileged EXEC mode.
Step 5	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

Use the **no** form of the power command to return the power setting to **maximum**, the default setting.

## Limiting the Power Level for Associated Client Devices

You can also limit the power level on client devices that associate to the wireless device. When a client device associates to the wireless device, the wireless device sends the maximum power level setting to the client.



### Note

Cisco AVVID documentation uses the term Dynamic Power Control (DTPC) to refer to limiting the power level on associated client devices.

Beginning in privileged EXEC mode, follow these steps to specify a maximum allowed power setting on all client devices that associate to the wireless device:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.

	Command	Purpose
Step 3	<p><b>power client</b></p> <p>These options are available for 802.11b, 2.4-GHz clients (in mW): { 1   5   20   30   50   100   maximum }</p> <p>These options are available for 802.11g, 2.4-GHz clients (in mW): { 1   5   10   20   30   50   100   maximum }</p> <p>These options are available for 5-GHz clients (in mW): { 5   10   20   40   maximum }</p>	<p>Set the maximum power level allowed on client devices that associate to the wireless device.</p> <p><b>Note</b> The settings allowed in your regulatory domain might differ from the settings listed here.</p>
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the client power command to disable the maximum power level for associated clients.

**Note**

Access Point extensions must be enabled to limit the power level on associated client devices. Access Point extensions are enabled by default.

## Configuring Radio Channel Settings

The default channel setting for the wireless device radios is least congested; at startup, the wireless device scans for and selects the least-congested channel. For the most consistent performance after a site survey, however, we recommend that you assign a static channel setting for each access point. The channel settings on the wireless device correspond to the frequencies available in your regulatory domain. See the access point's hardware installation guide for the frequencies allowed in your domain.

Each 2.4-GHz channel covers 22 MHz. The bandwidth for channels 1, 6, and 11 does not overlap, so you can set up multiple access points in the same vicinity without causing interference. Both 802.11b and 802.11g 2.4-GHz radios use the same channels and frequencies.

The 5-GHz radio operates on eight channels from 5180 to 5320 MHz. Each channel covers 20 MHz, and the bandwidth for the channels overlaps slightly. For best performance, use channels that are not adjacent (44 and 46, for example) for radios that are close to each other.

**Note**

Too many access points in the same vicinity creates radio congestion that can reduce throughput. A careful site survey can determine the best placement of access points for maximum radio coverage and throughput.

Beginning in privileged EXEC mode, follow these steps to set the wireless device's radio channel:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio {0   1 }</code>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<code>channel frequency   least-congested</code>	Set the default channel for the wireless device radio. <a href="#">Table 2-3</a> through <a href="#">Table 2-6</a> show the available channels and frequencies for all radios. To search for the least-congested channel on startup, enter <b>least-congested</b> .  <b>Note</b> The <b>channel</b> command is disabled for 5-GHz radios that comply with European Union regulations on dynamic frequency selection (DFS). See the “ <a href="#">DFS Automatically Enabled on Some 5-GHz Radio Channels</a> ” section on <a href="#">page 2-19</a> for more information.
Step 4	<code>end</code>	Return to privileged EXEC mode.
Step 5	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

[Table 2-3](#) shows the available channels and frequencies for the IEEE 802.11b 2.4-GHz radio.

**Table 2-3 Channels and Frequencies for 802.11b 2.4 GHz Radio**

Channel Identifier	Center Frequency (MHz)	Regulatory Domains			
		Americas (-A)	China (-C)	EMEA (-E)	Japan (-J)
1	2412	X	X	X	X
2	2417	X	X	X	X
3	2422	X	X	X	X
4	2427	X	X	X	X
5	2432	X	X	X	X
6	2437	X	X	X	X
7	2442	X	X	X	X
8	2447	X	X	X	X
9	2452	X	X	X	X
10	2457	X	X	X	X
11	2462	X	X	X	X
12	2467	-	-	X	X
13	2472	-	-	X	X
14	2484	-	-	-	-

Table 2-4 shows the available frequencies for the 802.11g 2.4 GHz radio.

**Table 2-4 Channels and Available Frequencies for 802.11g 2.4 GHz Radio**

Channel Identifier	Center Frequency (MHz)	Regulatory Domains					
		Americas (-A)		EMEA (-E)		Japan (-J)	
		CCK	OFDM	CCK	OFDM	CCK	OFDM
1	2412	X	X	X	X	X	X
2	2417	X	X	X	X	X	X
3	2422	X	X	X	X	X	X
4	2427	X	X	X	X	X	X
5	2432	X	X	X	X	X	X
6	2437	X	X	X	X	X	X
7	2442	X	X	X	X	X	X
8	2447	X	X	X	X	X	X
9	2452	X	X	X	X	X	X
10	2457	X	X	X	X	X	X
11	2462	X	X	X	X	X	X
12	2467	-	-	X	X	X	X
13	2472	-	-	X	X	X	X
14	2484	-	-	-	-	X	-

Table 2-5 shows the available channels and frequencies for the RM20A IEEE 802.11a radio

**Table 2-5 Channels and Available Frequencies for the 802.11a Radio**

Channel Identifier	Center Frequency (MHz)	Regulatory Domains					
		Americas (-A)		EMEA (-N)		Japan (-P)	
		CCK	OFDM	CCK	OFDM	CCK	OFDM
1	2412	X	X	X	X	X	X
2	2417	X	X	X	X	X	X
3	2422	X	X	X	X	X	X
4	2427	X	X	X	X	X	X
5	2432	X	X	X	X	X	X
6	2437	X	X	X	X	X	X
7	2442	X	X	X	X	X	X
8	2447	X	X	X	X	X	X
9	2452	X	X	X	X	X	X
10	2457	X	X	X	X	X	X
11	2462	X	X	X	X	X	X
12	2467	-	-	X	X	X	X

Channel Identifier	Center Frequency (MHz)	Regulatory Domains					
		Americas (-A)		EMEA (-N)		Japan (-P)	
		CCK	OFDM	CCK	OFDM	CCK	OFDM
13	2472	-	-	X	X	X	X
14	2484	-	-	-	-	X	-

Table 2-6 shows the available frequencies for the RM21A and RM22A IEEE 802.11a 5-GHz radios.

**Table 2-6 Channels and Available Frequencies for the 802.11a 5-GHz Radios**

Channel ID	Center Freq (MHz)	Americas (-B)	China (-C)	EMEA (-E)	New Zealand, Australia (-N)	Japan (-P)	–
34	5170	–	–	–	–	–	–
36	5180	x	–	x	x	x	–
38	5190	–	–	–	–	–	–
40	5200	x	–	x	x	x	–
42	5210	–	–	–	–	–	–
44	5220	x	–	x	x	x	–
46	5230	–	–	–	–	–	–
48	5240	x	–	x	x	x	–
52	5260	–	–	x	x	x	–
56	5280	–	–	x	x	x	–
60	5300	–	–	x	x	x	–
64	5320	–	–	x	x	x	–
100	5500	–	–	x	–	–	–
104	5520	–	–	x	–	–	–
108	5540	–	–	x	–	–	–
112	5560	–	–	x	–	–	–
116	5580	–	–	x	–	–	–
120	5600	–	–	x	–	–	–
124	5620	–	–	x	–	–	–
128	5640	–	–	x	–	–	–
132	5660	–	–	x	–	–	–
136	5680	–	–	x	–	–	–
140	5700	–	–	x	–	–	–
149	5745	x	x	–	x	–	–
153	5765	x	x	–	x	–	–
157	5785	x	x	–	x	–	–
161	5805	x	x	–	x	–	–
165	5825	–	–	x	–	–	–



**Note**

The frequencies allowed in your regulatory domain might differ from the frequencies listed here.

## DFS Automatically Enabled on Some 5-GHz Radio Channels

Access points with 5-GHz radios configured at the factory for use in Europe now comply with regulations that require radio devices to use Dynamic Frequency Selection (DFS) to detect radar signals and avoid interfering with them. Radios configured for use in other regulatory domains do not use DFS.

When a DFS-enabled 5-GHz radio operates on one of the 15 channels listed in [Table 2-7](#), the access point automatically uses DFS to set the operating frequency.


**Note**

You cannot manually select a channel for DFS-enabled 5-GHz radios.

**Table 2-7 DFS Automatically Enabled on these 5-GHz Channels**

5-GHz Channels on Which DFS is Automatically Enabled		
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)

When DFS is enabled, the access point monitors its operating frequency for radar signals. If it detects radar signals on the channel, the access point takes these steps:

- Blocks new transmissions on the channel.
- Flushes the power-save client queues.
- Broadcasts an 802.11h channel-switch announcement.
- Disassociates remaining client devices.
- Randomly selects a different 5-GHz channel.
- If the channel selected is one of the channels in [Table 2-7](#), scans the new channel for radar signals for 60 seconds.
- If there are no radar signals on the new channel, enables beacons and accepts client associations.


**Note**

The maximum legal transmit power is greater for some 5-GHz channels than for others. When it randomly selects a 5-GHz channel on which power is restricted, the access point automatically reduces transmit power to comply with power limits for that channel.


**Note**

We recommend that you use the **world-mode dot11d country-code** configuration interface command to configure a country code on DFS-enabled radios. The IEEE 802.11h protocol requires access points to include the country information element (IE) in beacons and probe responses. By default, however, the country code in the IE is blank. You use the **world-mode** command to populate the country code IE.

## Confirming that DFS is Enabled

Use the **show controller dot11radio1** command to confirm that DFS is enabled. This example shows a line from the output for the show controller command for a channel on which DFS is enabled:

```
Current Frequency: 5300 MHz Channel 60 (DFS enabled)
```

## Blocking Channels from DFS Selection

If your regulatory domain limits the channels that you can use in specific locations--for example, indoors or outdoors--you can block groups of channels to prevent the access point from selecting them when DFS is enabled. Use this configuration interface command to block groups of channels from DFS selection:

```
[no] dfs band [1] [2] [3] [4] block
```

The 1, 2, 3, and 4 options designate blocks of channels:

- **1**—Specifies frequencies 5.150 to 5.250 GHz. This group of frequencies is also known as the UNII-1 band.
- **2**—Specifies frequencies 5.250 to 5.350 GHz. This group of frequencies is also known as the UNII-2 band.
- **3**—Specifies frequencies 5.470 to 5.725 GHz.
- **4**—Specifies frequencies 5.725 to 5.825 GHz. This group of frequencies is also known as the UNII-3 band.

This example shows how to prevent the access point from selecting frequencies 5.150 to 5.350 GHz during DFS:

```
router(config-if)# dfs band 1 2 block
```

This example shows how to unblock frequencies 5.150 to 5.350 for DFS:

```
router(config-if)# no dfs band 1 2 block
```

This example shows how to unblock all frequencies for DFS:

```
router(config-if)# no dfs band block
```

## Enabling and Disabling World Mode

You can configure the wireless device to support 802.11d world mode or Cisco legacy world mode. When you enable world mode, the wireless device adds channel carrier set information to its beacon. Client devices with world mode enabled receive the carrier set information and adjust their settings automatically. For example, a client device used primarily in Japan could rely on world mode to adjust its channel and power settings automatically when it travels to Italy and joins a network there. Cisco client devices running firmware version 5.30.17 or later detect whether the wireless device is using 802.11d or Cisco legacy world mode and automatically use world mode that matches the mode used by the wireless device. World mode is disabled by default.

Beginning in privileged EXEC mode, follow these steps to enable world mode:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface.
Step 3	<code>world-mode</code> <code>dot11d country_code code</code> <code>{ both   indoor   outdoor }</code> <code>  legacy</code>	<p>Enable world mode.</p> <ul style="list-style-type: none"> <li>Enter the <b>dot11d</b> option to enable 802.11d world mode. <ul style="list-style-type: none"> <li>When you enter the <b>dot11d</b> option, you must enter a two-character ISO country code (for example, the ISO country code for the United States is <b>US</b>). You can find a list of ISO country codes at the ISO website.</li> <li>After the country code, you must enter <b>indoor</b>, <b>outdoor</b>, or <b>both</b> to indicate the placement of the wireless device.</li> </ul> </li> <li>Enter the <b>legacy</b> option to enable Cisco legacy world mode.</li> </ul> <p><b>Note</b> Access Point extensions must be enabled for legacy world mode operation, but Access Point extensions are not required for 802.11d world mode. Access Point extensions are enabled by default.</p>
Step 4	<code>end</code>	Return to privileged EXEC mode.
Step 5	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

Use the **no** form of the command to disable world mode.

## Enabling and Disabling Short Radio Preambles

The radio preamble (sometimes called a *header*) is a section of data at the head of a packet that contains information that the wireless device and client devices need when sending and receiving packets. You can set the radio preamble to long or short:

- Short—A short preamble improves throughput performance. Cisco Access Point Wireless LAN Client Adapters support short preambles.
- Long—A long preamble ensures compatibility between the wireless device and all early models of Cisco Access Point Wireless LAN Adapters (PC4800 and PC4800A). If these client devices do not associate to the wireless devices, you should use short preambles.

You cannot configure short or long radio preambles on the 5-GHz radio.

Beginning in privileged EXEC mode, follow these steps to disable short radio preambles:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0 }</code>	Enter interface configuration mode for the 2.4-GHz radio interface.

	Command	Purpose
Step 3	<b>no preamble-short</b>	Disable short preambles and enable long preambles.
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Short preambles are enabled by default. Use the **preamble-short** command to enable short preambles if they are disabled.

## Configuring Transmit and Receive Antennas

You can select the antenna the wireless device uses to receive and transmit data. There are three options for both the receive and the transmit antenna:

- **Diversity**—This default setting tells the wireless device to use the antenna that receives the best signal. If the wireless device has two fixed (non-removable) antennas, you should use this setting for both receive and transmit.
- **Right**—If the wireless device has removable antennas and you install a high-gain antenna on the wireless device's right connector, you should use this setting for both receive and transmit. When you look at the wireless device's back panel, the right antenna is on the right.
- **Left**—If the wireless device has removable antennas and you install a high-gain antenna on the wireless device's left connector, you should use this setting for both receive and transmit. When you look at the wireless device's back panel, the left antenna is on the left.

Beginning in privileged EXEC mode, follow these steps to select the antennas the wireless device uses to receive and transmit data:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<b>antenna receive { diversity   left   right }</b>	Set the receive antenna to diversity, left, or right.  <b>Note</b> For best performance, leave the receive antenna setting at the default setting, <b>diversity</b> .   <b>Note</b> The Cisco 850 series routers do not support diversity.
Step 4	<b>antenna transmit { diversity   left   right }</b>	Set the transmit antenna to diversity, left, or right.  <b>Note</b> For best performance, leave the transmit antenna setting at the default setting, <b>diversity</b> .
Step 5	<b>end</b>	Return to privileged EXEC mode.
Step 6	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Disabling and Enabling Access Point Extensions

By default, the wireless device uses Cisco Access Point extensions to detect the capabilities of Cisco Access Point client devices and to support features that require specific interaction between the wireless device and associated client devices. Cisco Access Point extensions must be enabled to support these features:

- **Load balancing**—The wireless device uses Access Point extensions to direct client devices to an access point that provides the best connection to the network based on factors such as number of users, bit error rates, and signal strength.
- **Message Integrity Check (MIC)**—MIC is an additional WEP security feature that prevents attacks on encrypted packets called bit-flip attacks. The MIC, implemented on both the wireless device and all associated client devices, adds a few bytes to each packet to make the packets tamper-proof.
- **World mode (legacy only)**—Client devices with legacy world mode enabled receive carrier set information from the wireless device and adjust their settings automatically. Access Point extensions are not required for 802.11d world mode operation.
- **Limiting the power level on associated client devices**—When a client device associates to the wireless device, the wireless device sends the maximum allowed power level setting to the client.

Disabling Access Point extensions disables the features listed above, but it sometimes improves the ability of other companies devices to associate to the wireless device.

Access Point extensions are enabled by default. Beginning in privileged EXEC mode, follow these steps to disable Access Point extensions:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<b>no dot11 extension aironet</b>	Disable Access Point extensions.
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **dot11 extension aironet** command to enable Access Point extensions if they are disabled.

## Configuring the Ethernet Encapsulation Transformation Method

When the wireless device receives data packets that are not 802.3 packets, the wireless device must format the packets to 802.3 using an encapsulation transformation method. These are the two transformation methods:

- **802.1H**—This method provides optimum performance for Cisco Access Point wireless products. This is the default setting.
- **snap**—Use this setting to ensure interoperability with non-Cisco Access Point wireless equipment. RFC1042 does not provide the interoperability advantages of 802.1H but is used by other manufacturers of wireless equipment. This is the default setting.

Beginning in privileged EXEC mode, follow these steps to configure the encapsulation transformation method:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<code>payload-encapsulation snap   dot1h</code>	Set the encapsulation transformation method to RFC1042 ( <b>snap</b> ) or 802.1h ( <b>dot1h</b> , the default setting).
Step 4	<code>end</code>	Return to privileged EXEC mode.
Step 5	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

## Enabling and Disabling Reliable Multicast to Workgroup Bridges

The *Reliable multicast messages from the access point to workgroup bridges* setting limits reliable delivery of multicast messages to approximately 20 Cisco Access Point Workgroup Bridges that are associated to the wireless device. The default setting, **disabled**, reduces the reliability of multicast delivery to allow more workgroup bridges to associate to the wireless device.

Access points and bridges normally treat workgroup bridges not as client devices but as infrastructure devices, like access points or bridges. Treating a workgroup bridge as an infrastructure device means that the wireless device reliably delivers multicast packets, including Address Resolution Protocol (ARP) packets, to the workgroup bridge.

The performance cost of reliable multicast delivery—duplication of each multicast packet sent to each workgroup bridge—limits the number of infrastructure devices, including workgroup bridges, that can associate to the wireless device. To increase beyond 20 the number of workgroup bridges that can maintain a radio link to the wireless device, the wireless device must reduce the delivery reliability of multicast packets to workgroup bridges. With reduced reliability, the wireless device cannot confirm whether multicast packets reach the intended workgroup bridge, so workgroup bridges at the edge of the wireless device's coverage area might lose IP connectivity. When you treat workgroup bridges as client devices, you increase performance but reduce reliability.



### Note

This feature is best suited for use with stationary workgroup bridges. Mobile workgroup bridges might encounter spots in the wireless device's coverage area where they do not receive multicast packets and lose communication with the wireless device even though they are still associated to it.

A Cisco Access Point Workgroup Bridge provides a wireless LAN connection for up to eight Ethernet-enabled devices.

This feature is not supported on the 5-GHz radio.

Beginning in privileged EXEC mode, follow these steps to configure the encapsulation transformation method:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0 }</b>	Enter interface configuration mode for the 2.4-GHz radio interface.
Step 3	<b>infrastructure-client</b>	Enable reliable multicast messages to workgroup bridges.
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the command to disable reliable multicast messages to workgroup bridges.

## Enabling and Disabling Public Secure Packet Forwarding

Public Secure Packet Forwarding (PSPF) prevents client devices associated to an access point from inadvertently sharing files or communicating with other client devices associated to the access point. It provides Internet access to client devices without providing other capabilities of a LAN. This feature is useful for public wireless networks like those installed in airports or on college campuses.



### Note

To prevent communication between clients associated to different access points, you must set up protected ports on the switch to which the wireless devices are connected. See the “[Configuring Protected Ports](#)” section on page 2-26 for instructions on setting up protected ports.

To enable and disable PSPF using CLI commands on the wireless device, you use bridge groups. You can find a detailed explanation of bridge groups and instructions for implementing them in this document:

- *Cisco IOS Bridging and IBM Networking Configuration Guide, Release 12.2*. Click this link to browse to the Configuring Transparent Bridging chapter:  
[http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fibm\\_c/bcftp1/bcftb.htm](http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fibm_c/bcftp1/bcftb.htm)

You can also enable and disable PSPF using the web-browser interface. The PSPF setting is on the Radio Settings pages.

PSPF is disabled by default. Beginning in privileged EXEC mode, follow these steps to enable PSPF:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<b>bridge-group <i>group</i> port-protected</b>	Enable PSPF.
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the command to disable PSPF.

## Configuring Protected Ports

To prevent communication between client devices associated to different access points on your wireless LAN, you must set up protected ports on the switch to which the wireless devices are connected.

Beginning in privileged EXEC mode, follow these steps to define a port on your switch as a protected port:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface</b> <i>interface-id</i>	Enter interface configuration mode, and enter the type and number of the switchport interface to configure, such as <b>gigabitethernet0/1</b> .
Step 3	<b>switchport protected</b>	Configure the interface to be a protected port.
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>show interfaces</b> <i>interface-id</i> <b>switchport</b>	Verify your entries.
Step 6	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

To disable protected port, use the **no switchport protected** interface configuration command.

For detailed information on protected ports and port blocking, see the “Configuring Port-Based Traffic Control” chapter in the *Catalyst 3550 Multilayer Switch Software Configuration Guide, 12.1(12c)E1* at:

[http://www.cisco.com/en/US/products/hw/switches/ps646/products\\_configuration\\_guide\\_book09186a008011591c.html](http://www.cisco.com/en/US/products/hw/switches/ps646/products_configuration_guide_book09186a008011591c.html)

## Configuring Beacon Period and DTIM

The beacon period is the amount of time between access point beacons in kilo-microseconds. One kilo-microseconds equals 1,024 microseconds. The Data Beacon Rate, always a multiple of the beacon period, determines how often the beacon contains a delivery traffic indication message (DTIM). The DTIM tells power-save client devices that a packet is waiting for them.

For example, if the beacon period is set at 100, its default setting, and the data beacon rate is set at 2, its default setting, then the wireless device sends a beacon containing a DTIM every 200 kilo-microseconds. One kilo-microsecond equals 1,024 microseconds.

The default beacon period is 100, and the default DTIM is 2. Beginning in privileged EXEC mode, follow these steps to configure the beacon period and the DTIM:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio</b> { 0   1 }	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.

	Command	Purpose
Step 3	<b>beacon period</b> <i>value</i>	Set the beacon period. Enter a value in Kilomicroseconds.
Step 4	<b>beacon dtim-period</b> <i>value</i>	Set the DTIM. Enter a value in Kilomicroseconds.
Step 5	<b>end</b>	Return to privileged EXEC mode.
Step 6	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

## Configuring RTS Threshold and Retries

The RTS threshold determines the packet size at which the wireless device issues a request to send (RTS) before sending the packet. A low RTS Threshold setting can be useful in areas where many client devices are associating with the wireless device, or in areas where the clients are far apart and can detect only the wireless device and not each other. You can enter a setting ranging from 0 to 2347 bytes.

Maximum RTS retries is the maximum number of times the wireless device issues an RTS before stopping the attempt to send the packet over the radio. Enter a value from 1 to 128.

The default RTS threshold is 2312, and the default maximum RTS retries setting is 32. Beginning in privileged EXEC mode, follow these steps to configure the RTS threshold and maximum RTS retries:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<b>rts threshold</b> <i>value</i>	Set the RTS threshold. Enter an RTS threshold from 0 to 2347.
Step 4	<b>rts retries</b> <i>value</i>	Set the maximum RTS retries. Enter a setting from 1 to 128.
Step 5	<b>end</b>	Return to privileged EXEC mode.
Step 6	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the command to reset the RTS settings to defaults.

## Configuring Maximum Data Retries

The maximum data retries setting determines the number of attempts the wireless device makes to send a packet before giving up and dropping the packet.

The default setting is 32. Beginning in privileged EXEC mode, follow these steps to configure the maximum data retries:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<b>packet retries</b> <i>value</i>	Set the maximum data retries. Enter a setting from 1 to 128.

	Command	Purpose
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the command to reset the setting to defaults.

## Configuring Fragmentation Threshold

The fragmentation threshold determines the size at which packets are fragmented (sent as several pieces instead of as one block). Use a low setting in areas where communication is poor or where there is a great deal of radio interference.

The default setting is 2338 bytes. Beginning in privileged EXEC mode, follow these steps to configure the fragmentation threshold:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<b>fragment-threshold <i>value</i></b>	Set the fragmentation threshold. Enter a setting from 256 to 2346 bytes for the 2.4-GHz radio. Enter a setting from 256 to 2346 bytes for the 5-GHz radio.
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the command to reset the setting to defaults.

## Enabling Short Slot Time for 802.11g Radios

You can increase throughput on the 802.11g, 2.4-GHz radio by enabling short slot time. Reducing the slot time from the standard 20 microseconds to the 9-microsecond short slot time decreases the overall backoff, which increases throughput. Backoff, which is a multiple of the slot time, is the random length of time that a station waits before sending a packet on the LAN.

Many 802.11g radios support short slot time, but some do not. When you enable short slot time, the wireless device uses the short slot time only when all clients associated to the 802.11g, 2.4-GHz radio support short slot time.

Short slot time is supported only on the 802.11g, 2.4-GHz radio. Short slot time is disabled by default.

	Command	Purpose
Step 1	<b>router(config-if)# slot-time-short</b>	In radio interface mode, enter this command to enable short slot time.
Step 2	<b>no slot-time-short</b>	(optional) Enter <b>no slot-time-short</b> to disable short slot time.

## Performing a Carrier Busy Test

You can perform a carrier busy test to check the radio activity on wireless channels. During the carrier busy test, the wireless device drops all associations with wireless networking devices for 4 seconds while it conducts the carrier test and then displays the test results.

In privileged EXEC mode, enter this command to perform a carrier busy test:

```
dot11 interface-number carrier busy
```

For *interface-number*, enter **dot11radio 0** to run the test on the 2.4-GHz radio, or enter **dot11radio 1** to run the test on the 5-GHz radio.

Use the **show dot11 carrier busy** command to re-display the carrier busy test results.





## Configuring Multiple SSIDs

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This chapter describes how to configure and manage multiple service set identifiers (SSIDs) on the access point. This chapter contains the following sections:

- [Understanding Multiple SSIDs, page 3-2](#)
- [Configuring Multiple SSIDs, page 3-3](#)
- [Configuring Multiple Basic SSIDs, page 3-6](#)
- [Enabling MBSSID and SSIDL at the same time, page 3-7](#)

# Understanding Multiple SSIDs

The SSID is a unique identifier that wireless networking devices use to establish and maintain wireless connectivity. Multiple access points on a network or subnetwork can use the same SSIDs. SSIDs are case sensitive and can contain up to 32 alphanumeric characters. Do not include spaces in your SSIDs.

You can configure up to 16 SSIDs on your HWIC-APs and assign different configuration settings to each SSID. All the SSIDs are active at the same time; that is, client devices can associate to the access point using any of the SSIDs. These are the settings you can assign to each SSID:

- VLAN
- Client authentication method



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**Note** For detailed information on client authentication types, see [Chapter 6, “Configuring Authentication Types.”](#)

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- Maximum number of client associations using the SSID
- RADIUS accounting for traffic using the SSID
- Guest mode
- Repeater mode, including authentication username and password
- Redirection of packets received from client devices

If you want the access point to allow associations from client devices that do not specify an SSID in their configurations, you can set up a guest SSID. The access point includes the guest SSID in its beacon.

If your access point will be a repeater or will be a root access point that acts as a parent for a repeater, you can set up an SSID for use in repeater mode. You can assign an authentication username and password to the repeater-mode SSID to allow the repeater to authenticate to your network like a client device.

If your network uses VLANs, you can assign one SSID to a VLAN, and client devices using the SSID are grouped in that VLAN.

## SSID Configuration Methods Supported by Cisco IOS Releases

Cisco introduced global-mode SSID configuration in a prior Cisco IOS Release to simplify configuration of SSID parameters under multiple interfaces. Configuration of SSID parameters at the interface level was supported in some Cisco IOS releases for backward compatibility, but configuration of SSID parameters at the interface level will be totally disabled in releases after Cisco IOS Release 12.4(15)T.

Cisco IOS Release 12.4(15)T supports configuration of SSID parameters at the interface level on the CLI, but the SSIDs are stored in global mode. Storing all SSIDs in global mode ensures that the SSID configuration remains correct when you upgrade to release later than Cisco IOS Release 12.4(15)T.

If you need to upgrade to a release later than 12.4(15)T, you should first upgrade to Cisco IOS Release 12.4(15)T, save the configuration file, upgrade to the target release, and load the saved configuration file. This process ensures that your interface-level SSID configuration correctly translates to global mode. If you upgrade directly from 12.4(15)T release or earlier to a 12.4(15)T or later release, your interface-level SSID configuration is deleted.

# Configuring Multiple SSIDs

This section contains configuration information for multiple SSIDs:

- [Creating an SSID Globally, page 3-3](#)
- [Using a RADIUS Server to Restrict SSIDs, page 3-5](#)



## Note

In Cisco IOS Release 12.4(15)T and later, you configure SSIDs globally and then apply them to a specific radio interface. Follow the instructions in the “[Creating an SSID Globally](#)” section on page 3-3 to configure SSIDs globally.

## Creating an SSID Globally

In Cisco IOS Releases 12.4 and later, you can configure SSIDs globally or for a specific radio interface. When you use the **dot11 ssid** global configuration command to create an SSID, you can use the **ssid** configuration interface command to assign the SSID to a specific interface.

When an SSID has been created in global configuration mode, the **ssid** configuration interface command attaches the SSID to the interface but does not enter **ssid** configuration mode. However, if the SSID has not been created in global configuration mode, the **ssid** command puts the CLI into SSID configuration mode for the new SSID.



## Note

SSIDs created in Cisco IOS Releases 12.3(7)JA and later become invalid if you downgrade the software version to an earlier release.

Beginning in privileged EXEC mode, follow these steps to create an SSID globally. After you create an SSID, you can assign it to specific radio interfaces.

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>dot11 ssid</b> <i>ssid-string</i>	Create an SSID and enter SSID configuration mode for the new SSID. The SSID can consist of up to 32 alphanumeric characters. SSIDs are case sensitive.  <b>Note</b> +, ,, ], ?, \$, TAB, and trailing spaces are invalid characters for SSIDs.
Step 3	<b>authentication client</b> <b>username</b> <i>username</i> <b>password</b> <i>password</i>	(Optional) Set an authentication username and password that the access point uses to authenticate to the network when in repeater mode. Set the username and password on the SSID that the repeater access point uses to associate to a root access point, or with another repeater.
Step 4	<b>accounting</b> <i>list-name</i>	(Optional) Enable RADIUS accounting for this SSID. For <i>list-name</i> , specify the accounting method list. Click this link for more information on method lists: <a href="http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fsecur_c/fsaaa/scfacet.htm#xtocid2">http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fsecur_c/fsaaa/scfacet.htm#xtocid2</a>

	Command	Purpose
Step 5	<code>vlan <i>vlan-id</i></code>	(Optional) Assign the SSID to a VLAN on your network. Client devices that associate using the SSID are grouped into this VLAN. You can assign only one SSID to a VLAN.
Step 6	<code>guest-mode</code>	(Optional) Designate the SSID as your access point's guest-mode SSID. The access point includes the SSID in its beacon and allows associations from client devices that do not specify an SSID.
Step 7	<code>infrastructure-ssid [optional]</code>	(Optional) Designate the SSID as the SSID that other access points and workgroup bridges use to associate to this access point. If you do not designate an SSID as the infrastructure SSID, infrastructure devices can associate to the access point using any SSID. If you designate an SSID as the infrastructure SSID, infrastructure devices must associate to the access point using that SSID unless you also enter the <b>optional</b> keyword.
Step 8	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface to which you want to assign the SSID. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 9	<code>ssid <i>ssid-string</i></code>	Assign the global SSID that you created in <a href="#">Step 2</a> to the radio interface.
Step 10	<code>end</code>	Return to privileged EXEC mode.
Step 11	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

**Note**

You use the `ssid` command's authentication options to configure an authentication type for each SSID. See [Chapter 6, "Configuring Authentication Types,"](#) for instructions on configuring authentication types.

Use the `no` form of the command to disable the SSID or to disable SSID features.

This example shows how to:

- Name an SSID
- Configure the SSID for RADIUS accounting
- Set the maximum number of client devices that can associate using this SSID to 15
- Assign the SSID to a VLAN
- Assign the SSID to a radio interface

```

router# configure terminal
router(config)# dot11 ssid batman
router(config-ssid)# accounting accounting-method-list
router(config-ssid)# max-associations 15
router(config-ssid)# vlan 3762
router(config-ssid)# exit
router(config)# interface dot11radio 0
router(config-if)# ssid batman

```

## Viewing SSIDs Configured Globally

Use this command to view configuration details for SSIDs that are configured globally:

```
router# show running-config ssid ssid-string
```

## Using Spaces in SSIDs

In Cisco IOS Release 12.4(15)T, you can include spaces in an SSID, but trailing spaces (spaces at the end of an SSID) are invalid. However, any SSIDs created in previous versions having trailing spaces are recognized. Trailing spaces make it appear that you have identical SSIDs configured on the same access point. If you think identical SSIDs are on the access point, use the **show dot11 associations** privileged EXEC command to check any SSIDs created in a previous release for trailing spaces.

For example, this sample output from a **show configuration** privileged EXEC command does not show spaces in SSIDs:

```
ssid buffalo
  vlan 77
  authentication open

ssid buffalo
  vlan 17
  authentication open

ssid buffalo
  vlan 7
  authentication open
```

However, this sample output from a **show dot11 associations** privileged EXEC command shows the spaces in the SSIDs:

```
SSID [buffalo] :
SSID [buffalo ] :
SSID [buffalo ] :
```

## Using a RADIUS Server to Restrict SSIDs

To prevent client devices from associating to the access point using an unauthorized SSID, you can create a list of authorized SSIDs that clients must use on your RADIUS authentication server.

The SSID authorization process consists of these steps:

1. A client device associates to the access point using any SSID configured on the access point.
2. The client begins RADIUS authentication.
3. The RADIUS server returns a list of SSIDs that the client is allowed to use. The access point checks the list for a match of the SSID used by the client. There are three possible outcomes:
  - a. If the SSID that the client used to associate to the access point matches an entry in the allowed list returned by the RADIUS server, the client is allowed network access after completing all authentication requirements.
  - b. If the access point does not find a match for the client in the allowed list of SSIDs, the access point disassociates the client.
  - c. If the RADIUS server does not return any SSIDs (no list) for the client, then the administrator has not configured the list, and the client is allowed to associate and attempt to authenticate.

The allowed list of SSIDs from the RADIUS server are in the form of Cisco VSAs. The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating vendor-specific information between the access point and the RADIUS server by using the vendor-specific attribute (attribute 26). Vendor-specific attributes (VSAs) allow vendors to support their own extended attributes not suitable for general use. The Cisco RADIUS implementation supports one vendor-specific option by using the format recommended in the specification. Cisco's vendor-ID is 9, and the supported option has vendor-type 1, which is named *cisco-avpair*. The Radius server is allowed to have zero or more SSID VSAs per client.

In this example, the following AV pair adds the SSID *batman* to the list of allowed SSIDs for a user:

```
cisco-avpair= "ssid=batman"
```

For instructions on configuring the access point to recognize and use VSAs, see the [“Configuring the Access Point to Use Vendor-Specific RADIUS Attributes”](#) section on page 7-14.

## Configuring Multiple Basic SSIDs

Access point 802.11a and 802.11g radios now support up to 8 basic SSIDs (BSSIDs), which are similar to MAC addresses. You use multiple BSSIDs to assign a unique DTIM setting for each SSID and to broadcast more than one SSID in beacons. A large DTIM value increases battery life for power-save client devices that use an SSID, and broadcasting multiple SSIDs makes your wireless LAN more accessible to guests.



### Note

Devices on your wireless LAN that are configured to associate to a specific access point based on the access point MAC address (for example, client devices, repeaters, hot standby units, or workgroup bridges) might lose their association when you add or delete a multiple BSSID. When you add or delete a multiple BSSID, check the association status of devices configured to associate to a specific access point. If necessary, reconfigure the disassociated device to use the BSSID's new MAC address.

## Requirements for Configuring Multiple BSSIDs

To configure multiple BSSIDs, your access points must meet these minimum requirements:

- VLANs must be configured
- Access points must run Cisco IOS Release 12.4(15)T or later
- Access points must contain an 802.11a or 802.11g radio that supports multiple BSSIDs. To determine whether a radio supports multiple basic SSIDs, enter the **show controllers radio\_interface** command. The radio supports multiple basic SSIDs if the results include this line:

```
Number of supported simultaneous BSSID on radio_interface: 8
```

## Guidelines for Using Multiple BSSIDs

Keep these guidelines in mind when configuring multiple BSSIDs:

- RADIUS-assigned VLANs are not supported when you enable multiple BSSIDs.
- When you enable BSSIDs, the access point automatically maps a BSSID to each SSID. You cannot manually map a BSSID to a specific SSID.

- When multiple BSSIDs are enabled on the access point, the SSIDL IE does not contain a list of SSIDs; it contains only extended capabilities.
- Any Wi-Fi certified client device can associate to an access point using multiple BSSIDs.
- You can enable multiple BSSIDs on access points that participate in WDS.

## CLI Configuration Example

This example shows the CLI commands that you use to enable multiple BSSIDs on a radio interface, create an SSID called *visitor*, designate the SSID as a BSSID, specify that the BSSID is included in beacons, set a DTIM period for the BSSID, and assign the SSID *visitor* to the radio interface:

```
router(config)# interface dot11 0
router(config-if)# mbssid
router(config-if)# exit
router(config)# dot11 ssid visitor
router(config-ssid)# mbssid guest-mode
router(config-ssid)# exit
router(config)# interface dot11 0
router(config-if)# ssid visitor
```

You can also use the **dot11 mbssid** global configuration command to simultaneously enable multiple BSSIDs on all radio interfaces that support multiple BSSIDs.

## Displaying Configured BSSIDs

Use the **show dot11 bssid** privileged EXEC command to display the relationship between SSIDs and BSSIDs or MAC addresses. This example shows the command output:

```
router1230#show dot11 bssid
Interface      BSSID          Guest  SSID
Dot11Radio1   0011.2161.b7c0 Yes    atlantic
Dot11Radio0   0005.9a3e.7c0f Yes    WPA2-TLS-g
```

## Enabling MBSSID and SSIDL at the same time

When multiple BSSIDs are enabled on the access point, the SSIDL IE does not contain a list of SSIDs; it contains only extended capabilities.

Beginning in privileged EXEC mode, follow these steps to include an SSID in an SSIDL IE:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>interface dot11radio { 0   1 }</b>	Enter interface configuration mode for the radio interface.
Step 3	<b>ssid ssid-string</b>	Enter configuration mode for a specific SSID.
Step 4	<b>information-element ssidl [advertisement] [wps]</b>	Include an SSIDL IE in the access point beacon that advertises the access point's extended capabilities, such as 802.1x and support for Microsoft Wireless Provisioning Services (WPS).  Use the <b>advertisement</b> option to include the SSID name and capabilities in the SSIDL IE. Use the <b>wps</b> option to set the WPS capability flag in the SSIDL IE.

Use the **no** form of the command to disable SSIDL IEs.

## Sample Configuration for Enabling MBSSID and SSIDL

Below is a sample configuration for enabling MBSSID:

```
dot11 ssid 181x_gvlan01
  vlan 1
  authentication open
  mbssid guest-mode
!
dot11 ssid 181x_gvlan02
  vlan 2
  authentication open
  wpa-psk ascii 0 12345678
  mbssid guest-mode
!
dot11 ssid 181x_gvlan03
  vlan 3
  authentication open
  authentication key-management wpa
  wpa-psk ascii 0 12345678
!
dot11 ssid 181x_gvlan04
  vlan 4
  authentication open
  authentication key-management wpa
  wpa-psk ascii 0 12345678
!
interface Dot11Radio0
  no ip address
  !
  encryption vlan 1 key 1 size 40bit 0 1234567890 transmit-key
  encryption vlan 1 mode ciphers wep40
  !
  encryption vlan 2 mode ciphers tkip
  !
  encryption vlan 3 mode ciphers tkip
  !
  encryption vlan 4 mode ciphers tkip
  !
  ssid 181x_gvlan01
  !
  ssid 181x_gvlan02
  !
  ssid 181x_gvlan03
  !
  ssid 181x_gvlan04
  !
  speed basic-1.0 basic-2.0 basic-5.5 6.0 9.0 basic-11.0 12.0 18.0 24.0 36.0 48.0 54.0
  mbssid
  station-role root
!
```

Below is a sample configuration for enabling SSIDL:

```
dot11 ssid 1841-wep128
  vlan 1
  authentication open
  information-element ssid advertisement
```

```
!
dot11 ssid 1841-tkip-psk
  vlan 2
  authentication open
  authentication key-management wpa
  wpa-psk ascii 0 12345678
  information-element ssidl advertisement
!
dot11 ssid 1841-aes-psk
  vlan 3
  authentication open
  authentication key-management wpa
  wpa-psk ascii 0 12345678
  information-element ssidl advertisement wps
!
interface Dot11Radio0/0/0
  no ip address
  no snmp trap link-status
  !
  encryption vlan 1 key 1 size 128bit 0 12345678901234567890123456 transmit-key
  encryption vlan 1 key 2 size 128bit 0 12345678901234567890123456
  encryption vlan 1 mode ciphers wep128
  !
  encryption vlan 2 mode ciphers tkip
  !
  encryption vlan 3 mode ciphers aes-ccm
  !
  ssid 1841-wep128
  !
  ssid 1841-tkip-psk
  !
  ssid 1841-aes-psk
  !
  speed basic-1.0 basic-2.0 basic-5.5 6.0 9.0 basic-11.0 12.0 18.0 24.0 36.0 48.0 54.0
  station-role root
```





## Configuring an Access Point as a Local Authenticator

---

This chapter describes how to configure the access point as a local authenticator to serve as a stand-alone authenticator for a small wireless LAN or to provide backup authentication service. As a local authenticator, the access point performs LEAP, EAP-FAST, and MAC-based authentication for up to 1000 client devices. This chapter contains these sections:

- [Understand Local Authentication, page 4-2](#)
- [Configure a Local Authenticator, page 4-2](#)

# Understand Local Authentication

Many small wireless LANs that could be made more secure with 802.1x authentication do not have access to a RADIUS server. On many wireless LANs that use 802.1x authentication, access points rely on RADIUS servers housed in a distant location to authenticate client devices, and the authentication traffic must cross a WAN link. If the WAN link fails, or if the access points cannot access the RADIUS servers for any reason, client devices cannot access the wireless network even if the work they wish to do is entirely local.

To provide local authentication service or backup authentication service in case of a WAN link or a server failure, you can configure an access point to act as a local authentication server. The access point can authenticate up to 50 wireless client devices using LEAP, EAP-FAST, or MAC-based authentication. The access point performs up to 5 authentications per second.

You configure the local authenticator access point manually with client usernames and passwords because it does not synchronize its database with the main RADIUS servers. You can also specify a VLAN and a list of SSIDs that a client is allowed to use.



---

**Note** If your wireless LAN contains only one access point, you can configure the access point as both the 802.1x authenticator and the local authenticator. However, users associated to the local authenticator access point might notice a drop in performance when the access point authenticates client devices.

---

You can configure your access points to use the local authenticator when they cannot reach the main servers, or you can configure your access points to use the local authenticator or as the main authenticator if you do not have a RADIUS server. When you configure the local authenticator as a backup to your main servers, the access points periodically check the link to the main servers and stop using the local authenticator automatically when the link to the main servers is restored.

**Caution**

---

The access point you use as an authenticator contains detailed authentication information for your wireless LAN, so you should secure it physically to protect its configuration.

---

# Configure a Local Authenticator

This section provides instructions for setting up an access point as a local authenticator and includes these sections:

- [Guidelines for Local Authenticators, page 4-3](#)
- [Configuration Overview, page 4-3](#)
- [Configuring the Local Authenticator Access Point, page 4-3](#)
- [Configuring Other Access Points to Use the Local Authenticator, page 4-8](#)
- [Configuring EAP-FAST Settings, page 4-9](#)
- [Unblocking Locked Usernames, page 4-11](#)
- [Viewing Local Authenticator Statistics, page 4-11](#)
- [Using Debug Messages, page 4-12](#)

## Guidelines for Local Authenticators

Follow these guidelines when configuring an access point as a local authenticator:

- Use an access point that does not serve a large number of client devices. When the access point acts as an authenticator, performance might degrade for associated client devices.
- Secure the access point physically to protect its configuration.

## Configuration Overview

You complete four major steps when you set up a local authenticator:

1. On the local authenticator, create a list of access points authorized to use the authenticator to authenticate client devices. Each access point that uses the local authenticator is a network access server (NAS).



**Note** If your local authenticator access point also serves client devices, you must enter the local authenticator access point as a NAS. When a client associates to the local authenticator access point, the access point uses itself to authenticate the client.

2. On the local authenticator, create user groups and configure parameters to be applied to each group (optional).
3. On the local authenticator, create a list of up to 50 LEAP users, EAP-FAST users, or MAC addresses that the local authenticator is authorized to authenticate.



**Note** You do not have to specify which type of authentication that you want the local authenticator to perform. It automatically performs LEAP, EAP-FAST, or MAC-address authentication for the users in its user database.

4. On the access points that use the local authenticator, enter the local authenticator as a RADIUS server.



**Note** If your local authenticator access point also serves client devices, you must enter the local authenticator as a RADIUS server in the local authenticator's configuration. When a client associates to the local authenticator access point, the access point uses itself to authenticate the client.

## Configuring the Local Authenticator Access Point

Beginning in Privileged Exec mode, follow these steps to configure the access point as a local authenticator:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>aaa new-model</code>	Enable AAA.

	Command	Purpose
Step 3	<b>radius-server local</b>	Enable the access point as a local authenticator and enter configuration mode for the authenticator.
Step 4	<b>nas ip-address key shared-key</b>	<p>Add an access point to the list of units that use the local authenticator. Enter the access point's IP address and the shared key used to authenticate communication between the local authenticator and other access points. You must enter this shared key on the access points that use the local authenticator. If your local authenticator also serves client devices, you must enter the local authenticator access point as a NAS.</p> <p><b>Note</b> Leading spaces in the key string are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.</p> <p>Repeat this step to add each access point that uses the local authenticator.</p>
Step 5	<b>group group-name</b>	(Optional) Enter user group configuration mode and configure a user group to which you can assign shared settings.
Step 6	<b>vlan vlan</b>	(Optional) Specify a VLAN to be used by members of the user group. The access point moves group members into that VLAN, overriding other VLAN assignments. You can assign only one VLAN to the group.
Step 7	<b>ssid ssid</b>	(Optional) Enter up to 20 SSIDs to limit members of the user group to those SSIDs. The access point checks that the SSID that the client used to associate matches one of the SSIDs in the list. If the SSID does not match, the client is disassociated.
Step 8	<b>reauthentication time seconds</b>	(Optional) Enter the number of seconds after which access points should reauthenticate members of the group. The reauthentication provides users with a new encryption key. The default setting is 0, which means that group members are never required to reauthenticate.
Step 9	<b>block count count time { seconds   infinite }</b>	<p>(Optional) To help protect against password guessing attacks, you can lock out members of a user group for a length of time after a set number of incorrect passwords.</p> <ul style="list-style-type: none"> <li>count—The number of failed passwords that triggers a lockout of the username.</li> <li>time—The number of seconds the lockout should last. If you enter <b>infinite</b>, an administrator must manually unblock the locked username. See the <a href="#">“Unblocking Locked Usernames” section on page 4-11</a> for instructions on unblocking client devices.</li> </ul>
Step 10	<b>exit</b>	Exit group configuration mode and return to authenticator configuration mode.

	Command	Purpose
Step 11	<b>user</b> <i>username</i> { <b>password</b>   <b>nthash</b> } <i>password</i> [ <b>group</b> <i>group-name</i> ] [ <b>mac-auth-only</b> ]	Enter the LEAP and EAP-FAST users allowed to authenticate using the local authenticator. You must enter a username and password for each user. If you only know the NT value of the password, which you can often find in the authentication server database, you can enter the NT hash as a string of hexadecimal digits.  To add a client device for MAC-based authentication, enter the client's MAC address as both the username and password. Enter 12 hexadecimal digits without a dot or dash between the numbers as the username and the password. For example, for the MAC address 0009.5125.d02b, enter <i>00095125d02b</i> as both the username and the password.  To limit the user to MAC authentication only, enter <b>mac-auth-only</b> .  To add the user to a user group, enter the group name. If you do not specify a group, the user is not assigned to a specific VLAN and is never forced to reauthenticate.
Step 12	<b>end</b>	Return to privileged EXEC mode.
Step 13	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

This example shows how to set up a local authenticator used by three access points with three user groups and several users:

```

router# configure terminal
router(config)# radius-server local
router(config-radsrv)# nas 10.91.6.159 key 110337
router(config-radsrv)# nas 10.91.6.162 key 110337
router(config-radsrv)# nas 10.91.6.181 key 110337
router(config-radsrv)# group clerks
router(config-radsrv-group)# vlan 87
router(config-radsrv-group)# ssid batman
router(config-radsrv-group)# ssid robin
router(config-radsrv-group)# reauthentication time 1800
router(config-radsrv-group)# block count 2 time 600
router(config-radsrv-group)# group cashiers
router(config-radsrv-group)# vlan 97
router(config-radsrv-group)# ssid deer
router(config-radsrv-group)# ssid antelope
router(config-radsrv-group)# ssid elk
router(config-radsrv-group)# reauthentication time 1800
router(config-radsrv-group)# block count 2 time 600
router(config-radsrv-group)# group managers
router(config-radsrv-group)# vlan 77
router(config-radsrv-group)# ssid mouse
router(config-radsrv-group)# ssid chipmunk
router(config-radsrv-group)# reauthentication time 1800
router(config-radsrv-group)# block count 2 time 600
router(config-radsrv-group)# exit
router(config-radsrv)# user jsmith password twain74 group clerks
router(config-radsrv)# user stpatrick password snake100 group clerks
router(config-radsrv)# user nick password uptown group clerks
router(config-radsrv)# user 00095125d02b password 00095125d02b group clerks mac-auth-only

```

```

router(config-radsrv)# user 00095125d02b password 00095125d02b group cashiers
router(config-radsrv)# user 00079431f04a password 00079431f04a group cashiers
router(config-radsrv)# user carl password 272165 group managers
router(config-radsrv)# user vic password lid178 group managers
router(config-radsrv)# end

```

This example shows how to set up EAP-FAST authentication:

```

Router#show run
Building configuration...

Current configuration : 2119 bytes
!
version 12.3
no service pad
service timestamps debug datetime msec
service timestamps log datetime msec
service password-encryption
!
hostname Router
!
enable secret 5 $1$dkOn$EcccqZvFdjoEi3geC66da0
!
ip subnet-zero
!
!
aaa new-model
!
!
aaa group server radius rad_eap
server 192.168.1.66 auth-port 1812 acct-port 1813
!
aaa authentication login eap_methods group rad_eap
aaa session-id common
!
dot11 ssid test-ssid
authentication open eap eap_methods
authentication network-eap eap_methods
authentication key-management wpa
!
!
!
username Cisco password 7 00271A150754
!
bridge irb
!
!
interface Dot11Radio0
no ip address
no ip route-cache
!
encryption mode ciphers aes-ccm tkip
!
ssid test-ssid
!
speed basic-1.0 basic-2.0 basic-5.5 6.0 9.0 basic-11.0 12.0 18.0 24.0 36.0 48.0
54.0
station-role root
bridge-group 1
bridge-group 1 subscriber-loop-control
bridge-group 1 block-unknown-source
no bridge-group 1 source-learning
no bridge-group 1 unicast-flooding
bridge-group 1 spanning-disabled

```

```
!
interface FastEthernet0
no ip address
no ip route-cache
duplex auto
speed auto
bridge-group 1
no bridge-group 1 source-learning
bridge-group 1 spanning-disabled
!
interface BVI1
ip address 192.168.1.66 255.255.255.0
no ip route-cache
!
ip http server
no ip http secure-server
ip http help-path http://www.cisco.com/warp/public/779/smbiz/prodconfig/help/eag
ip radius source-interface BVI1
!
radius-server local
eapfast authority id 12345678901234567890123456789012
eapfast authority info sample_eap-fast
eapfast server-key primary 7 41754A0073F16A0E093EA2089A3FDECD32
nas 192.168.1.66 key 7 110A1016141D
group EAP_FAST-usr
eapfast pac expiry 30 grace 120
!
user cisco nhash 7 06532C791C1E2F4856364128295C7C0E007A6661723723422656050A09
760D2F51
!
radius-server host 192.168.1.66 auth-port 1812 acct-port 1813 key 7 060506324F41
!
control-plane
!
bridge 1 route ip
!
!
!
line con 0
transport preferred all
transport output all
line vty 0 4
transport preferred all
transport input all
transport output all
line vty 5 15
transport preferred all
transport input all
transport output all
!
end
```

## Configuring Other Access Points to Use the Local Authenticator

You add the local authenticator to the list of servers on the access point the same way that you add other servers. For detailed instructions on setting up RADIUS servers on your access points, see [Chapter 7, “Configuring RADIUS Servers.”](#)



### Note

If your local authenticator access point also serves client devices, you must configure the local authenticator to use itself to authenticate client devices.

On the access points that use the local authenticator, use the **radius-server host** command to enter the local authenticator as a RADIUS server. The order in which the access point attempts to use the servers matches the order in which you enter the servers in the access point configuration. If you are configuring the access point to use RADIUS for the first time, enter the main RADIUS servers first, and enter the local authenticator last.



### Note

You must enter **1812** as the authentication port and **1813** as the accounting port. The local authenticator listens on UDP port 1813 for RADIUS accounting packets. It discards the accounting packets but sends acknowledge packets back to RADIUS clients to prevent clients from assuming that the server is down.

Use the **radius-server deadtime** command to set an interval during which the access point does not attempt to use servers that do not respond, thus avoiding the wait for a request to time out before trying the next configured server. A server marked as dead is skipped by additional requests for the duration of minutes that you specify, up to 1440 (24 hours).

This example shows how to set up two main servers and a local authenticator with a server deadtime of 10 minutes:

```
router(config)# aaa new-model
router(config)# radius-server host 172.20.0.1 auth-port 1000 acct-port 1001 key 77654
router(config)# radius-server host 172.10.0.1 auth-port 1645 acct-port 1646 key 77654
router(config)# radius-server host 10.91.6.151 auth-port 1812 acct-port 1813 key 110337
router(config)# radius-server deadtime 10
```

In this example, if the WAN link to the main servers fails, the access point completes these steps when a LEAP-enabled client device associates:

1. It tries the first server, times out multiple times, and marks the first server as dead.
2. It tries the second server, times out multiple times, and marks the second server as dead.
3. It tries and succeeds using the local authenticator.

If another client device needs to authenticate during the 10-minute dead-time interval, the access point skips the first two servers and tries the local authenticator first. After the dead-time interval, the access point tries to use the main servers for authentication. When setting a dead time, you must balance the need to skip dead servers with the need to check the WAN link and begin using the main servers again as soon as possible.

Each time the access point tries to use the main servers while they are down, the client device trying to authenticate might report an authentication timeout. The client device retries and succeeds when the main servers time out and the access point tries the local authenticator. You can extend the timeout value on Cisco client devices to accommodate expected server timeouts.

To remove the local authenticator from the access point configuration, use the **no radius-server host hostname | ip-address** global configuration command.

## Configuring EAP-FAST Settings

The default settings for EAP-FAST authentication are suitable for most wireless LANs. However, you can customize the credential timeout values, authority ID, and server keys to match your network requirements.

## Configuring PAC Settings

This section describes how to configure Protected Access Credential (PAC) settings. The first time that an EAP-FAST client device attempts to authenticate to the local authenticator, the local authenticator generates a PAC for the client. You can also generate PACs manually and use the Aironet Client Utility to import the PAC file.

### PAC Expiration Times

You can limit the number of days for which PACs are valid, and a grace period during which PACs are valid after they have expired. By default, PACs are valid for infinite days, with a grace period of infinite days. You apply the expiration time and the grace period settings to a group of users.

Use this command to configure the expiration time and grace period for PACs:

```
router(config-radsrv-group)# [no] eapfast pac expiry days [grace days]
```

Enter a number of days from 2 to 4095. Enter the **no** form of the command to reset the expiration time or grace period to infinite days.

In this example, PACs for the user group expire in 100 days with a grace period of two days:

```
router(config-radsrv-group)# eapfast pac expiry 100 grace 2
```

### Generating PACs Manually

The local authenticator automatically generates PACs for EAP-FAST clients that request them. However, you might need to generate a PAC manually for some client devices. When you enter the command, the local authenticator generates a PAC file and writes it to the network location that you specify. The user imports the PAC file into the client profile.

Use this command to generate a PAC manually:

```
router# radius local-server pac-generate filename username [password password] [expiry days]
```

When you enter the PAC filename, enter the full path to which the local authenticator writes the PAC file (such as `tftp://172.1.1.1/test/user.pac`). The password is optional and, if not specified, a default password understood by the CCX client is used. Expiry is also optional and, if not specified, the default period is 1 day.

In this example, the local authenticator generates a PAC for the username *joe*, password-protects the file with the password *bingo*, sets the PAC to expire in 10 days, and writes the PAC file to the TFTP server at 10.0.0.5:

```
router# radius local-server pac-generate tftp://10.0.0.5 joe password bingo expiry 10
```

## Configuring an Authority ID

All EAP-FAST authenticators are identified by an authority identity (AID). The local authenticator sends its AID to an authenticating client, and the client checks its database for a matching AID. If the client does not recognize the AID, it requests a new PAC.

Use these commands to assign an AID to the local authenticator:

```
router(config-radsevr)# [no] eapfast authority id identifier
router(config-radsevr)# [no] eapfast authority info identifier
```

The **eapfast authority id** command assigns an AID that the client device uses during authentication.

## Configuring Server Keys

The local authenticator uses server keys to encrypt PACs that it generates and to decrypt PACs when authenticating clients. The server maintains two keys, a primary key and a secondary key, and uses the primary key to encrypt PACs. By default, the server uses a default value as the primary key but does not use a secondary key unless you configure one.

When the local authenticator receives a client PAC, it attempts to decrypt the PAC with the primary key. If decryption fails with the primary, the authenticator attempts to decrypt the PAC with the secondary key if one is configured. If decryption fails, the authenticator rejects the PAC as invalid.

Use these commands to configure server keys:

```
router(config-radsevr)# [no] eapfast server-key primary {[auto-generate] | [ [0 | 7] key]}
router(config-radsevr)# [no] eapfast server-key secondary [0 | 7] key
```

Keys can contain up to 32 hexadecimal digits. Enter **0** before the key to enter an unencrypted key. Enter **7** before the key to enter an encrypted key. Use the **no** form of the commands to reset the local authenticator to the default setting, which is to use a default value as a primary key.

## Possible PAC Failures Caused by Access Point Clock

The local authenticator uses the access point clock to both generate PACs and to determine whether PACs are valid. However, relying on the access point clock can lead to PAC failures.

If your local authenticator access point receives its time setting from an NTP server, there is an interval between boot up and synchronization with the NTP server during which the access point uses its default time setting. If the local authenticator generates a PAC during that interval, the PAC might be expired when the access point receives a new time setting from the NTP server. If an EAP-FAST client attempts to authenticate during the interval between boot and NTP-synch, the local authenticator might reject the client's PAC as invalid.

If your local authenticator does not receive its time setting from an NTP server and it reboots frequently, PACs generated by the local authenticator might not expire when they should. The access point clock is reset when the access point reboots, so the elapsed time on the clock would not reach the PAC expiration time.

## Limiting the Local Authenticator to One Authentication Type

By default, a local authenticator access point performs LEAP, EAP-FAST, and MAC-based authentication for client devices. However, you can limit the local authenticator to perform only one or two authentication types. Use the **no** form of the authentication command to restrict the authenticator to an authentication type:

```
router(config-radsrv)# [no] authentication [eapfast] [leap] [mac]
```

Because all authentication types are enabled by default, you enter the **no** form of the command to disable authentication types. For example, if you want the authenticator to perform only LEAP authentication, you enter these commands:

```
router(config-radsrv)# no authentication eapfast
router(config-radsrv)# no authentication mac
```

## Unblocking Locked Usernames

You can unblock usernames before the lockout time expires, or when the lockout time is set to infinite. In Privileged Exec mode on the local authenticator, enter this command to unblock a locked username:

```
router# clear radius local-server user username
```

## Viewing Local Authenticator Statistics

In privileged exec mode, enter this command to view statistics collected by the local authenticator:

```
router# show radius local-server statistics
```

This example shows local authenticator statistics:

```
Successes           : 0           Unknown usernames   : 0
Client blocks       : 0           Invalid passwords   : 0
Unknown NAS         : 0           Invalid packet from NAS: 0

NAS : 10.91.6.158
Successes           : 0           Unknown usernames   : 0
Client blocks       : 0           Invalid passwords   : 0
Corrupted packet    : 0           Unknown RADIUS message : 0
No username attribute : 0       Missing auth attribute : 0
Shared key mismatch : 0           Invalid state attribute: 0
Unknown EAP message : 0           Unknown EAP auth type : 0
Auto provision success : 0       Auto provision failure : 0
PAC refresh         : 0           Invalid PAC received  : 0

Username            Successes  Failures  Blocks
nicky                0          0         0
jones                 0          0         0
jsmith               0          0         0
Router#sh radius local-server statistics
Successes           : 1           Unknown usernames   : 0
Client blocks       : 0           Invalid passwords   : 0
Unknown NAS         : 0           Invalid packet from NAS: 0
```

The first section of statistics lists cumulative statistics from the local authenticator.

The second section lists stats for each access point (NAS) authorized to use the local authenticator. The EAP-FAST statistics in this section include these stats:

- Auto provision success—the number of PACs generated automatically
- Auto provision failure—the number of PACs not generated because of an invalid handshake packet or invalid username or password
- PAC refresh—the number of PACs renewed by clients
- Invalid PAC received—the number of PACs received that were expired, that the authenticator could not decrypt, or that were assigned to a client username not in the authenticator's database

The third section lists stats for individual users. If a user is blocked and the lockout time is set to infinite, *blocked* appears at the end of the stat line for that user. If the lockout time is not infinite, *Unblocked in x seconds* appears at the end of the stat line for that user.

Use this privileged exec mode command to reset local authenticator statistics to zero:

```
router# clear radius local-server statistics
```

## Using Debug Messages

In privileged exec mode, enter this command to control the display of debug messages for the local authenticator:

```
router# debug radius local-server { client | eapfast | error | packets }
```

Use the command options to display this debug information:

- Use the **client** option to display error messages related to failed client authentications.
- Use the **eapfast** option to display error messages related to EAP-FAST authentication. Use the sub-options to select specific debugging information:
  - **encryption**—displays information on the encryption and decryption of received and transmitted packets
  - **events**—displays information on all EAP-FAST events
  - **pac**—displays information on events related to PACs, such as PAC generation and verification
  - **pkts**—displays packets sent to and received from EAP-FAST clients
- Use the **error** option to display error messages related to the local authenticator.
- Use the **packets** option to turn on display of the content of RADIUS packets sent and received.



## Configuring Encryption Types

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This chapter describes how to configure the encryption types required to use WPA authenticated key management, Wired Equivalent Privacy (WEP), AES-CCM, Temporal Key Integrity Protocol (TKIP), and broadcast key rotation. This chapter contains these sections:

- [Understand Encryption Types, page 5-2](#)
- [Configure Encryption Types, page 5-3](#)

# Understand Encryption Types

This section describes how encryption types protect traffic on your wireless LAN.

Just as anyone within range of a radio station can tune to the station's frequency and listen to the signal, any wireless networking device within range of an access point can receive the access point's radio transmissions. Because encryption is the first line of defense against intruders, Cisco recommends that you use full encryption on your wireless network.

One type of wireless encryption is Wired Equivalent Privacy (WEP). WEP encryption scrambles the communication between the access point and client devices to keep the communication private. Both the access point and client devices use the same WEP key to encrypt and unencrypt radio signals. WEP keys encrypt both unicast and multicast messages. Unicast messages are addressed to just one device on the network. Multicast messages are addressed to multiple devices on the network.

Extensible Authentication Protocol (EAP) authentication, also called 802.1x authentication, provides dynamic WEP keys to wireless users. Dynamic WEP keys are more secure than static, or unchanging, WEP keys. If an intruder passively receives enough packets encrypted by the same WEP key, the intruder can perform a calculation to learn the key and use it to join your network. Because they change frequently, dynamic WEP keys prevent intruders from performing the calculation and learning the key. See [Chapter 6, “Configuring Authentication Types,”](#) for detailed information on EAP and other authentication types.

Cipher suites are sets of encryption and integrity algorithms designed to protect radio communication on your wireless LAN. You must use a cipher suite to enable Wi-Fi Protected Access (WPA). Because cipher suites provide the protection of WEP while also allowing use of authenticated key management, Cisco recommends that you enable encryption by using the **encryption mode cipher** command in the CLI or by using the cipher drop-down menu in the web-browser interface. Cipher suites that contain AES-CCM provide the best security for your wireless LAN, and cipher suites that contain only WEP are the least secure.

These security features protect the data traffic on your wireless LAN:

- AES-CCMP—Based on the Advanced Encryption Standard (AES) defined in the National Institute of Standards and Technology's *FIPS Publication 197*, AES-CCMP is a symmetric block cipher that can encrypt and decrypt data using keys of 128, 192, and 256 bits. AES-CCMP is superior to WEP encryption and is defined in the IEEE 802.11i standard.
- WEP—WEP is an 802.11 standard encryption algorithm originally designed to provide your wireless LAN with the same level of privacy available on a wired LAN. However, the basic WEP construction is flawed, and an attacker can compromise the privacy with reasonable effort.
- TKIP (Temporal Key Integrity Protocol)—TKIP is a suite of algorithms surrounding WEP that is designed to achieve the best possible security on legacy hardware built to run WEP. TKIP adds four enhancements to WEP:
  - A per-packet key mixing function to defeat weak-key attacks
  - A new IV sequencing discipline to detect replay attacks
  - A cryptographic message integrity check (MIC), called *Michael*, to detect forgeries such as bit flipping and altering packet source and destination
  - An extension of IV space, to virtually eliminate the need for re-keying
- Broadcast key rotation (also known as Group Key Update)—Broadcast key rotation allows the access point to generate the best possible random group key and update all key-management capable clients periodically. Wi-Fi Protected Access (WPA) also provides additional options for group key updates. See the [“Using WPA Key Management”](#) section on [page 6-6](#) for details on WPA.

**Note**

Client devices using static WEP cannot use the access point when you enable broadcast key rotation. When you enable broadcast key rotation, only wireless client devices using 802.1x authentication (such as LEAP, EAP-TLS, or PEAP) can use the access point.

## Configure Encryption Types

These sections describe how to configure encryption, such as WEP, AES-CCM, and broadcast key rotation:

- [Creating WEP Keys, page 5-3](#)
- [Creating Cipher Suites, page 5-5](#)
- [Enabling and Disabling Broadcast Key Rotation, page 5-7](#)

**Note**

All encryption types are disabled by default.

## Creating WEP Keys

**Note**

You need to configure static WEP keys only if your access point needs to support client devices that use static WEP. If all the client devices that associate to the access point use key management (WPA or 802.1x authentication) you do not need to configure static WEP keys.

Beginning in privileged EXEC mode, follow these steps to create a WEP key and set the key properties:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.

	Command	Purpose
Step 3	<b>encryption</b> [vlan <i>vlan-id</i> ] <b>key</b> <i>1-4</i> <b>size</b> { <b>40</b>   <b>128</b> } <i>encryption-key</i> [ <b>0</b>   <b>7</b> ] [transmit-key]	Create a WEP key and set up its properties. <ul style="list-style-type: none"> <li>• (Optional) Select the VLAN for which you want to create a key.</li> <li>• Name the key slot in which this WEP key resides. You can assign up to 4 WEP keys for each VLAN.</li> <li>• Enter the key and set the size of the key, either 40-bit or 128-bit. 40-bit keys contain 10 hexadecimal digits; 128-bit keys contain 26 hexadecimal digits.</li> <li>• (Optional) Specify whether the key is encrypted (<b>7</b>) or unencrypted (<b>0</b>).</li> <li>• (Optional) Set this key as the transmit key. The key in slot 1 is the transmit key by default.</li> </ul> <p><b>Note</b> Using security features such as authenticated key management can limit WEP key configurations. See the <a href="#">“WEP Key Restrictions” section on page 5-4</a> for a list of features that impact WEP keys.</p>
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

This example shows how to create a 128-bit WEP key in slot 3 for VLAN 22 and sets the key as the transmit key:

```

router# configure terminal
router(config)# interface dot11radio 0
router(config-if)# encryption vlan 22 key 3 size 128 12345678901234567890123456
transmit-key
router(config-ssid)# end

```

## WEP Key Restrictions

[Table 5-1](#) lists WEP key restrictions based on your security configuration.

**Table 5-1** WEP Key Restrictions

Security Configuration	WEP Key Restriction
WPA authenticated key management	Cannot configure a WEP key in key slot 1
LEAP or EAP authentication	Cannot configure a WEP key in key slot 4
Cipher suite with 40-bit WEP	Cannot configure a 128-bit key
Cipher suite with 128-bit WEP	Cannot configure a 40-bit key
Cipher suite with TKIP	Cannot configure any WEP keys

**Table 5-1** WEP Key Restrictions (continued)

Security Configuration	WEP Key Restriction
Cipher suite with TKIP and 40-bit WEP or 128-bit WEP	Cannot configure a WEP key in key slot 1 and 4
Broadcast key rotation	Keys in slots 2 and 3 are overwritten by rotating broadcast keys  <b>Note</b> Client devices using static WEP cannot use the access point when you enable broadcast key rotation. When you enable broadcast key rotation, only wireless client devices using 802.1x authentication (such as LEAP, EAP-TLS, or PEAP) can use the access point.

## Example WEP Key Setup

Table 5-2 shows an example WEP key setup that would work for the access point and an associated device:

**Table 5-2** WEP Key Setup Example

Key Slot	Access Point		Associated Device	
	Transmit?	Key Contents	Transmit?	Key Contents
1	x	12345678901234567890abcdef	—	12345678901234567890abcdef
2	—	09876543210987654321fedcba	x	09876543210987654321fedcba
3	—	not set	—	not set
4	—	not set	—	FEDCBA09876543211234567890

Because the access point's WEP key 1 is selected as the transmit key, WEP key 1 on the other device must have the same contents. WEP key 4 on the other device is set, but because it is not selected as the transmit key, WEP key 4 on the access point does not need to be set at all.

## Creating Cipher Suites

Beginning in privileged EXEC mode, follow these steps to create a cipher suite:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.

	Command	Purpose
Step 3	<b>encryption</b> [vlan <i>vlan-id</i> ] <b>mode ciphers</b> {[aes-ccm   tkip]} {[wep128   wep40]}	<p>Enable a cipher suite containing the encryption you need. <a href="#">Table 5-3</a> lists guidelines for selecting a cipher suite that matches the type of authenticated key management you configure.</p> <ul style="list-style-type: none"> <li>(Optional) Select the VLAN for which you want to enable WEP and WEP features.</li> <li>Set the cipher options and WEP level. You can combine TKIP with 128-bit or 40-bit WEP.</li> </ul> <p><b>Note</b> You can also use the <b>encryption mode wep</b> command to set up static WEP. However, you should use <b>encryption mode wep</b> only if no clients that associate to the access point are capable of key management. See the <i>Cisco IOS Command Reference for Cisco Access Points and Bridges</i> for a detailed description of the <b>encryption mode wep</b> command.</p> <p><b>Note</b> When you configure the cipher TKIP and AES-CCM (not <b>TKIP + WEP 128</b> or <b>TKIP + WEP 40</b>) for an SSID, the SSID must use WPA key management. Client authentication fails on an SSID that uses the cipher TKIP without enabling WPA key management.</p>
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the encryption command to disable a cipher suite.

This example sets up a cipher suite for VLAN 22 that enables AES-CCM, and 128-bit WEP.

```
router# configure terminal
router(config)# interface dot11radio 0
router(config-if)# encryption vlan 22 mode ciphers aes-ccm wep128
router(config-if)# exit
```

## Cipher Suites Compatible with WPA

If you configure your access point to use WPA authenticated key management, you must select a cipher suite compatible with the authenticated key management type. [Table 5-3](#) lists the cipher suites that are compatible with WPA.

Table 5-3 Cipher Suites Compatible with WPA

Authenticated Key Management Types	Compatible Cipher Suites
WPA	<ul style="list-style-type: none"> <li>• encryption mode ciphers aes-ccm</li> <li>• encryption mode ciphers aes-ccm wep128</li> <li>• encryption mode ciphers aes-ccm wep40</li> <li>• encryption mode ciphers aes-ccm tkip</li> <li>• encryption mode ciphers aes-ccm tkip wep128</li> <li>• encryption mode ciphers aes-ccm tkip wep128 wep40</li> <li>• encryption mode ciphers tkip wep128 wep40</li> <li>•</li> </ul>

**Note**

When you configure AES-CCM-only, TKIP-only, or AES-CCM + TKIP cipher TKIP encryption (not including any WEP 40 or WEP 128) on a radio interface or VLAN, every SSID on that radio or VLAN must be set to use the WPA key management. If you configure AES-CCM or TKIP on a radio or VLAN but do not configure key management on the SSIDs, client authentication fails on the SSIDs.

For a complete description of WPA and instructions for configuring authenticated key management, see the [“Using WPA Key Management” section on page 6-6](#).

## Enabling and Disabling Broadcast Key Rotation

Broadcast key rotation is disabled by default.

**Note**

Client devices using static WEP cannot use the access point when you enable broadcast key rotation. When you enable broadcast key rotation, only wireless client devices using 802.1x authentication (such as LEAP, EAP-TLS, or PEAP) can use the access point.

Beginning in privileged EXEC mode, follow these steps to enable broadcast key rotation:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.

	Command	Purpose
Step 3	<b>broadcast-key change</b> <i>seconds</i> [ <i>vlan vlan-id</i> ] [ <b>membership-termination</b> ] [ <b>capability-change</b> ]	<p>Enable broadcast key rotation.</p> <ul style="list-style-type: none"> <li>• Enter the number of seconds between each rotation of the broadcast key.</li> <li>• (Optional) Enter a VLAN for which you want to enable broadcast key rotation.</li> <li>• (Optional) If you enable WPA authenticated key management, you can enable additional circumstances under which the access point changes and distributes the WPA group key. <ul style="list-style-type: none"> <li>– Membership termination—the access point generates and distributes a new group key when any authenticated client device disassociates from the access point. This feature protects the privacy of the group key for associated clients. However, it might generate some overhead if clients on your network roam frequently.</li> <li>– Capability change—the access point generates and distributes a dynamic group key when the last non-key management (static WEP) client disassociates, and it distributes the statically configured WEP key when the first non-key management (static WEP) client authenticates. In WPA migration mode, this feature significantly improves the security of key-management capable clients when there are no static-WEP clients associated to the access point.</li> </ul> </li> </ul> <p>See <a href="#">Chapter 6, “Configuring Authentication Types,”</a> for detailed instructions on enabling authenticated key management.</p>
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the encryption command to disable broadcast key rotation.

This example enables broadcast key rotation on VLAN 22 and sets the rotation interval to 300 seconds:

```
router# configure terminal
router(config)# interface dot11radio 0
router(config-if)# broadcast-key vlan 22 change 300
router(config-ssid)# end
```

## Security Type in Universal Client Mode

### Security

In universal client mode, the security type must be configured exactly as that of the access point it is associating to. For example, if the access point is configured with AES and TKIP encryption, the universal client must also have AES+TKIP in order for the devices to associate properly.

- TKIP
- AES
- TKIP+AES
- WEP 40-bit
- WEP 128-bit

## Universal client configuration

```

!
dot11 ssid test10
    authentication open
    authentication key-management wpa
    wpa-psk ascii 7 11584B5643475D5B5C737B
!
!
interface Dot11Radio0/1/0
    ip address dhcp
    !
    encryption mode ciphers aes-ccm
    !
    ssid test10
    !
    speed basic-1.0 basic-2.0 basic-5.5 6.0 9.0 basic-11.0 12.0 18.0 24.0 36.0 48.0 54.0
    station-role non-root
!
End

```

The access point is configured with AES+TKIP WPA-PSK encryption. The universal client will display the following system message when there is a mismatch in the encryption types during association between the AP and the universal client:

```
%DOT11-4-CANT_ASSOC: Interface Dot11Radio0/1/0, cannot associate: WPAIE invalid multicast suite exp=0x0050F204 act=0x0050F202
```

In this example, the universal client would have the multicast suite of 0x0050F204 (for TKIP) but instead received the multicast suite of 0x0050F202 (for AES+ TKIP). Here are the different scenarios:

- If the universal client is configured for AES WPAv2 (encryption mode ciphers aes-ccm), the access point must be configured for AES WPAv2. The universal client will associate with AES encryption.
- If the universal client is configured for TKIP (encryption mode ciphers tkip) The access point must be configured for either 1. TKIP WPA or 2. TKIP+AES. The universal client will associate with TKIP encryption.
- If the universal client is configured for AES+TKIP (encryption mode ciphers tkip aes) The access point must be configured for TKIP+AES. The universal client will associate with AES encryption.
- If the access point is configured for AES WPAv2 WPAv2 (encryption mode ciphers aes-ccm), and the universal client is configured with TKIP+AES (encryption mode ciphers aes-ccm tkip), you will get a system message stating the multicast suite was not found.

```
%DOT11-4-CANT_ASSOC: Interface Dot11Radio0/1/0, cannot associate: WPAIE not found and required
```

## Debugging

To determine if the universal client has associated to the access point, the user can issue the 'show dot11 association all' command for a detailed output of which access point it was associating to and how it has associated to the access point.

The "show dot11 association" command will have the following output:

```
c2801_uc#
c2801_uc#sh dot11 ass all
Address          : 0015.2b06.17d0      Name           : ap
IP Address       : 200.1.1.1        Interface      : Dot11Radio0/1/0
Device           : ap1200-Parent    Software Version : 12.3
CCX Version      : NONE

State            : Assoc           Parent         : Our Parent
SSID             : test10          VLAN           : 0
Hops to Infra    : 0              Association Id  : 1
Tunnel Address   : 0.0.0.0
Key Mgmt type    : NONE            Encryption     : Off
Current Rate     : 54.0            Capability     : WMM ShortHdr ShortSlot
Supported Rates  : 1.0 2.0 5.5 6.0 9.0 11.0 12.0 18.0 24.0 36.0 48.0 54.0
Signal Strength  : -14 dBm          Connected for  : 236 seconds
Signal Quality   : N/A            Activity Timeout : 15 seconds
Power-save       : Off             Last Activity   : 0 seconds ago

Packets Input    : 2449            Packets Output  : 15
Bytes Input      : 451711          Bytes Output    : 4664
Duplicates Rcvd : 3              Data Retries    : 1
Decrypt Failed   : 0              RTS Retries     : 0
MIC Failed       : 0              MIC Missing     : 0
Packets Redirected: 0            Redirect Filtered: 0

c2801_uc#
```

## Caveats

When the Cisco dot11radio is in the universal client mode and associates to a 3rd party access point, there are some additional caveats. The first is on the "show dot11 association" output. The "Device" area shows a result of "unknown" when associated to a 3rd party access point (non-Cisco). In the example below, a Cisco 876W universal client is associated to a Symbol 4131 Access Point. The "Software Version" and "Name" fields also result in "NONE". This is because the Cisco Aironet messages between Cisco devices carry this information and not between 3rd party and Cisco devices.

Example:

```
c876#sh dot11 assoc

802.11 Client Stations on Dot11Radio0:

SSID [symbol] :

MAC Address   IP address   Device      Name      Parent      State
00a0.f8dc.133a 192.168.1.4  unknown    -         -           Assoc

c876#sh dot11 ass all
Address       : 00a0.f8dc.133a      Name           : NONE
IP Address    : 192.168.1.4       Interface      : Dot11Radio0
Device        : unknown    Software Version : NONE
CCX Version   : NONE

State         : Assoc           Parent         : Our Parent
```

```
SSID                : symbol                VLAN                : 0
Hops to Infra       : -1                   Association Id       : 2
Tunnel Address      : 0.0.0.0
Key Mgmt type       : NONE                  Encryption          : WEP
Current Rate        : 11.0                  Capability          :
Supported Rates     : 1.0 2.0 5.5 11.0
Signal Strength     : -55 dBm
Signal Quality      : N/A
Power-save          : Off
Packets Input       : 408                   Packets Output      : 16
Bytes Input         : 46619                  Bytes Output        : 3495
Duplicates Rcvd    : 2                     Data Retries        : 8
Decrypt Failed     : 0                     RTS Retries         : 0
MIC Failed         : 0                     MIC Missing         : 0
Packets Redirected: 0                     Redirect Filtered   : 0
```

c876#





## Configuring Authentication Types

---

This chapter describes how to configure authentication types on the access point. This chapter contains these sections:

- [Understand Authentication Types, page 6-2](#)
- [Configure Authentication Types, page 6-9](#)
- [Matching Access Point and Client Device Authentication Types, page 6-16](#)

# Understand Authentication Types

This section describes the authentication types that you can configure on the access point. The authentication types are tied to the SSIDs that you configure for the access point. If you want to serve different types of client devices with the same access point, you can configure multiple SSIDs. See [Chapter 3, “Configuring Multiple SSIDs,”](#) for complete instructions on configuring multiple SSIDs.

Before a wireless client device can communicate on your network through the access point, it must authenticate to the access point using open or shared-key authentication. For maximum security, client devices should also authenticate to your network using MAC-address or EAP authentication, authentication types that rely on an authentication server on your network.

**Note**

By default, the access point sends reauthentication requests to the authentication server with the service-type attribute set to `authenticate-only`. However, some Microsoft IAS servers do not support the `authenticate-only` service-type attribute. Changing the service-type attribute to `login-only` ensures that Microsoft IAS servers recognize reauthentication requests from the access point. Use the **`dot11 aaa authentication attributes service-type login-only`** global configuration command to set the service-type attribute in reauthentication requests to `login-only`.

The access point uses several authentication mechanisms or types and can use more than one at the same time. These sections explain each authentication type:

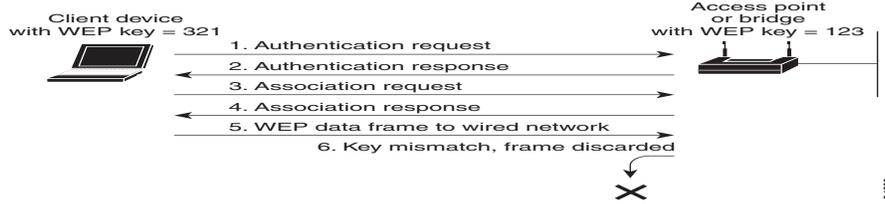
- [Open Authentication to Access Point, page 6-2](#)
- [Shared Key Authentication to Access Point, page 6-3](#)
- [EAP Authentication to Network, page 6-4](#)
- [MAC Address Authentication to the Network, page 6-5](#)
- [Combining MAC-Based, EAP, and Open Authentication, page 6-6](#)
- [Using WPA Key Management, page 6-6](#)
- [Using WPA Key Management, page 6-6](#)

## Open Authentication to Access Point

Open authentication allows any device to authenticate and then attempt to communicate with the access point. Using open authentication, any wireless device can authenticate with the access point, but the device can communicate only if its WEP keys match the access point's. Devices not using WEP do not attempt to authenticate with an access point that is using WEP. Open authentication does not rely on a RADIUS server on your network.

[Figure 6-1](#) shows the authentication sequence between a device trying to authenticate and an access point using open authentication. In this example, the device's WEP key does not match the access point's key, so it can authenticate but not pass data.

**Figure 6-1** Sequence for Open Authentication



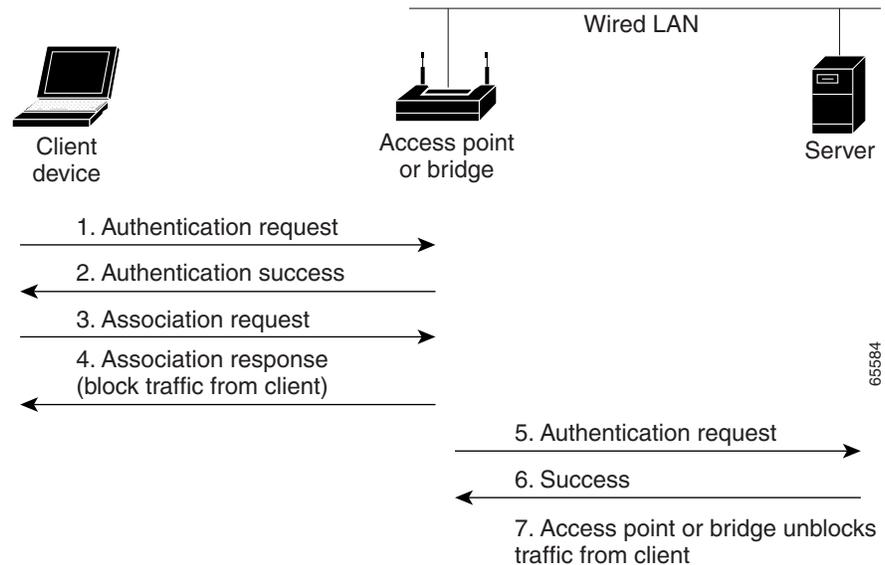
## Shared Key Authentication to Access Point

Cisco provides shared key authentication to comply with the IEEE 802.11b standard. However, because of shared key’s security flaws, Cisco recommends that you avoid using it.

During shared key authentication, the access point sends an unencrypted challenge text string to any device attempting to communicate with the access point. The device requesting authentication encrypts the challenge text and sends it back to the access point. If the challenge text is encrypted correctly, the access point allows the requesting device to authenticate. Both the unencrypted challenge and the encrypted challenge can be monitored, however, which leaves the access point open to attack from an intruder who calculates the WEP key by comparing the unencrypted and encrypted text strings. Because of this weakness, shared key authentication can be less secure than open authentication. Like open authentication, shared key authentication does not rely on a RADIUS server on your network.

Figure 6-2 shows the authentication sequence between a device trying to authenticate and an access point using shared key authentication. In this example the device’s WEP key matches the access point’s key, so it can authenticate and communicate.

**Figure 6-2** Sequence for Shared Key Authentication

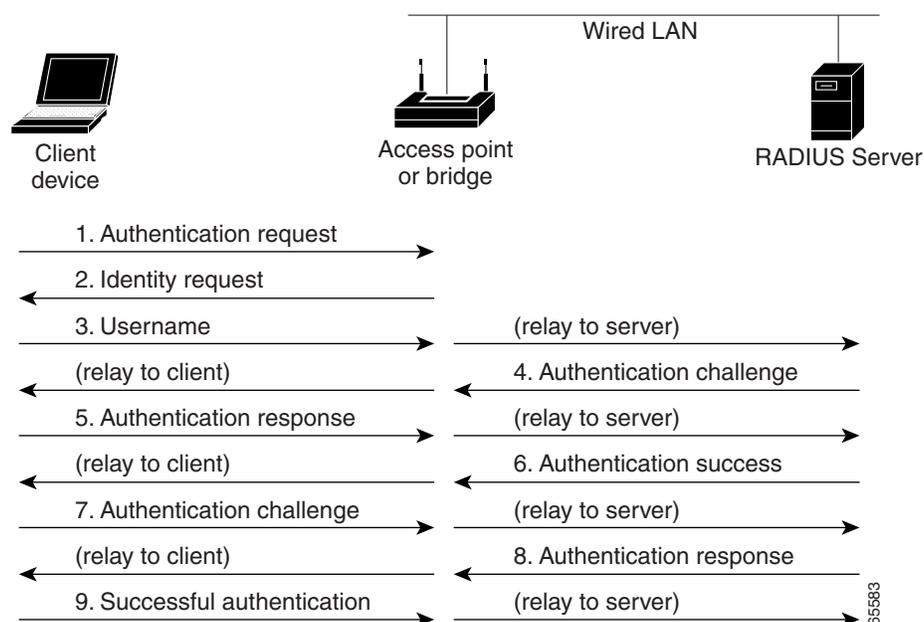


# EAP Authentication to Network

This authentication type provides the highest level of security for your wireless network. By using the Extensible Authentication Protocol (EAP) to interact with an EAP-compatible RADIUS server, the access point helps a wireless client device and the RADIUS server to perform mutual authentication and derive a dynamic unicast WEP key. The RADIUS server sends the WEP key to the access point, which uses it for all unicast data signals that it sends to or receives from the client. The access point also encrypts its broadcast WEP key (entered in the access point's WEP key slot 1) with the client's unicast key and sends it to the client.

When you enable EAP on your access points and client devices, authentication to the network occurs in the sequence shown in Figure 6-3:

**Figure 6-3** Sequence for EAP Authentication



In Steps 1 through 9 in Figure 6-3, a wireless client device and a RADIUS server on the wired LAN use 802.1x and EAP to perform a mutual authentication through the access point. The RADIUS server sends an authentication challenge to the client. The client uses a one-way encryption of the user-supplied password to generate a response to the challenge and sends that response to the RADIUS server. Using information from its user database, the RADIUS server creates its own response and compares that to the response from the client. When the RADIUS server authenticates the client, the process repeats in reverse, and the client authenticates the RADIUS server.

When mutual authentication is complete, the RADIUS server and the client determine a WEP key that is unique to the client and provides the client with the appropriate level of network access, thereby approximating the level of security in a wired switched segment to an individual desktop. The client loads this key and prepares to use it for the logon session.

During the logon session, the RADIUS server encrypts and sends the WEP key, called a *session key*, over the wired LAN to the access point. The access point encrypts its broadcast key with the session key and sends the encrypted broadcast key to the client, which uses the session key to decrypt it. The client and access point activate WEP and use the session and broadcast WEP keys for all communications during the remainder of the session.

There is more than one type of EAP authentication, but the access point behaves the same way for each type: it relays authentication messages from the wireless client device to the RADIUS server and from the RADIUS server to the wireless client device. See the [“Assigning Authentication Types to an SSID” section on page 6-9](#) for instructions on setting up EAP on the access point.

**Note**

If you use EAP authentication, you can select open or shared key authentication, but you don't have to. EAP authentication controls authentication both to your access point and to your network.

## MAC Address Authentication to the Network

The access point relays the MAC address of the wireless client device to a RADIUS server on your network, and the server checks the address against a list of allowed MAC addresses. Intruders can create counterfeit MAC addresses, so MAC-based authentication is less secure than EAP authentication. However, MAC-based authentication provides an alternate authentication method for client devices that do not have EAP capability. See the [“Assigning Authentication Types to an SSID” section on page 6-9](#) for instructions on enabling MAC-based authentication.

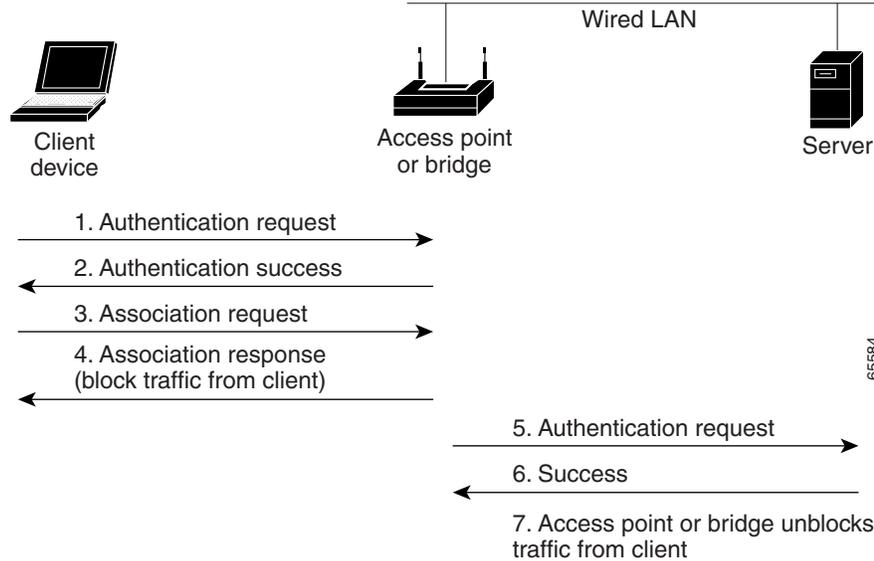
**Tip**

If you don't have a RADIUS server on your network, you can create a list of allowed MAC addresses on the access point's Advanced Security: MAC Address Authentication page. Devices with MAC addresses not on the list are not allowed to authenticate.

**Tip**

If MAC-authenticated clients on your wireless LAN roam frequently, you can enable a MAC authentication cache on your access points. MAC authentication caching reduces overhead because the access point authenticates devices in its MAC-address cache without sending the request to your authentication server. See the [“Configuring MAC Authentication Caching” section on page 6-14](#) for instructions on enabling this feature.

[Figure 6-4](#) shows the authentication sequence for MAC-based authentication.

**Figure 6-4** Sequence for MAC-Based Authentication

## Combining MAC-Based, EAP, and Open Authentication

You can set up the access point to authenticate client devices using a combination of MAC-based and EAP authentication. When you enable this feature, client devices that associate to the access point using 802.11 open authentication first attempt MAC authentication; if MAC authentication succeeds, the client device joins the network. If MAC authentication fails, the access point waits for the client device to attempt EAP authentication. See the “[Assigning Authentication Types to an SSID](#)” section on page 6-9 for instructions on setting up this combination of authentications.

## Using WPA Key Management

Wi-Fi Protected Access is a standards-based, interoperable security enhancement that strongly increases the level of data protection and access control for existing and future wireless LAN systems. It is derived from and will be forward-compatible with the upcoming IEEE 802.11i standard. WPA leverages AES-CCM and TKIP (Temporal Key Integrity Protocol) for data protection and 802.1X for authenticated key management.

WPA key management supports two mutually exclusive management types: WPA and WPA-Pre-shared key (WPA-PSK). Using WPA key management, clients and the authentication server authenticate to each other using an EAP authentication method, and the client and server generate a pairwise master key (PMK). Using WPA, the server generates the PMK dynamically and passes it to the access point. Using WPA-PSK, however, you configure a pre-shared key on both the client and the access point, and that pre-shared key is used as the PMK.



### Note

In Cisco IOS releases 12.3(4)JA and later, you cannot enable both MAC-address authentication and WPA-PSK.



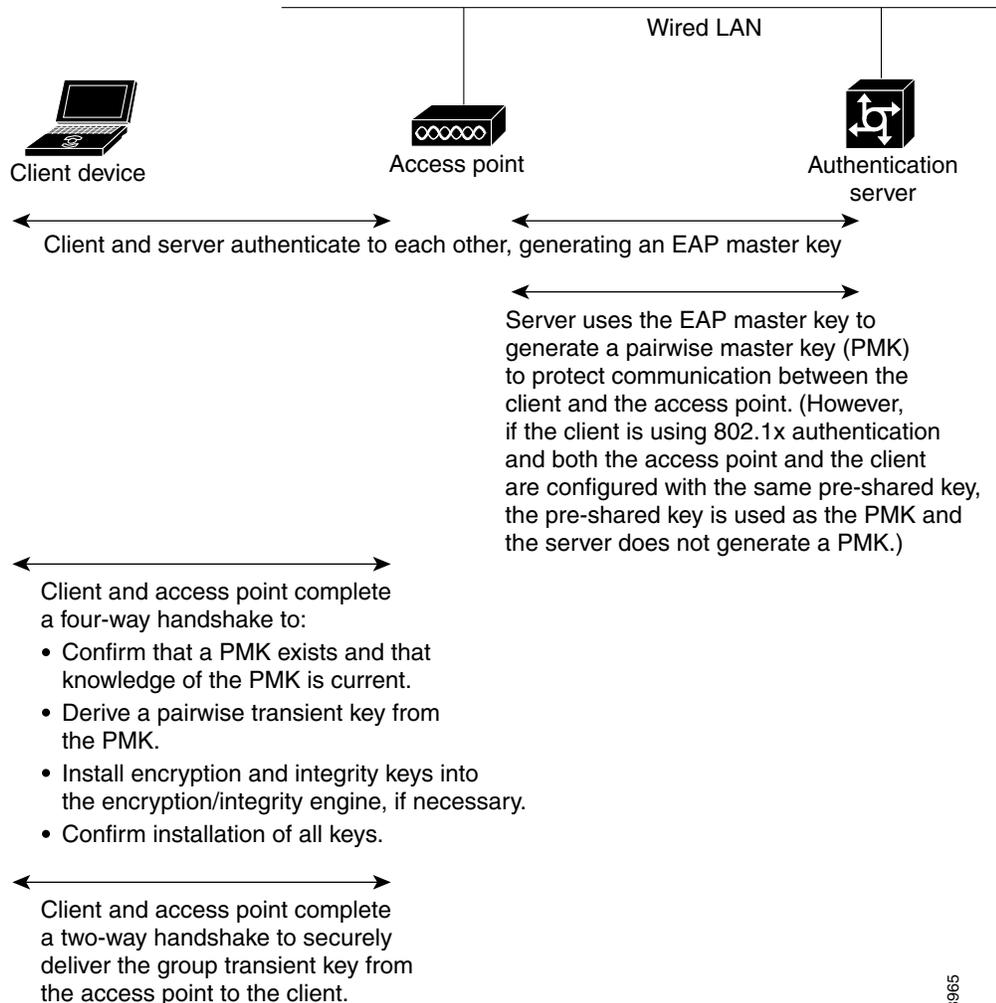
**Note**

Unicast and multicast cipher suites advertised in WPA information element (and negotiated during 802.11 association) may potentially mismatch with the cipher suite supported in an explicitly assigned VLAN. If the RADIUS server assigns a new vlan ID which uses a different cipher suite from the previously negotiated cipher suite, there is no way for the access point and client to switch back to the new cipher suite. Currently, the WPA protocol does not allow the cipher suite to be changed after the initial 802.11 cipher negotiation phase. In this scenario, the client device is disassociated from the wireless LAN.

See the “[Assigning Authentication Types to an SSID](#)” section on page 6-9 for instructions on configuring WPA key management on your access point.

Figure 6-5 shows the WPA key management process.

**Figure 6-5 WPA Key Management Process**



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## Software and Firmware Requirements for WPA and WPA-TKIP

Table 6-1 lists the firmware and software requirements required on access points and Cisco client devices to support WPA key management and WPA-TKIP encryption protocols.

To support the security combinations in Table 6-1, your access points and client devices must run the following software and firmware versions:

- Cisco IOS Release 12.4(2)T or later on access points
- Install Wizard version 1.2 for 340, 350, and CB20A client devices, which includes these components:
  - PC, LM, and PCI card driver version 8.4
  - Mini PCI and PC-cardbus card driver version 3.7
  - Aironet Client Utility (ACU) version 6.2
  - Client firmware version 5.30.13

**Table 6-1** Software and Firmware Requirements for WPA and WPA-TKIP

Key Management and Encryption Protocol	Third Party Host Supplicant <sup>1</sup> Required?	Supported Platform Operating Systems
LEAP with WPA-TKIP	No	Windows XP and 2000
LEAP with WPA	No	Windows XP and 2000
Host-based EAP (such as PEAP, EAP-SIM, and EAP-TLS) with WPA	No <sup>2</sup>	Windows XP
Host-based EAP (such as PEAP, EAP-SIM, and EAP-TLS) with WPA	Yes	Windows 2000
WPA-PSK Mode	No <sup>2</sup>	Windows XP
WPA-PSK Mode	Yes	Windows 2000

1. Such as Funk Odyssey Client supplicant version 2.2 or Meetinghouse Data Communications Aegis Client version 2.1.

2. Windows XP does not require a third-party supplicant, but you must install Windows XP Service Pack 1 and Microsoft support patch 815485.



### Note

When you configure AES-CCM and **TKIP-only** cipher encryption (not **TKIP + WEP 128** or **TKIP + WEP 40**) on any radio interface or VLAN, every SSID on that radio or VLAN must be set to use WPA key management. If you configure TKIP on a radio or VLAN but you do not configure key management on the SSIDs, client authentication fails on the SSIDs.

# Configure Authentication Types

This section describes how to configure authentication types. You attach configuration types to the access point's SSIDs. See [Chapter 3, “Configuring Multiple SSIDs,”](#) for details on setting up multiple SSIDs. This section contains these topics:

- [Assigning Authentication Types to an SSID, page 6-9](#)
- [Configuring Authentication Holdoffs, Timeouts, and Intervals, page 6-15](#)

## Assigning Authentication Types to an SSID

Beginning in privileged EXEC mode, follow these steps to configure authentication types for SSIDs:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>dot11 ssid <i>ssid-string</i></code>	Create an SSID and enter SSID configuration mode for the new SSID. The SSID can consist of up to 32 alphanumeric characters. SSIDs are case sensitive.

Command	Purpose
<b>Step 3</b> <b>authentication open</b> <b>[mac-address list-name [alternate]]</b> <b>[[optional] eap list-name]</b>	<p>(Optional) Set the authentication type to open for this SSID. Open authentication allows any device to authenticate and then attempt to communicate with the access point.</p> <p> <b>Note</b> The following EAP methods are supported: EAP-MD5, EAP_SIM, EAP-TTLS, EAP-LEAP, EAP-PEAP (v0 and v1), EAP-TLS, AND EAP-FAST.</p> <ul style="list-style-type: none"> <li>(Optional) Set the SSID authentication type to open with MAC address authentication. The access point forces all client devices to perform MAC-address authentication before they are allowed to join the network. For <i>list-name</i>, specify the authentication method list. Click this link for more information on method lists:  <a href="http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgr/fsecur_c/fsaaa/scfathen.htm#xtocid2">http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgr/fsecur_c/fsaaa/scfathen.htm#xtocid2</a>            Use the <b>alternate</b> keyword to allow client devices to join the network using either MAC or EAP authentication; clients that successfully complete either authentication are allowed to join the network.</li> <li>(Optional) Set the SSID authentication type to open with EAP authentication. The access point forces all client devices to perform EAP authentication before they are allowed to join the network. For <i>list-name</i>, specify the authentication method list.            Use the <b>optional</b> keyword to allow client devices using either open or EAP authentication to associate and become authenticated. This setting is used mainly by service providers that require special client accessibility.</li> </ul> <p><b>Note</b> An access point configured for EAP authentication forces all client devices that associate to perform EAP authentication. Client devices that do not use EAP cannot use the access point.</p>

	Command	Purpose
Step 4	<b>authentication shared</b> [mac-address <i>list-name</i> ] [eap <i>list-name</i> ]	<p>(Optional) Set the authentication type for the SSID to shared key.</p> <p><b>Note</b> Because of shared key's security flaws, Cisco recommends that you avoid using it.</p> <p><b>Note</b> You can assign shared key authentication to only one SSID.</p> <ul style="list-style-type: none"> <li>(Optional) Set the SSID's authentication type to shared key with MAC address authentication. For <i>list-name</i>, specify the authentication method list.</li> <li>(Optional) Set the SSID's authentication type to shared key with EAP authentication. For <i>list-name</i>, specify the authentication method list.</li> </ul>
Step 5	<b>authentication network-eap</b> <i>list-name</i> [mac-address <i>list-name</i> ]	<p>(Optional) Set the authentication type for the SSID to Network-EAP. Using the Extensible Authentication Protocol (EAP) to interact with an EAP-compatible RADIUS server, the access point helps a wireless client device and the RADIUS server to perform mutual authentication and derive a dynamic unicast WEP key. However, the access point does not force all client devices to perform EAP authentication.</p> <ul style="list-style-type: none"> <li>(Optional) Set the SSID's authentication type to Network-EAP with MAC address authentication. All client devices that associate to the access point are required to perform MAC-address authentication. For <i>list-name</i>, specify the authentication method list.</li> </ul>
Step 6	<b>authentication key-management</b> { [wpa]} [ optional ]	<p>(Optional) Set the authentication type for the SSID to WPA. If you use the <b>optional</b> keyword, client devices other than WPA clients can use this SSID. If you do not use the <b>optional</b> keyword, only WPA client devices are allowed to use the SSID.</p> <p>When Network EAP is enabled for an SSID, client devices using LEAP, EAP-FAST, PEAP/GTC, MSPEAP, and EAP-TLS can authenticate using the SSID.</p> <p>To enable WPA for an SSID, you must also enable Open authentication or Network-EAP or both.</p> <p><b>Note</b> Before you can enable WPA, you must set the encryption mode for the SSID's VLAN to one of the cipher suite options. See the <a href="#">“Configure Encryption Types” section on page 5-3</a> for instructions on configuring the VLAN encryption mode.</p> <p><b>Note</b> If you enable WPA for an SSID without a pre-shared key, the key management type is WPA. If you enable WPA with a pre-shared key, the key management type is WPA-PSK. See the <a href="#">“Configuring Additional WPA Settings” section on page 6-13</a> for instructions on configuring a pre-shared key.</p>

	Command	Purpose
Step 7	<b>end</b>	Return to privileged EXEC mode.
Step 8	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the SSID commands to disable the SSID or to disable SSID features.

This example sets the authentication type for the SSID *batman* to Network-EAP authenticated key management. Client devices using the *batman* SSID authenticate using the *adam* server list.

```
router# configure terminal
router(config)# interface dot11radio 0
router(config-if)# ssid batman
router(config-ssid)# authentication network-eap adam
router(config-ssid)# authentication key-management optional
router(config-ssid)# end
```

## Configuring WPA Migration Mode

WPA migration mode allows these client device types to associate to the access point using the same SSID:

- WPA clients capable of AES-CCM, TKIP and authenticated key management
- 802.1X-2001 clients (such as legacy LEAP clients and clients using TLS) capable of authenticated key management but not TKIP
- Static-WEP clients not capable of TKIP or authenticated key management

If all three client types associate using the same SSID, the multicast cipher suite for the SSID must be WEP. If only the first two types of clients use the same SSID the multicast key can be dynamic, but if the static-WEP clients use the SSID, the key must be static. The access point can switch automatically between a static and a dynamic group key to accommodate associated client devices. To support all three types of clients on the same SSID, you must configure the static key in key slots 2 or 3.

To set up an SSID for WPA migration mode, configure these settings:

- WPA optional
- A cipher suite containing TKIP and 40-bit or 128-bit WEP
- A static WEP key in key slot 2 or 3

This example sets the SSID migrate for WPA migration mode:

```
router# configure terminal
router(config)# interface dot11radio 0
router(config-if)# encryption mode cipher tkip wep128
router(config-if)# encryption key 3 size 128 12345678901234567890123456 transmit-key
router(config-if)# ssid migrate
router(config-ssid)# authentication open
router(config-ssid)# authentication network-eap adam
router(config-ssid)# authentication key-management wpa optional
router(config-ssid)# wpa-psk ascii batmobile65
router(config-ssid)# exit
```

## Configuring Additional WPA Settings

Use two optional settings to configure a pre-shared key on the access point and adjust the frequency of group key updates.

### Setting a Pre-Shared Key

To support WPA on a wireless LAN where 802.1x-based authentication is not available, you must configure a pre-shared key on the access point. You can enter the pre-shared key as ASCII or hexadecimal characters. If you enter the key as ASCII characters, you enter between 8 and 63 characters, and the access point expands the key using the process described in the *Password-based Cryptography Standard* (RFC2898). If you enter the key as hexadecimal characters, you must enter 64 hexadecimal characters.

### Configuring Group Key Updates

In the last step in the WPA process, the access point distributes a group key to the authenticated client device. You can use these optional settings to configure the access point to change and distribute the group key based on client association and disassociation:

- **Membership termination**—the access point generates and distributes a new group key when any authenticated device disassociates from the access point. This feature keeps the group key private for associated devices, but it might generate some overhead traffic if clients on your network roam frequently among access points.
- **Capability change**—the access point generates and distributes a dynamic group key when the last non-key management (static WEP) client disassociates, and it distributes the statically configured WEP key when the first non-key management (static WEP) client authenticates. In WPA migration mode, this feature significantly improves the security of key-management capable clients when there are no static-WEP clients associated to the access point.

Beginning in privileged EXEC mode, follow these steps to configure a WPA pre-shared key and group key update options:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio { 0   1 }</code>	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 3	<code>ssid ssid-string</code>	Enter SSID configuration mode for the SSID.
Step 4	<code>wpa-psk { hex   ascii } [ 0   7 ] encryption-key</code>	Enter a pre-shared key for client devices using WPA that also use static WEP keys.  Enter the key using either hexadecimal or ASCII characters. If you use hexadecimal, you must enter 64 hexadecimal characters to complete the 256-bit key. If you use ASCII, you must enter a minimum of 8 letters, numbers, or symbols, and the access point expands the key for you. You can enter a maximum of 63 ASCII characters.
Step 5	<code>end</code>	Return to privileged EXEC mode.

	Command	Purpose
Step 6	<b>broadcast-key</b> [ vlan <i>vlan-id</i> ] { <b>change</b> <i>seconds</i> } [ <b>membership-termination</b> ] [ <b>capability-change</b> ]	Use the <b>broadcast key rotation</b> command to configure additional updates of the WPA group key.
Step 7	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

This example shows how to configure a pre-shared key for clients using WPA and static WEP, with group key update options:

```
ap# configure terminal
ap(config)# interface dot11radio 0
ap(config-if)# ssid batman
ap(config-ssid)# wpa-psk ascii batmobile65
ap(config-ssid)# exit
ap(config-if)# exit
ap(config)# broadcast-key vlan 87 membership-termination capability-change
```

## Configuring MAC Authentication Caching

If MAC-authenticated clients on your wireless LAN roam frequently, you can enable a MAC authentication cache on your access points. MAC authentication caching reduces overhead because the access point authenticates devices in its MAC-address cache without sending the request to your authentication server. When a client device completes MAC authentication to your authentication server, the access point adds the client's MAC address to the cache.

Beginning in privileged EXEC mode, follow these steps to enable MAC authentication caching:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>dot11 aaa authentication mac-authen filter-cache</b> [ <i>timeout seconds</i> ]	Enable MAC authentication caching on the access point. Use the <b>timeout</b> option to configure a timeout value for MAC addresses in the cache. Enter a value from 30 to 65555 seconds. The default value is 1800 (30 minutes). When you enter a timeout value, MAC-authentication caching is enabled automatically.
Step 3	<b>exit</b>	Return to privileged EXEC mode.
Step 4	<b>show dot11 aaa authentication mac-authen filter-cache</b> [ <i>address</i> ]	Show entries in the MAC-authentication cache. Include client MAC addresses to show entries for specific clients.
Step 5	<b>clear dot11 aaa authentication mac-authen filter-cache</b> [ <i>address</i> ]	Clear all entries in the cache. Include client MAC addresses to clear specific clients from the cache.
Step 6	<b>end</b>	Return to privileged EXEC mode.
Step 7	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the **dot11 aaa mac-authen filter-cache** command to disable MAC authentication caching. This example shows how to enable MAC authentication caching with a one-hour timeout:

```
ap# configure terminal
ap(config)# dot11 aaa authentication mac-authen filter-cache timeout 3600
ap(config)# end
```

## Configuring Authentication Holdoffs, Timeouts, and Intervals

Beginning in privileged EXEC mode, follow these steps to configure holdoff times, reauthentication periods, and authentication timeouts for client devices authenticating through your access point:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>dot11 holdoff-time</b> <i>seconds</i>	Enter the number of seconds a client device must wait before it can reattempt to authenticate following a failed authentication. The holdoff time is invoked when a client fails three login attempts or fails to respond to three authentication requests from the access point. Enter a value from 1 to 65555 seconds.
Step 3	<b>interface dot11radio</b> { <b>0</b>   <b>1</b> }	Enter interface configuration mode for the radio interface. The 2.4-GHz radio is radio 0, and the 5-GHz radio is radio 1.
Step 4	<b>dot1x client-timeout</b> <i>seconds</i>	Enter the number of seconds the access point should wait for a reply from a client attempting to authenticate before the authentication fails. Enter a value from 1 to 65555 seconds.
Step 5	<b>dot1x reauth-period</b> { <i>seconds</i>   <b>server</b> }	<p>Enter the interval in seconds that the access point waits before forcing an authenticated client to reauthenticate.</p> <p>Enter the <b>server</b> keyword to configure the access point to use the reauthentication period specified by the authentication server. If you use this option, configure your authentication server with RADIUS attribute 27, Session-Timeout. This attribute sets the maximum number of seconds of service to be provided to the client before termination of the session or prompt. The server sends this attribute to the access point when a client device performs EAP authentication.</p> <p><b>Note</b> If you configure both MAC address authentication and EAP authentication for an SSID, the server sends the Session-Timeout attribute for both MAC and EAP authentications for a client device. The access point uses the Session-Timeout attribute for the last authentication that the client performs. For example, if a client performs MAC address authentication and then performs EAP authentication, the access point uses the server's Session-Timeout value for the EAP authentication. To avoid confusion on which Session-Timeout attribute is used, configure the same Session-Timeout value on your authentication server for both MAC and EAP authentication.</p>

	Command	Purpose
Step 6	<code>countermeasure tkip hold-time seconds</code>	Configure a TKIP MIC failure holdtime. If the access point detects two MIC failures within 60 seconds, it blocks all the TKIP clients on that interface for the holdtime period.
Step 7	<code>end</code>	Return to privileged EXEC mode.
Step 8	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

Use the **no** form of these commands to reset the values to default settings.

## Matching Access Point and Client Device Authentication Types

To use the authentication types described in this section, the access point authentication settings must match the authentication settings on the client adapters that associate to the access point. Refer to the *Cisco Aironet Wireless LAN Client Adapters Installation and Configuration Guide for Windows* for instructions on setting authentication types on wireless client adapters. Refer to [Chapter 5, “Configuring Encryption Types,”](#) for instructions on configuring encryption on the access point.

[Table 6-2](#) lists the client and access point settings required for each authentication type.



### Note

Some non-Cisco client adapters do not perform 802.1x authentication to the access point unless you configure **Open authentication with EAP**. To allow both the Cisco access point clients using LEAP and non-Cisco clients using LEAP to associate using the same SSID, you might need to configure the SSID for both **Network EAP** authentication and **Open authentication with EAP**.

**Table 6-2** Client and Access Point Security Settings

Security Feature	Client Setting	Access Point Setting
Static WEP with open authentication	Create a WEP key and enable Use Static WEP Keys and Open Authentication	Set up and enable WEP and enable Open Authentication for the SSID
Static WEP with shared key authentication	Create a WEP key and enable Use Static WEP Keys and Shared Key Authentication	Set up and enable WEP and enable Shared Key Authentication for the SSID
LEAP authentication	Enable LEAP	Set up and enable WEP and enable Network-EAP for the SSID <sup>1</sup>
EAP-FAST authentication	Enable EAP-FAST and enable automatic provisioning or import a PAC file	Set up and enable WEP and enable Network-EAP for the SSID <sup>1</sup>

Table 6-2 Client and Access Point Security Settings (continued)

Security Feature	Client Setting	Access Point Setting
EAP-FAST authentication with WPA	<p>Enable EAP-FAST and Wi-Fi Protected Access (WPA) and enable automatic provisioning or import a PAC file.</p> <p>To allow the client to associate to both WPA and non-WPA access points, enable Allow Association to both WPA and non-WPA authenticators.</p>	<p>Select a cipher suite that includes TKIP, set up and enable WEP, and enable Network-EAP and WPA for the SSID.</p> <p><b>Note</b> To allow both WPA and non-WPA clients to use the SSID, enable optional WPA.</p>
802.1x authentication	Enable LEAP	Select a cipher suite and enable Network-EAP for the SSID
802.1x authentication and WPA	Enable any 802.1x authentication method	<p>Select a cipher suite and enable Open authentication and WPA for the SSID (you can also enable Network-EAP authentication in addition to or instead of Open authentication)</p> <p><b>Note</b> To allow both WPA clients and non-WPA clients to use the SSID, enable optional WPA.</p>
802.1x authentication and WPA-PSK	Enable any 802.1x authentication method	<p>Select a cipher suite and enable Open authentication and WPA for the SSID (you can also enable Network-EAP authentication in addition to or instead of Open authentication). Enter a WPA pre-shared key.</p> <p><b>Note</b> To allow both WPA clients and non-WPA clients to use the SSID, enable optional WPA.</p>
EAP-TLS authentication		
If using ACU to configure card	Enable Host Based EAP and Use Dynamic WEP Keys in ACU and select Enable network access control using IEEE 802.1X and Smart Card or Other Certificate as the EAP Type in Windows 2000 (with Service Pack 3) or Windows XP	Set up and enable WEP and enable EAP and Open authentication for the SSID
If using Windows XP to configure card	Select Enable network access control using IEEE 802.1X and Smart Card or other Certificate as the EAP Type	Set up and enable WEP and enable EAP and Open Authentication for the SSID

**Table 6-2 Client and Access Point Security Settings (continued)**

Security Feature	Client Setting	Access Point Setting
<b>EAP-MD5 authentication</b>		
If using ACU to configure card	Create a WEP key, enable Host Based EAP, and enable Use Static WEP Keys in ACU and select Enable network access control using IEEE 802.1X and MD5-Challenge as the EAP Type in Windows 2000 (with Service Pack 3) or Windows XP	Set up and enable WEP and enable EAP and Open authentication for the SSID
If using Windows XP to configure card	Select Enable network access control using IEEE 802.1X and MD5-Challenge as the EAP Type	Set up and enable WEP and enable EAP and Open Authentication for the SSID
<b>PEAP authentication</b>		
If using ACU to configure card	Enable Host Based EAP and Use Dynamic WEP Keys in ACU and select Enable network access control using IEEE 802.1X and PEAP as the EAP Type in Windows 2000 (with Service Pack 3) or Windows XP	Set up and enable WEP and enable EAP and Open authentication for the SSID
If using Windows XP to configure card	Select Enable network access control using IEEE 802.1X and PEAP as the EAP Type	Set up and enable WEP and enable Require EAP and Open Authentication for the SSID
<b>EAP-SIM authentication</b>		
If using ACU to configure card	Enable Host Based EAP and Use Dynamic WEP Keys in ACU and select Enable network access control using IEEE 802.1X and SIM Authentication as the EAP Type in Windows 2000 (with Service Pack 3) or Windows XP	Set up and enable WEP with full encryption and enable EAP and Open authentication for the SSID
If using Windows XP to configure card	Select Enable network access control using IEEE 802.1X and SIM Authentication as the EAP Type	Set up and enable WEP with full encryption and enable Require EAP and Open Authentication for the SSID

1.



## Configuring RADIUS Servers

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This chapter describes how to enable and configure the Remote Authentication Dial-In User Service (RADIUS), that provides detailed accounting information and flexible administrative control over authentication and authorization processes. RADIUS is facilitated through AAA and can be enabled only through AAA commands.



**Note**

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You can configure your access point as a local authenticator to provide a backup for your main server or to provide authentication service on a network without a RADIUS server. See [Chapter 6, “Configuring Authentication Types,”](#) for detailed instructions on configuring your access point as a local authenticator.

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**Note**

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For complete syntax and usage information for the commands used in this chapter, refer to the *Cisco IOS Security Command Reference for Release 12.2*.

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# Configuring and Enabling RADIUS

This section describes how to configure and enable RADIUS. These sections describe RADIUS configuration:

- [Understanding RADIUS, page 7-2](#)
- [RADIUS Operation, page 7-3](#)
- [Configuring RADIUS, page 7-4](#)
- [Displaying the RADIUS Configuration, page 7-17](#)
- [RADIUS Attributes Sent by the Access Point, page 7-18](#)

## Understanding RADIUS

RADIUS is a distributed client/server system that secures networks against unauthorized access. RADIUS clients run on supported Cisco devices and send authentication requests to a central RADIUS server, which contains all user authentication and network service access information. The RADIUS host is normally a multiuser system running RADIUS server software from Cisco (Cisco Secure Access Control Server version 3.0), Livingston, Merit, Microsoft, or another software provider. For more information, refer to the RADIUS server documentation.

Use RADIUS in these network environments, which require access security:

- Networks with multiple-vendor access servers, each supporting RADIUS. For example, access servers from several vendors use a single RADIUS server-based security database. In an IP-based network with multiple vendors' access servers, dial-in users are authenticated through a RADIUS server that is customized to work with the Kerberos security system.
- Turnkey network security environments in which applications support the RADIUS protocol, such as an access environment that uses a *smart card* access control system. In one case, RADIUS has been used with Enigma's security cards to validate users and to grant access to network resources.
- Networks already using RADIUS. You can add a Cisco access point containing a RADIUS client to the network.
- Networks that require resource accounting. You can use RADIUS accounting independently of RADIUS authentication or authorization. The RADIUS accounting functions allow data to be sent at the start and end of services, showing the amount of resources (such as time, packets, bytes, and so forth) used during the session. An Internet service provider might use a freeware-based version of RADIUS access control and accounting software to meet special security and billing needs.

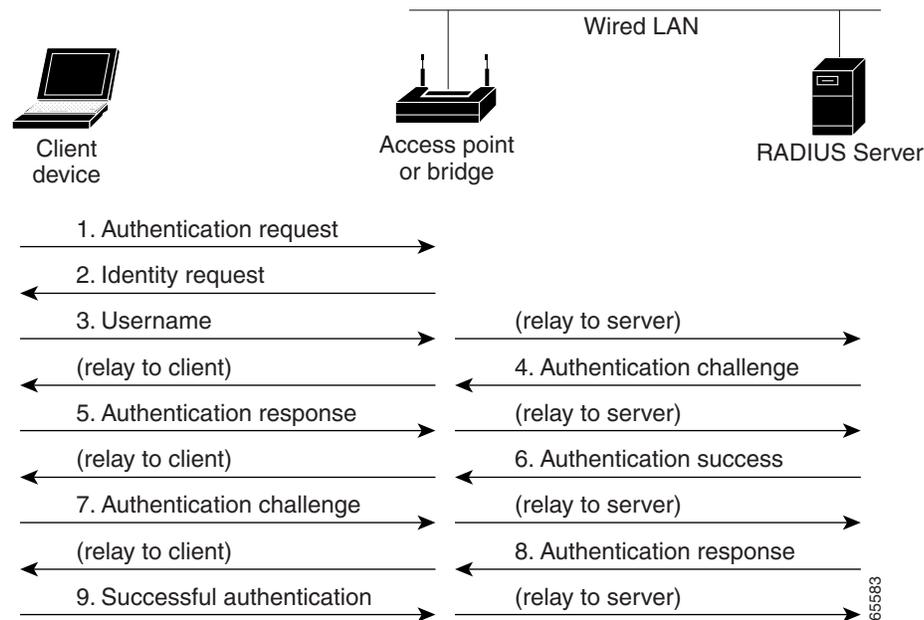
RADIUS is not suitable in these network security situations:

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

## RADIUS Operation

When a wireless user attempts to log in and authenticate to an access point whose access is controlled by a RADIUS server, authentication to the network occurs in the steps shown in [Figure 7-1](#):

**Figure 7-1** Sequence for EAP Authentication



In Steps 1 through 9 in [Figure 7-1](#), a wireless client device and a RADIUS server on the wired LAN use 802.1x and EAP to perform a mutual authentication through the access point. The RADIUS server sends an authentication challenge to the client. The client uses a one-way encryption of the user-supplied password to generate a response to the challenge and sends that response to the RADIUS server. Using information from its user database, the RADIUS server creates its own response and compares that to the response from the client. When the RADIUS server authenticates the client, the process repeats in reverse, and the client authenticates the RADIUS server.

When mutual authentication is complete, the RADIUS server and the client determine a WEP key that is unique to the client and provides the client with the appropriate level of network access, thereby approximating the level of security in a wired switched segment to an individual desktop. The client loads this key and prepares to use it for the logon session.

During the logon session, the RADIUS server encrypts and sends the WEP key, called a *session key*, over the wired LAN to the access point. The access point encrypts its broadcast key with the session key and sends the encrypted broadcast key to the client, which uses the session key to decrypt it. The client and access point activate WEP and use the session and broadcast WEP keys for all communications during the remainder of the session.

There is more than one type of EAP authentication, but the access point behaves the same way for each type: it relays authentication messages from the wireless client device to the RADIUS server and from the RADIUS server to the wireless client device. See the [“Assigning Authentication Types to an SSID” section on page 6-9](#) for instructions on setting up client authentication using a RADIUS server.

## Configuring RADIUS

This section describes how to configure your access point to support RADIUS. At a minimum, you must identify the host or hosts that run the RADIUS server software and define the method lists for RADIUS authentication. You can optionally define method lists for RADIUS authorization and accounting.

A method list defines the sequence and methods to be used to authenticate, to authorize, or to keep accounts on a user. You can use method lists to designate one or more security protocols to be used, thus ensuring a backup system if the initial method fails. The software uses the first method listed to authenticate, to authorize, or to keep accounts on users; if that method does not respond, the software selects the next method in the list. This process continues until there is successful communication with a listed method or the method list is exhausted.

You should have access to and should configure a RADIUS server before configuring RADIUS features on your access point.

This section contains this configuration information:

- [Default RADIUS Configuration, page 7-4](#)
- [Identifying the RADIUS Server Host, page 7-5](#) (required)
- [Configuring RADIUS Login Authentication, page 7-7](#) (required)
- [Defining AAA Server Groups, page 7-9](#) (optional)
- [Configuring RADIUS Authorization for User Privileged Access and Network Services, page 7-11](#) (optional)
- [Starting RADIUS Accounting, page 7-12](#) (optional)
- [Selecting the CSID Format, page 7-13](#) (optional)
- [Configuring Settings for All RADIUS Servers, page 7-13](#) (optional)
- [Configuring the Access Point to Use Vendor-Specific RADIUS Attributes, page 7-14](#) (optional)
- [Configuring the Access Point for Vendor-Proprietary RADIUS Server Communication, page 7-15](#) (optional)
- [Configuring WISPr RADIUS Attributes, page 7-16](#) (optional)

**Note**

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The RADIUS server CLI commands are disabled until you enter the **aaa new-model** command.

---

### Default RADIUS Configuration

RADIUS and AAA are disabled by default.

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

## Identifying the RADIUS Server Host

Access point-to-RADIUS-server communication involves several components:

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

You identify RADIUS security servers by their host name or IP address, host name and specific UDP port numbers, or their IP address and specific UDP port numbers. The combination of the IP address and the UDP port number creates a unique identifier allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. This unique identifier enables RADIUS requests to be sent to multiple UDP ports on a server at the same IP address.

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

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

The timeout, retransmission, and encryption key values can be configured globally per server for all RADIUS servers or in some combination of global and per-server settings. To apply these settings globally to all RADIUS servers communicating with the access point, use the three unique global configuration commands: **radius-server timeout**, **radius-server retransmit**, and **radius-server key**. To apply these values on a specific RADIUS server, use the **radius-server host** global configuration command.



### Note

If you configure both global and per-server functions (timeout, retransmission, and key commands) on the access point, the per-server timer, retransmission, and key value commands override global timer, retransmission, and key value commands. For information on configuring these setting on all RADIUS servers, see the [“Configuring Settings for All RADIUS Servers”](#) section on page 7-13.

You can configure the access point to use AAA server groups to group existing server hosts for authentication. For more information, see the [“Defining AAA Server Groups”](#) section on page 7-9.

Beginning in privileged EXEC mode, follow these steps to configure per-server RADIUS server communication. This procedure is required.

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>aaa new-model</b>	Enable AAA.

Command	Purpose
<p><b>Step 3</b> <b>radius-server host</b> {<i>hostname</i>   <i>ip-address</i>} [<b>auth-port</b> <i>port-number</i>] [<b>acct-port</b> <i>port-number</i>] [<b>timeout</b> <i>seconds</i>] [<b>retransmit</b> <i>retries</i>] [<b>key</b> <i>string</i>]</p>	<p>Specify the IP address or host name of the remote RADIUS server host.</p> <ul style="list-style-type: none"> <li>• (Optional) For <b>auth-port</b> <i>port-number</i>, specify the UDP destination port for authentication requests. (Optional) For <b>acct-port</b> <i>port-number</i>, specify the UDP destination port for accounting requests.</li> <li>• (Optional) For <b>timeout</b> <i>seconds</i>, specify the time interval that the access point waits for the RADIUS server to reply before retransmitting. The range is 1 to 1000. This setting overrides the <b>radius-server timeout</b> global configuration command setting. If no timeout is set with the <b>radius-server host</b> command, the setting of the <b>radius-server timeout</b> command is used.</li> <li>• (Optional) For <b>retransmit</b> <i>retries</i>, specify the number of times a RADIUS request is resent to a server if that server is not responding or responding slowly. The range is 1 to 1000. If no retransmit value is set with the <b>radius-server host</b> command, the setting of the <b>radius-server retransmit</b> global configuration command is used.</li> <li>• (Optional) For <b>key</b> <i>string</i>, specify the authentication and encryption key used between the access point and the RADIUS daemon running on the RADIUS server.</li> </ul> <p><b>Note</b> The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the <b>radius-server host</b> command. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.</p> <p>To configure the access point to recognize more than one host entry associated with a single IP address, enter this command as many times as necessary, making sure that each UDP port number is different. The access point software searches for hosts in the order in which you specify them. Set the timeout, retransmit, and encryption key values to use with the specific RADIUS host.</p>
<p><b>Step 4</b> <b>dot11 ssid</b> <i>ssid-string</i></p>	<p>Enter SSID configuration mode for an SSID on which you need to enable accounting. The SSID can consist of up to 32 alphanumeric characters. SSIDs are case sensitive.</p>
<p><b>Step 5</b> <b>accounting</b> <i>list-name</i></p>	<p>Enable RADIUS accounting for this SSID. For <i>list-name</i>, specify the accounting method list. Click this URL for more information on method lists:  <a href="http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgr/fs Secur_c/fsaaa/scfacct.htm#xtocid2">http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgr/fs Secur_c/fsaaa/scfacct.htm#xtocid2</a></p> <p><b>Note</b> To enable accounting for an SSID, you must include the <b>accounting</b> command in the SSID configuration. Click this URL to browse to a detailed description of the SSID configuration mode <b>accounting</b> command:  <a href="http://www.cisco.com/en/US/products/hw/wireless/ps4570/products_command_reference_chapter09186a008041757f.html#wp2449819">http://www.cisco.com/en/US/products/hw/wireless/ps4570/products_command_reference_chapter09186a008041757f.html#wp2449819</a></p>

	Command	Purpose
Step 6	<b>end</b>	Return to privileged EXEC mode.
Step 7	<b>show running-config</b>	Verify your entries.
Step 8	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

To remove the specified RADIUS server, use the **no radius-server host** *hostname | ip-address* global configuration command.

This example shows how to configure one RADIUS server to be used for authentication and another to be used for accounting:

```
router(config)# radius-server host 172.29.36.49 auth-port 1612 key rad1
router(config)# radius-server host 172.20.36.50 acct-port 1618 key rad2
```

This example shows how to configure an SSID for RADIUS accounting:

```
router(config)# dot11 ssid batman
router(config-ssid)# accounting accounting-method-list
```

This example shows how to configure *host1* as the RADIUS server and to use the default ports for both authentication and accounting:

```
router(config)# radius-server host host1
```



#### Note

You also need to configure some settings on the RADIUS server. These settings include the IP address of the access point and the key string to be shared by both the server and the access point. For more information, refer to the RADIUS server documentation.

## Configuring RADIUS Login Authentication

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

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

Beginning in privileged EXEC mode, follow these steps to configure login authentication. This procedure is required.

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>aaa new-model</b>	Enable AAA.

	Command	Purpose
Step 3	<b>aaa authentication login</b> { <b>default</b>   <i>list-name</i> } <i>method1</i> [ <i>method2</i> ...]	<p>Create a login authentication method list.</p> <ul style="list-style-type: none"> <li>To create a default list that is used when a named list is <i>not</i> specified in the <b>login authentication</b> command, use the <b>default</b> keyword followed by the methods that are to be used in default situations. The default method list is automatically applied to all interfaces. For more information on list names, click this link: <a href="http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgr/fsecur_c/fsaaa/scfathen.htm#xtocid2">http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgr/fsecur_c/fsaaa/scfathen.htm#xtocid2</a></li> <li>For <i>method1</i>..., specify the actual method the authentication algorithm tries. The additional methods of authentication are used only if the previous method returns an error, not if it fails.</li> </ul> <p>Select one of these methods:</p> <ul style="list-style-type: none"> <li><b>line</b>—Use the line password for authentication. You must define a line password before you can use this authentication method. Use the <b>password</b> <i>password</i> line configuration command.</li> <li><b>local</b>—Use the local username database for authentication. You must enter username information in the database. Use the <b>username</b> <i>password</i> global configuration command.</li> <li><b>radius</b>—Use RADIUS authentication. You must configure the RADIUS server before you can use this authentication method. For more information, see the “Identifying the RADIUS Server Host” section on page 7-5.</li> </ul>
Step 4	<b>line</b> [ <b>console</b>   <b>tty</b>   <b>vty</b> ] <i>line-number</i> [ <i>ending-line-number</i> ]	Enter line configuration mode, and configure the lines to which you want to apply the authentication list.
Step 5	<b>login authentication</b> { <b>default</b>   <i>list-name</i> }	<p>Apply the authentication list to a line or set of lines.</p> <ul style="list-style-type: none"> <li>If you specify <b>default</b>, use the default list created with the <b>aaa authentication login</b> command.</li> <li>For <i>list-name</i>, specify the list created with the <b>aaa authentication login</b> command.</li> </ul>
Step 6	<b>radius-server attribute 32 include-in-access-req format %h</b>	Configure the access point to send its system name in the NAS_ID attribute for authentication.
Step 7	<b>end</b>	Return to privileged EXEC mode.
Step 8	<b>show running-config</b>	Verify your entries.
Step 9	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

To disable AAA, use the **no aaa new-model** global configuration command. To disable AAA authentication, use the **no aaa authentication login** { **default** | *list-name* } *method1* [*method2*...] global configuration command. To either disable RADIUS authentication for logins or to return to the default value, use the **no login authentication** { **default** | *list-name* } line configuration command.

## Defining AAA Server Groups

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

Server groups also can include multiple host entries for the same server if each entry has a unique identifier (the combination of the IP address and UDP port number), allowing different ports to be individually defined as RADIUS hosts providing a specific AAA service. If you configure two different host entries on the same RADIUS server for the same service (such as accounting), the second configured host entry acts as a fail-over backup to the first one.

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

Beginning in privileged EXEC mode, follow these steps to define the AAA server group and associate a particular RADIUS server with it:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>aaa new-model</b>	Enable AAA.

Command	Purpose
<b>Step 3</b> <b>radius-server host</b> { <i>hostname</i>   <i>ip-address</i> } [ <b>auth-port</b> <i>port-number</i> ] [ <b>acct-port</b> <i>port-number</i> ] [ <b>timeout</b> <i>seconds</i> ] [ <b>retransmit</b> <i>retries</i> ] [ <b>key</b> <i>string</i> ]	<p>Specify the IP address or host name of the remote RADIUS server host.</p> <ul style="list-style-type: none"> <li>• (Optional) For <b>auth-port</b> <i>port-number</i>, specify the UDP destination port for authentication requests.</li> <li>• (Optional) For <b>acct-port</b> <i>port-number</i>, specify the UDP destination port for accounting requests.</li> <li>• (Optional) For <b>timeout</b> <i>seconds</i>, specify the time interval that the access point waits for the RADIUS server to reply before retransmitting. The range is 1 to 1000. This setting overrides the <b>radius-server timeout</b> global configuration command setting. If no timeout is set with the <b>radius-server host</b> command, the setting of the <b>radius-server timeout</b> command is used.</li> <li>• (Optional) For <b>retransmit</b> <i>retries</i>, specify the number of times a RADIUS request is resent to a server if that server is not responding or responding slowly. The range is 1 to 1000. If no retransmit value is set with the <b>radius-server host</b> command, the setting of the <b>radius-server retransmit</b> global configuration command is used.</li> <li>• (Optional) For <b>key</b> <i>string</i>, specify the authentication and encryption key used between the access point and the RADIUS daemon running on the RADIUS server.</li> </ul> <p><b>Note</b> The key is a text string that must match the encryption key used on the RADIUS server. Always configure the key as the last item in the <b>radius-server host</b> command. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.</p> <p>To configure the access point to recognize more than one host entry associated with a single IP address, enter this command as many times as necessary, making sure that each UDP port number is different. The access point software searches for hosts in the order in which you specify them. Set the timeout, retransmit, and encryption key values to use with the specific RADIUS host.</p>
<b>Step 4</b> <b>aaa group server radius</b> <i>group-name</i>	<p>Define the AAA server-group with a group name.</p> <p>This command puts the access point in a server group configuration mode.</p>
<b>Step 5</b> <b>server</b> <i>ip-address</i>	<p>Associate a particular RADIUS server with the defined server group. Repeat this step for each RADIUS server in the AAA server group.</p> <p>Each server in the group must be previously defined in Step 2.</p>
<b>Step 6</b> <b>end</b>	<p>Return to privileged EXEC mode.</p>
<b>Step 7</b> <b>show running-config</b>	<p>Verify your entries.</p>
<b>Step 8</b> <b>copy running-config startup-config</b>	<p>(Optional) Save your entries in the configuration file.</p>
<b>Step 9</b>	<p>Enable RADIUS login authentication. See the <a href="#">“Configuring RADIUS Login Authentication”</a> section on page 7-7.</p>

To remove the specified RADIUS server, use the **no radius-server host** *hostname | ip-address* global configuration command. To remove a server group from the configuration list, use the **no aaa group server radius** *group-name* global configuration command. To remove the IP address of a RADIUS server, use the **no server** *ip-address* server group configuration command.

In this example, the access point is configured to recognize two different RADIUS group servers (*group1* and *group2*). Group1 has two different host entries on the same RADIUS server configured for the same services. The second host entry acts as a fail-over backup to the first entry.

```
router(config)# aaa new-model
router(config)# radius-server host 172.20.0.1 auth-port 1000 acct-port 1001
router(config)# radius-server host 172.10.0.1 auth-port 1645 acct-port 1646
router(config)# aaa group server radius group1
router(config-sg-radius)# server 172.20.0.1 auth-port 1000 acct-port 1001
router(config-sg-radius)# exit
router(config)# aaa group server radius group2
router(config-sg-radius)# server 172.20.0.1 auth-port 2000 acct-port 2001
router(config-sg-radius)# exit
```

## Configuring RADIUS Authorization for User Privileged Access and Network Services

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

**Note**

This section describes setting up authorization for access point administrators, not for wireless client devices.

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

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

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

**Note**

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

Beginning in privileged EXEC mode, follow these steps to specify RADIUS authorization for privileged EXEC access and network services:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>aaa authorization network radius</b>	Configure the access point for user RADIUS authorization for all network-related service requests.
Step 3	<b>aaa authorization exec radius</b>	Configure the access point for user RADIUS authorization to determine if the user has privileged EXEC access.  The <b>exec</b> keyword might return user profile information (such as <b>autocommand</b> information).
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>show running-config</b>	Verify your entries.
Step 6	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

To disable authorization, use the **no aaa authorization {network | exec} method1** global configuration command.

## Starting RADIUS Accounting

The AAA accounting feature tracks the services that users are accessing and the amount of network resources that they are consuming. When AAA accounting is enabled, the access point reports user activity to the RADIUS security server in the form of accounting records. Each accounting record contains accounting attribute-value (AV) pairs and is stored on the security server. This data can then be analyzed for network management, client billing, or auditing. See the [“RADIUS Attributes Sent by the Access Point” section on page 7-18](#) for a complete list of attributes sent and honored by the access point.

Beginning in privileged EXEC mode, follow these steps to enable RADIUS accounting for each Cisco IOS privilege level and for network services:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>aaa accounting network start-stop radius</b>	Enable RADIUS accounting for all network-related service requests.
Step 3	<b>ip radius source-interface bvi1</b>	Configure the access point to send its BVI IP address in the NAS_IP_ADDRESS attribute for accounting records.
Step 4	<b>aaa accounting update periodic minutes</b>	Enter an accounting update interval in minutes.
Step 5	<b>end</b>	Return to privileged EXEC mode.
Step 6	<b>show running-config</b>	Verify your entries.
Step 7	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

To disable accounting, use the **no aaa accounting {network | exec} {start-stop} method1...** global configuration command.

## Selecting the CSID Format

You can select the format for MAC addresses in Called-Station-ID (CSID) and Calling-Station-ID attributes in RADIUS packets. Use the **dot11 aaa csid** global configuration command to select the CSID format. Table 7-1 lists the format options with corresponding MAC address examples.

**Table 7-1 CSID Format Options**

Option	MAC Address Example
default	0007.85b3.5f4a
ietf	00-07-85-b3-5f-4a
unformatted	000785b35f4a

To return to the default CSID format, use the **no** form of the **dot11 aaa csid** command, or enter **dot11 aaa csid default**.



**Note**

You can also use the **aaa csid** command to select the CSID format.

## Configuring Settings for All RADIUS Servers

Beginning in privileged EXEC mode, follow these steps to configure global communication settings between the access point and all RADIUS servers:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>radius-server key <i>string</i></b>	Specify the shared secret text string used between the access point and all RADIUS servers.  <b>Note</b> The key is a text string that must match the encryption key used on the RADIUS server. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
Step 3	<b>radius-server retransmit <i>retries</i></b>	Specify the number of times the access point sends each RADIUS request to the server before giving up. The default is 3; the range 1 to 1000.
Step 4	<b>radius-server timeout <i>seconds</i></b>	Specify the number of seconds an access point waits for a reply to a RADIUS request before resending the request. The default is 5 seconds; the range is 1 to 1000.
Step 5	<b>radius-server deadtime <i>minutes</i></b>	Use this command to cause the Cisco IOS software to mark as “dead” any RADIUS servers that fail to respond to authentication requests, thus avoiding the wait for the request to time out before trying the next configured server. A RADIUS server marked as dead is skipped by additional requests for the duration of minutes that you specify, up to a maximum of 1440 (24 hours).  <b>Note</b> If you set up more than one RADIUS server, you must configure the RADIUS server deadtime for optimal performance.

	Command	Purpose
Step 6	<b>radius-server attribute 32 include-in-access-req format %h</b>	Configure the access point to send its system name in the NAS_ID attribute for authentication.
Step 7	<b>end</b>	Return to privileged EXEC mode.
Step 8	<b>show running-config</b>	Verify your settings.
Step 9	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

To return to the default setting for retransmit, timeout, and deadtime, use the **no** forms of these commands.

## Configuring the Access Point to Use Vendor-Specific RADIUS Attributes

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

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

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

For example, the following AV pair activates Cisco's *multiple named ip address pools* feature during IP authorization (during PPP's IPCP address assignment):

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

The following example shows how to provide a user logging in from an access point with immediate access to privileged EXEC commands:

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

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

Beginning in privileged EXEC mode, follow these steps to configure the access point to recognize and use VSAs:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>radius-server vsa send [accounting   authentication]</b>	<p>Enable the access point to recognize and use VSAs as defined by RADIUS IETF attribute 26.</p> <ul style="list-style-type: none"> <li>(Optional) Use the <b>accounting</b> keyword to limit the set of recognized vendor-specific attributes to only accounting attributes.</li> <li>(Optional) Use the <b>authentication</b> keyword to limit the set of recognized vendor-specific attributes to only authentication attributes.</li> </ul> <p>If you enter this command without keywords, both accounting and authentication vendor-specific attributes are used.</p>
Step 3	<b>end</b>	Return to privileged EXEC mode.
Step 4	<b>show running-config</b>	Verify your settings.
Step 5	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

For a complete list of RADIUS attributes or more information about VSA 26, refer to the “RADIUS Attributes” appendix in the *Cisco IOS Security Configuration Guide for Release 12.2*.

## Configuring the Access Point for Vendor-Proprietary RADIUS Server Communication

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

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

Beginning in privileged EXEC mode, follow these steps to specify a vendor-proprietary RADIUS server host and a shared secret text string:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>radius-server host {hostname   ip-address} non-standard</b>	Specify the IP address or host name of the remote RADIUS server host and identify that it is using a vendor-proprietary implementation of RADIUS.

	Command	Purpose
Step 3	<code>radius-server key string</code>	Specify the shared secret text string used between the access point and the vendor-proprietary RADIUS server. The access point and the RADIUS server use this text string to encrypt passwords and exchange responses.  <b>Note</b> The key is a text string that must match the encryption key used on the RADIUS server. Leading spaces are ignored, but spaces within and at the end of the key are used. If you use spaces in your key, do not enclose the key in quotation marks unless the quotation marks are part of the key.
Step 4	<code>end</code>	Return to privileged EXEC mode.
Step 5	<code>show running-config</code>	Verify your settings.
Step 6	<code>copy running-config startup-config</code>	(Optional) Save your entries in the configuration file.

To delete the vendor-proprietary RADIUS host, use the **no radius-server host** {hostname | ip-address} **non-standard** global configuration command. To disable the key, use the **no radius-server key** global configuration command.

This example shows how to specify a vendor-proprietary RADIUS host and to use a secret key of `rad124` between the access point and the server:

```
router(config)# radius-server host 172.20.30.15 nonstandard
router(config)# radius-server key rad124
```

## Configuring WISPr RADIUS Attributes

The Wi-Fi Alliance's *WISPr Best Current Practices for Wireless Internet Service Provider (WISP) Roaming* document lists RADIUS attributes that access points must send with RADIUS accounting and authentication requests. The access point currently supports only the WISPr location-name and the ISO and International Telecommunications Union (ITU) country and area codes attributes. Use the **snmp-server location** and the **dot11 location isocc** commands to configure these attributes on the access point.

The *WISPr Best Current Practices for Wireless Internet Service Provider (WISP) Roaming* document also requires the access point to include a class attribute in RADIUS authentication replies and accounting requests. The access point includes the class attribute automatically and does not have to be configured to do so.

You can find a list of ISO and ITU country and area codes at the ISO and ITU websites. Cisco IOS software does not check the validity of the country and area codes that you configure on the access point.

Beginning in privileged EXEC mode, follow these steps to specify WISPr RADIUS attributes on the access point:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>snmp-server location</b> <i>location</i>	Specify the WISPr location-name attribute. The <i>WISPr Best Current Practices for Wireless Internet Service Provider (WISP) Roaming</i> document recommends that you enter the location name in this format:  <i>hotspot_operator_name,location</i>
Step 3	<b>dot11 location isocc</b> <i>ISO-country-code</i> <b>cc</b> <i>country-code</i> <b>ac</b> <i>area-code</i>	Specify ISO and ITU country and area codes that the access point includes in accounting and authentication requests. <ul style="list-style-type: none"> <li><b>isocc</b> <i>ISO-country-code</i>—specifies the ISO country code that the access point includes in RADIUS authentication and accounting requests</li> <li><b>cc</b> <i>country-code</i>—specifies the ITU country code that the access point includes in RADIUS authentication and accounting requests</li> <li><b>ac</b> <i>area-code</i>—specifies the ITU area code that the access point includes in RADIUS authentication and accounting requests</li> </ul>
Step 4	<b>end</b>	Return to privileged EXEC mode.
Step 5	<b>show running-config</b>	Verify your settings.
Step 6	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

This example shows how to configure the WISPr location-name attribute:

```
router# snmp-server location ACMEWISP,Gate_14_Terminal_C_of_Newark_Airport
```

This example shows how to configure the ISO and ITU location codes on the access point:

```
router# dot11 location isocc us cc 1 ac 408
```

This example shows how the access point adds the SSID used by the client device and formats the location-ID string:

```
isocc=us,cc=1,ac=408,network=ACMEWISP_NewarkAirport
```

## Displaying the RADIUS Configuration

To display the RADIUS configuration, use the **show running-config** privileged EXEC command.



### Note

When DNS is configured on the access point, the **show running-config** command sometimes displays a server's IP address instead of its name.

## RADIUS Attributes Sent by the Access Point

Table 7-2 through Table 7-6 identify the attributes sent by an access point to a client in access-request, access-accept, and accounting-request packets.



### Note

You can configure the access point to include in its RADIUS accounting and authentication requests attributes recommended by the Wi-Fi Alliance's *WISPr Best Current Practices for Wireless Internet Service Provider (WISP) Roaming* document. Refer to the [“Configuring WISPr RADIUS Attributes” section on page 7-16](#) for instructions.

**Table 7-2 Attributes Sent in Access-Request Packets**

Attribute ID	Description
1	User-Name
4	NAS-IP-Address
5	NAS-Port
12	Framed-MTU
30	Called-Station-ID (MAC address)
31	Calling-Station-ID (MAC address)
32	NAS-Identifier <sup>1</sup>
61	NAS-Port-Type
79	EAP-Message
80	Message-Authenticator

1. The access point sends the NAS-Identifier if attribute 32 (include-in-access-req) is configured.

**Table 7-3 Attributes Honored in Access-Accept Packets**

Attribute ID	Description
25	Class
27	Session-Timeout
64	Tunnel-Type <sup>1</sup>
65	Tunnel-Medium-Type <sup>1</sup>
79	EAP-Message
80	Message-Authenticator
81	Tunnel-Private-Group-ID <sup>1</sup>
VSA (attribute 26)	LEAP session-key
VSA (attribute 26)	Auth-Algo-Type
VSA (attribute 26)	SSID

1. RFC2868; defines a VLAN override number.

**Table 7-4** *Attributes Sent in Accounting-Request (start) Packets*

Attribute ID	Description
1	User-Name
4	NAS-IP-Address
5	NAS-Port
6	Service-Type
25	Class
41	Acct-Delay-Time
44	Acct-Session-Id
61	NAS-Port-Type
VSA (attribute 26)	SSID
VSA (attribute 26)	NAS-Location
VSA (attribute 26)	Cisco-NAS-Port
VSA (attribute 26)	Interface

**Table 7-5** *Attributes Sent in Accounting-Request (update) Packets*

Attribute ID	Description
1	User-Name
4	NAS-IP-Address
5	NAS-Port
6	Service-Type
25	Class
41	Acct-Delay-Time
42	Acct-Input-Octets
43	Acct-Output-Octets
44	Acct-Session-Id
46	Acct-Session-Time
47	Acct-Input-Packets
48	Acct-Output-Packets
61	NAS-Port-Type
VSA (attribute 26)	SSID
VSA (attribute 26)	NAS-Location
VSA (attribute 26)	VLAN-ID
VSA (attribute 26)	Connect-Progress
VSA (attribute 26)	Cisco-NAS-Port
VSA (attribute 26)	Interface

**Table 7-6** *Attributes Sent in Accounting-Request (stop) Packets*

Attribute ID	Description
1	User-Name
4	NAS-IP-Address
5	NAS-Port
6	Service-Type
25	Class
41	Acct-Delay-Time
42	Acct-Input-Octets
43	Acct-Output-Octets
44	Acct-Session-Id
46	Acct-Session-Time
47	Acct-Input-Packets
48	Acct-Output-Packets
49	Acct-Terminate-Cause
61	NAS-Port-Type
VSA (attribute 26)	SSID
VSA (attribute 26)	NAS-Location
VSA (attribute 26)	Disc-Cause-Ext
VSA (attribute 26)	VLAN-ID
VSA (attribute 26)	Connect-Progress
VSA (attribute 26)	Cisco-NAS-Port
VSA (attribute 26)	Interface
VSA (attribute 26)	Auth-Algo-Type

**Note**

By default, the access point sends reauthentication requests to the authentication server with the service-type attribute set to authenticate-only. However, some Microsoft IAS servers do not support the authenticate-only service-type attribute. Changing the service-type attribute to login-only ensures that Microsoft IAS servers recognize reauthentication requests from the access point. Use the **dot11 aaa authentication attributes service-type login-only** global configuration command to set the service-type attribute in reauthentication requests to login-only.



## Configuring VLANs

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This chapter describes how to configure your access point to operate with the VLANs set up on your wired LAN. These sections describe how to configure your access point to support VLANs:

- [Understanding VLANs, page 8-2](#)
- [Configuring VLANs, page 8-4](#)
- [VLAN Configuration Example, page 8-9](#)

# Understanding VLANs

A VLAN is a switched network that is logically segmented, by functions, project teams, or applications rather than on a physical or geographical basis. For example, all workstations and servers used by a particular workgroup team can be connected to the same VLAN, regardless of their physical connections to the network or the fact that they might be intermingled with other teams. You use VLANs to reconfigure the network through software rather than physically unplugging and moving devices or wires.

A VLAN can be thought of as a broadcast domain that exists within a defined set of switches. A VLAN consists of a number of end systems, either hosts or network equipment (such as bridges and routers), connected by a single bridging domain. The bridging domain is supported on various pieces of network equipment such as LAN switches that operate bridging protocols between them with a separate group for each VLAN.

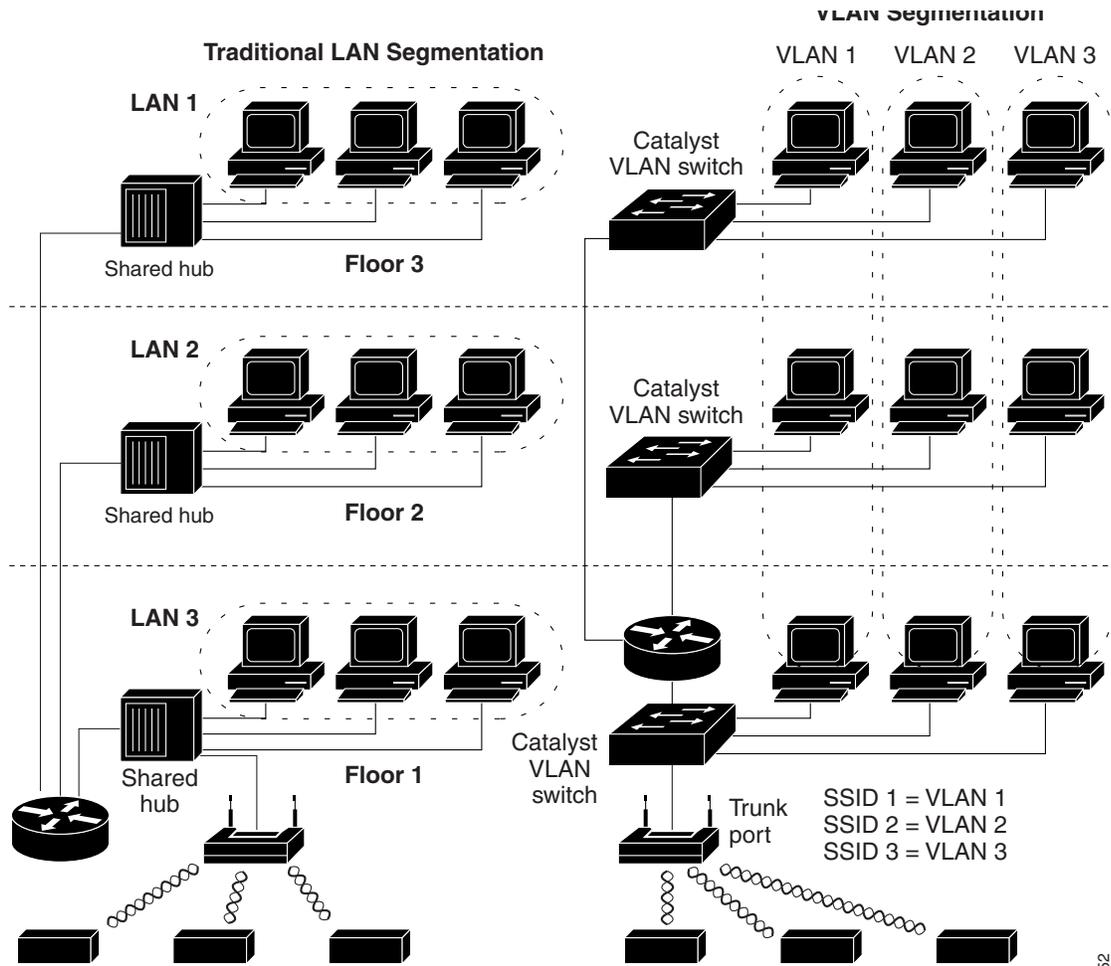
VLANs provide the segmentation services traditionally provided by routers in LAN configurations. VLANs address scalability, security, and network management. You should consider several key issues when designing and building switched LAN networks:

- LAN segmentation
- Security
- Broadcast control
- Performance
- Network management
- Communication between VLANs

You extend VLANs into a wireless LAN by adding IEEE 802.11Q tag awareness to the access point. Frames destined for different VLANs are transmitted by the access point wirelessly on different SSIDs with different WEP keys. Only the clients associated with that VLAN receive those packets. Conversely, packets coming from a client associated with a certain VLAN are 802.11Q tagged before they are forwarded onto the wired network.

[Figure 8-1](#) shows the difference between traditional physical LAN segmentation and logical VLAN segmentation with wireless devices connected.

Figure 8-1 LAN and VLAN Segmentation with Wireless Devices



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## Related Documents

These documents provide more detailed information pertaining to VLAN design and configuration:

- *Cisco IOS Switching Services Configuration Guide*. Click this link to browse to this document: [http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fswtch\\_c/index.htm](http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fswtch_c/index.htm)
- *Cisco Internetwork Design Guide*. Click this link to browse to this document: <http://www.cisco.com/univercd/cc/td/doc/cisintwk/idg4/index.htm>
- *Cisco Internetworking Technology Handbook*. Click this link to browse to this document: [http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito\\_doc/index.htm](http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/index.htm)
- *Cisco Internetworking Troubleshooting Guide*. Click this link to browse to this document: [http://www.cisco.com/univercd/cc/td/doc/cisintwk/itg\\_v1/index.htm](http://www.cisco.com/univercd/cc/td/doc/cisintwk/itg_v1/index.htm)

## Incorporating Wireless Devices into VLANs

The basic wireless components of a VLAN consist of an access point and a client associated to it using wireless technology. The access point is physically connected through a trunk port to the network VLAN switch on which the VLAN is configured. The physical connection to the VLAN switch is through the access point's Ethernet port.

In fundamental terms, the key to configuring an access point to connect to a specific VLAN is to configure its SSID to recognize that VLAN. Because VLANs are identified by a VLAN ID or name, it follows that if the SSID on an access point is configured to recognize a specific VLAN ID or name, a connection to the VLAN is established. When this connection is made, associated wireless client devices having the same SSID can access the VLAN through the access point. The VLAN processes data to and from the clients the same way that it processes data to and from wired connections. You can configure up to 16 SSIDs on your access point, so you can support up to 16 VLANs. You can assign only one SSID to a VLAN.

You can use the VLAN feature to deploy wireless devices with greater efficiency and flexibility. For example, one access point can now handle the specific requirements of multiple users having widely varied network access and permissions. Without VLAN capability, multiple access points would have to be employed to serve classes of users based on the access and permissions they were assigned.

These are two common strategies for deploying wireless VLANs:

- **Segmentation by user groups:** You can segment your wireless LAN user community and enforce a different security policy for each user group. For example, you can create three wired and wireless VLANs in an enterprise environment for full-time and part-time employees and also provide guest access.
- **Segmentation by device types:** You can segment your wireless LAN to allow different devices with different security capabilities to join the network. For example, some wireless users might have handheld devices that support only static WEP, and some wireless users might have more sophisticated devices using dynamic WEP. You can group and isolate these devices into separate VLANs.

**Note**

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You cannot configure multiple VLANs on repeater access points. Repeater access points support only the native VLAN.

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## Configuring VLANs

These sections describe how to configure VLANs on your access point:

- [Configuring a VLAN, page 8-5](#)
- [Assigning Names to VLANs, page 8-7](#)
- [Using a RADIUS Server to Assign Users to VLANs, page 8-7](#)
- [Viewing VLANs Configured on the Access Point, page 8-8](#)

## Configuring a VLAN



### Note

When you configure VLANs on access points, the Native VLAN must be VLAN1. In a single architecture, client traffic received by the access point is tunneled through an IP-GRE tunnel, which is established on the access point's Ethernet interface native VLAN. Because of the IP-GRE tunnel, some users may configure another switch port as VLAN1. This misconfiguration causes errors on the switch port.

Configuring your access point to support VLANs is a three-step process:

1. Enable the VLAN on the radio and Ethernet ports.
2. Assign SSIDs to VLANs.
3. Assign authentication settings to SSIDs.

This section describes how to assign SSIDs to VLANs and how to enable a VLAN on the access point radio and Ethernet ports. For detailed instructions on assigning authentication types to SSIDs, see [Chapter 6, “Configuring Authentication Types.”](#) For instructions on assigning other settings to SSIDs, see [Chapter 3, “Configuring Multiple SSIDs.”](#)

You can configure up to 16 SSIDs on the access point, so you can support up to 16 VLANs that are configured on your LAN.

Beginning in privileged EXEC mode, follow these steps to assign an SSID to a VLAN and enable the VLAN on the access point radio and Ethernet ports:

	Command	Purpose
Step 1	<code>configure terminal</code>	Enter global configuration mode.
Step 2	<code>interface dot11radio 0   1</code>	Enter interface configuration mode for the radio interface.
Step 3	<code>ssid ssid-string</code>	Create an SSID and enter SSID configuration mode for the new SSID. The SSID can consist of up to 32 alphanumeric characters. SSIDs are case sensitive.  <b>Note</b> You use the <code>ssid</code> command's authentication options to configure an authentication type for each SSID. See <a href="#">Chapter 6, “Configuring Authentication Types,”</a> for instructions on configuring authentication types.
Step 4	<code>vlan vlan-id</code>	(Optional) Assign the SSID to a VLAN on your network. Client devices that associate using the SSID are grouped into this VLAN. Enter a VLAN ID from 1 to 4095. You can assign only one SSID to a VLAN.  <b>Tip</b> If your network uses VLAN names, you can also assign names to the VLANs on your access point. See the <a href="#">“Assigning Names to VLANs”</a> section on page 8-7 for instructions.
Step 5	<code>exit</code>	Return to interface configuration mode for the radio interface.
Step 6	<code>interface dot11radio 0.x   1.x</code>	Enter interface configuration mode for the radio VLAN sub interface.

	<b>Command</b>	<b>Purpose</b>
<b>Step 7</b>	<b>encapsulation dot1q</b> <i>vlan-id</i> [ <b>native</b> ]	Enable a VLAN on the radio interface.  (Optional) Designate the VLAN as the native VLAN. On many networks, the native VLAN is VLAN 1.
<b>Step 8</b>	<b>exit</b>	Return to global configuration mode.
<b>Step 9</b>	<b>interface fastEthernet0.x</b>	Enter interface configuration mode for the Ethernet VLAN subinterface.
<b>Step 10</b>	<b>encapsulation dot1q</b> <i>vlan-id</i> [ <b>native</b> ]	Enable a VLAN on the Ethernet interface.  (Optional) Designate the VLAN as the native VLAN. On many networks, the native VLAN is VLAN 1.
<b>Step 11</b>	<b>end</b>	Return to privileged EXEC mode.
<b>Step 12</b>	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

This example shows how to:

- Name an SSID
- Assign the SSID to a VLAN
- Enable the VLAN on the radio and Ethernet ports as the native VLAN

```

router# configure terminal
router(config)# interface dot11radio0
router(config-if)# ssid batman
router(config-ssid)# vlan 1
router(config-ssid)# exit
router(config)# interface dot11radio0.1
router(config-subif)# encapsulation dot1q 1 native
router(config-subif)# exit
router(config)# interface fastEthernet0.1
router(config-subif)# encapsulation dot1q 1 native
router(config-subif)# exit
router(config)# end

```

## Assigning Names to VLANs

You can assign a name to a VLAN in addition to its numerical ID. VLAN names can contain up to 32 ASCII characters. The access point stores each VLAN name and ID pair in a table.

### Guidelines for Using VLAN Names

Keep these guidelines in mind when using VLAN names:

- The mapping of a VLAN name to a VLAN ID is local to each access point, so across your network, you can assign the same VLAN name to a different VLAN ID.



**Note** If clients on your wireless LAN require seamless roaming, Cisco recommends that you assign the same VLAN name to the same VLAN ID across all access points, or that you use only VLAN IDs without names.

- Every VLAN configured on your access point must have an ID, but VLAN names are optional.
- VLAN names can contain up to 32 ASCII characters. However, a VLAN name cannot be a number between 1 and 4095. For example, *vlan4095* is a valid VLAN name, but *4095* is not. The access point reserves the numbers 1 through 4095 for VLAN IDs.

### Creating a VLAN Name

Beginning in privileged EXEC mode, follow these steps to assign a name to a VLAN:

	Command	Purpose
Step 1	<b>configure terminal</b>	Enter global configuration mode.
Step 2	<b>dot11 vlan-name name vlan vlan-id</b>	Assign a VLAN name to a VLAN ID. The name can contain up to 32 ASCII characters.
Step 3	<b>end</b>	Return to privileged EXEC mode.
Step 4	<b>copy running-config startup-config</b>	(Optional) Save your entries in the configuration file.

Use the **no** form of the command to remove the name from the VLAN. Use the **show dot11 vlan-name** privileged EXEC command to list all the VLAN name and ID pairs configured on the access point.

## Using a RADIUS Server to Assign Users to VLANs

You can configure your RADIUS authentication server to assign users or groups of users to a specific VLAN when they authenticate to the network.



**Note**

Unicast and multicast cipher suites advertised in WPA information element (and negotiated during 802.11 association) may potentially mismatch with the cipher suite supported in an explicitly assigned VLAN. If the RADIUS server assigns a new vlan ID which uses a different cipher suite from the previously negotiated cipher suite, there is no way for the access point and client to switch back to the

new cipher suite. Currently, the WPA protocol does not allow the cipher suite to be changed after the initial 802.11 cipher negotiation phase. In this scenario, the client device is disassociated from the wireless LAN.

The VLAN-mapping process consists of these steps:

1. A client device associates to the access point using any SSID configured on the access point.
2. The client begins RADIUS authentication.
3. When the client authenticates successfully, the RADIUS server maps the client to a specific VLAN, regardless of the VLAN mapping defined for the SSID the client is using on the access point. If the server does not return any VLAN attribute for the client, the client is assigned to the VLAN specified by the SSID mapped locally on the access point.

These are the RADIUS user attributes used for vlan-id assignment. Each attribute must have a common tag value between 1 and 31 to identify the grouped relationship.

- IETF 64 (Tunnel Type): Set this attribute to **VLAN**
- IETF 65 (Tunnel Medium Type): Set this attribute to **802**
- IETF 81 (Tunnel Private Group ID): Set this attribute to *vlan-id*

## Viewing VLANs Configured on the Access Point

In privileged EXEC mode, use the **show vlan** command to view the VLANs that the access point supports. This is sample output from a **show vlan** command:

```
Virtual LAN ID: 1 (IEEE 802.1Q Encapsulation)

    vLAN Trunk Interfaces: Dot11Radio0
FastEthernet0
Virtual-Dot11Radio0

    This is configured as native Vlan for the following interface(s) :
Dot11Radio0
FastEthernet0
Virtual-Dot11Radio0

    Protocols Configured:  Address:                Received:        Transmitted:
    Bridging              Bridge Group 1   201688          0
    Bridging              Bridge Group 1   201688          0
    Bridging              Bridge Group 1   201688          0

Virtual LAN ID: 2 (IEEE 802.1Q Encapsulation)

    vLAN Trunk Interfaces: Dot11Radio0.2
FastEthernet0.2
Virtual-Dot11Radio0.2

    Protocols Configured:  Address:                Received:        Transmitted:
```

# VLAN Configuration Example

This example shows how to use VLANs to manage wireless devices on a college campus. In this example, three levels of access are available through VLANs configured on the wired network:

- Management access—Highest level of access; users can access all internal drives and files, departmental databases, top-level financial information, and other sensitive information. Management users are required to authenticate using Cisco LEAP.
- Faculty access—Medium level of access; users can access school's Intranet and Internet, access internal files, access student databases, and view internal information such as human resources, payroll, and other faculty-related material. Faculty users are required to authenticate using Cisco LEAP.
- Student access—Lowest level of access; users can access school's Intranet and the Internet, obtain class schedules, view grades, make appointments, and perform other student-related activities. Students are allowed to join the network using static WEP.

In this scenario, a minimum of three VLAN connections are required, one for each level of access. Because the access point can handle up to 16 SSIDs, you can use the basic design shown in [Table 8-1](#).

**Table 8-1** Access Level SSID and VLAN Assignment

Level of Access	SSID	VLAN ID
Management	boss	1
Faculty	teach	2
Student	learn	3

Managers configure their wireless client adapters to use SSID boss, faculty members configure their clients to use SSID teach, and students configure their wireless client adapters to use SSID learn. When these clients associate to the access point, they automatically belong to the correct VLAN.

You would complete these steps to support the VLANs in this example:

1. Configure or confirm the configuration of these VLANs on one of the switches on your LAN.
2. On the access point, assign an SSID to each VLAN.
3. Assign authentication types to each SSID.
4. Configure VLAN 1, the Management VLAN, on both the fastEthernet and dot11radio interfaces on the access point. You should make this VLAN the native VLAN.
5. Configure VLANs 2 and 3 on both the fastEthernet and dot11radio interfaces on the access point.
6. Configure the client devices.

Table 8-2 shows the commands needed to configure the three VLANs in this example.

**Table 8-2 Configuration Commands for VLAN Example**

Configuring VLAN 1	Configuring VLAN 2	Configuring VLAN 3
<pre>router# configure terminal router(config)# interface dot11radio 0 router(config-if)# ssid boss router(config-ssid)# vlan 01 router(config-ssid)# end</pre>	<pre>router# configure terminal router(config)# interface dot11radio 0 router(config-if)# ssid teach router(config-ssid)# vlan 02 router(config-ssid)# end</pre>	<pre>router# configure terminal router(config)# interface dot11radio 0 router(config-if)# ssid learn router(config-ssid)# vlan 03 router(config-ssid)# end</pre>
<pre>router configure terminal router(config) interface FastEthernet0.1 router(config-subif) encapsulation dot1Q 1 native router(config-subif) exit</pre>	<pre>router(config) interface FastEthernet0.2 router(config-subif) encapsulation dot1Q 2 router(config-subif) bridge-group 2 router(config-subif) exit</pre>	<pre>router(config) interface FastEthernet0.3 router(config-subif) encapsulation dot1Q 3 router(config-subif) bridge-group 3 router(config-subif) exit</pre>
<pre>router(config)# interface Dot11Radio 0.1 router(config-subif)# encapsulation dot1Q 1 native router(config-subif) bridge-group 1 router(config-subif)# exit</pre>	<pre>router(config) interface Dot11Radio 0.2 router(config-subif) encapsulation dot1Q 2 router(config-subif) bridge-group 2 router(config-subif) exit</pre>	<pre>router(config) interface Dot11Radio 0.3 router(config-subif) encapsulation dot1Q 3 router(config-subif) bridge-group 3 router(config-subif) exit</pre>

Table 8-3 shows the results of the configuration commands in Table 8-2. Use the **show running** command to display the running configuration on the access point.

**Table 8-3 Results of Example Configuration Commands**

VLAN 1 Interfaces	VLAN 2 Interfaces	VLAN 3 Interfaces
<pre>interface Dot11Radio0.1 encapsulation dot1Q 1 native no ip route-cache no cdp enable bridge-group 1 bridge-group 1 subscriber-loop-control bridge-group 1 block-unknown-source no bridge-group 1 source-learning no bridge-group 1 unicast-flooding bridge-group 1 spanning-disabled</pre>	<pre>interface Dot11Radio0.2 encapsulation dot1Q 2 no ip route-cache no cdp enable bridge-group 2 bridge-group 2 subscriber-loop-control bridge-group 2 block-unknown-source no bridge-group 2 source-learning no bridge-group 2 unicast-flooding bridge-group 2 spanning-disabled</pre>	<pre>interface Dot11Radio0.3 encapsulation dot1Q 3 no ip route-cache bridge-group 3 bridge-group 3 subscriber-loop-control bridge-group 3 block-unknown-source no bridge-group 3 source-learning no bridge-group 3 unicast-flooding bridge-group 3 spanning-disabled</pre>
<pre>interface FastEthernet0.1 encapsulation dot1Q 1 native no ip route-cache bridge-group 1 no bridge-group 1 source-learning bridge-group 1 spanning-disabled</pre>	<pre>interface FastEthernet0.2 encapsulation dot1Q 2 no ip route-cache bridge-group 2 no bridge-group 2 source-learning bridge-group 2 spanning-disabled</pre>	<pre>interface FastEthernet0.3 encapsulation dot1Q 3 no ip route-cache bridge-group 3 no bridge-group 3 source-learning bridge-group 3 spanning-disabled</pre>

Notice that when you configure a bridge group on the radio interface, these commands are set automatically:

```
bridge-group 2 subscriber-loop-control
bridge-group 2 block-unknown-source
no bridge-group 2 source-learning
no bridge-group 2 unicast-flooding
bridge-group 2 spanning-disabled
```

When you configure a bridge group on the FastEthernet interface, these commands are set automatically:

```
no bridge-group 2 source-learning
bridge-group 2 spanning-disabled
```





## Configuring QoS

---

This chapter describes how to configure quality of service (QoS) on your access point. With this feature, you can provide preferential treatment to certain traffic at the expense of others. Without QoS, the access point offers best-effort service to each packet, regardless of the packet contents or size. It sends the packets without any assurance of reliability, delay bounds, or throughput.

This chapter consists of these sections:

- [Understanding QoS for Wireless LANs, page 9-2](#)
- [Configuring QoS, page 9-4](#)

# Understanding QoS for Wireless LANs

Typically, networks operate on a best-effort delivery basis, which means that all traffic has equal priority and an equal chance of being delivered in a timely manner. When congestion occurs, all traffic has an equal chance of being dropped.

When you configure QoS on the access point, you can select specific network traffic, prioritize it, and use congestion-management and congestion-avoidance techniques to provide preferential treatment. Implementing QoS in your wireless LAN makes network performance more predictable and bandwidth utilization more effective.

When you configure QoS, you create QoS policies and apply the policies to the VLANs configured on your access point. If you do not use VLANs on your network, you can apply your QoS policies to the access point's Ethernet and radio ports.

**Note**

When you enable QoS, the access point uses Wi-Fi Multimedia (WMM) mode by default. See the “[Using Wi-Fi Multimedia Mode](#)” section on page 9-4 for information on WMM.

## QoS for Wireless LANs Versus QoS on Wired LANs

The QoS implementation for wireless LANs differs from QoS implementations on other Cisco devices. With QoS enabled, access points perform the following:

- They do not classify packets; they prioritize packets based on DSCP value, client type (such as a wireless phone), or the priority value in the 802.1q or 802.1p tag.
- They do not construct internal DSCP values; they only support mapping by assigning IP DSCP, Precedence, or Protocol values to Layer 2 COS values.
- They carry out EDCF like queuing on the radio egress port only.
- They do only FIFO queueing on the Ethernet egress port.
- They support only 802.1Q/P tagged packets. Access points do not support ISL.
- They support only MQC policy-map **set cos** action.
- They prioritize the traffic from voice clients (such as Symbol phones) over traffic from other clients when the QoS Element for Wireless Phones feature is enabled.
- They support Spectralink phones using the class-map IP protocol clause with the protocol value set to 119.

To contrast the wireless LAN QoS implementation with the QoS implementation on other Cisco network devices, see the *Cisco IOS Quality of Service Solutions Configuration Guide* at this URL:

[http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fqos\\_c/index.htm](http://www.cisco.com/univercd/cc/td/doc/product/software/ios122/122cgcr/fqos_c/index.htm)

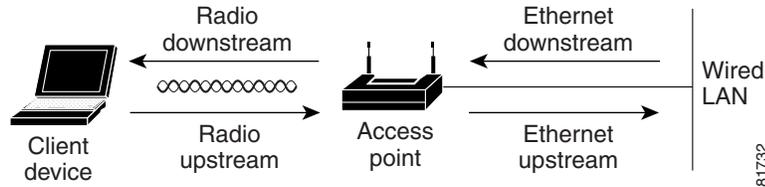
## Impact of QoS on a Wireless LAN

Wireless LAN QoS features are a subset of the proposed 802.11e draft. QoS on wireless LANs provides prioritization of traffic from the access point over the WLAN based on traffic classification.

Just as in other media, you might not notice the effects of QoS on a lightly loaded wireless LAN. The benefits of QoS become more obvious as the load on the wireless LAN increases, keeping the latency, jitter, and loss for selected traffic types within an acceptable range.

QoS on the wireless LAN focuses on downstream prioritization from the access point. Figure 9-1 shows the upstream and downstream traffic flow.

**Figure 9-1 Upstream and Downstream Traffic Flow**



- The radio downstream flow is traffic transmitted out the access point radio to a wireless client device. This traffic is the main focus for QoS on a wireless LAN.
- The radio upstream flow is traffic transmitted out the wireless client device to the access point. QoS for wireless LANs does not affect this traffic.
- The Ethernet downstream flow is traffic sent from a switch or a router to the Ethernet port on the access point. If QoS is enabled on the switch or router, the switch or router might prioritize and rate-limit traffic to the access point.
- The Ethernet upstream flow is traffic sent from the access point Ethernet port to a switch or router on the wired LAN. The access point does not prioritize traffic that it sends to the wired LAN based on traffic classification.

## Precedence of QoS Settings

When you enable QoS, the access point queues packets based on the Layer 2 class of service value for each packet. The access point applies QoS policies in this order:

1. **Packets already classified**—When the access point receives packets from a QoS-enabled switch or router that has already classified the packets with non-zero 802.1Q/P user\_priority values, the access point uses that classification and does not apply other QoS policy rules to the packets. An existing classification takes precedence over all other policies on the access point.



**Note** Even if you have not configured a QoS policy, the access point always honors tagged 802.1P packets that it receives over the radio interface.

2. **QoS Element for Wireless Phones setting**—If you enable the *QoS Element for Wireless Phones* setting, dynamic voice classifiers are created for some of the wireless phone vendor clients, which allows the wireless phone traffic to be a higher priority than other clients' traffic. Additionally, the QoS Basic Service Set (QBSS) is enabled to advertise channel load information in the beacon and probe response frames. Some IP phones use QBSS elements to determine which access point to associate to, based on the traffic load.

You can use the Cisco IOS command **dot11 phone dot11e** command to enable the future upgrade of the 7920 Wireless Phone firmware to support the standard QBSS Load IE. The new 7920 Wireless Phone firmware will be announced at a later date.

**Note**

This release continues to support existing 7920 wireless phone firmware. Do not attempt to use the new standard (IEEE 802.11e draft 13) QBSS Load IE with the 7920 Wireless Phone until new phone firmware is available for you to upgrade your phones.

This example shows how to enable IEEE 802.11 phone support with the legacy QBSS Load element:

```
AP(config)# dot11 phone
```

This example shows how to enable IEEE 802.11 phone support with the standard (IEEE 802.11e draft 13) QBSS Load element:

```
AP(config)# no dot11 phone dot11e
```

This example shows how to stop or disable the IEEE 802.11 phone support:

```
AP(config)# no dot11 phone
```

3. Policies you create on the access point—QoS Policies that you create and apply to VLANs or to the access point interfaces are third in precedence after previously classified packets and the *QoS Element for Wireless Phones* setting.
4. Default classification for all packets on VLAN—If you set a default classification for all packets on a VLAN, that policy is fourth in the precedence list.

## Using Wi-Fi Multimedia Mode

When you enable QoS, the access point uses Wi-Fi Multimedia (WMM) mode by default. WMM provides these enhancements over basic QoS mode:

- The access point adds each packet's class of service to the packet's 802.11 header to be passed to the receiving station.
- Each access class has its own 802.11 sequence number. The sequence number allows a high-priority packet to interrupt the retries of a lower-priority packet without overflowing the duplicate checking buffer on the receiving side.
- For access classes that are configured to allow it, transmitters that are qualified to transmit through the normal backoff procedure are allowed to send a set of pending packets during the configured transmit opportunity (a specific number of microseconds). Sending a set of pending packets improves throughput because each packet does not have to wait for a backoff to gain access; instead, the packets can be transmitted immediately one after the other.

The access point uses WMM enhancements in packets sent to client devices that support WMM. The access point applies basic QoS policies to packets sent to clients that do not support WMM.

Use the **no dot11 qos mode wmm** configuration interface command to disable WMM using the CLI. To disable WMM using the web-browser interface, unselect the check boxes for the radio interfaces on the QoS Advanced page.

## Configuring QoS

QoS is disabled by default (however, the radio interface always honors tagged 802.1P packets even when you have not configured a QoS policy). This section describes how to configure QoS on your access point. It contains this configuration information:

- [Configuration Guidelines, page 9-5](#)
- [Adjusting Radio Access Categories, page 9-5](#)
- [Disabling IGMP Snooping Helper, page 9-6](#)

## Configuration Guidelines

Before configuring QoS on your access point, you should be aware of this information:

- The most important guideline in QoS deployment is to be familiar with the traffic on your wireless LAN. If you know the applications used by wireless client devices, the applications' sensitivity to delay, and the amount of traffic associated with the applications, you can configure QoS to improve performance.
- QoS does not create additional bandwidth for your wireless LAN; it helps control the allocation of bandwidth. If you have plenty of bandwidth on your wireless LAN, you might not need to configure QoS.

## Adjusting Radio Access Categories

The access point uses the radio access categories to calculate backoff times for each packet. As a rule, high-priority packets have short backoff times.

The default values in the Min and Max Contention Window fields and in the Slot Time fields are based on settings recommended in IEEE Draft Standard 802.11e. For detailed information on these values, consult that standard.

Cisco strongly recommends that you use the default settings on the Radio Access Categories page. Changing these values can lead to unexpected blockages of traffic on your wireless LAN, and the blockages might be difficult to diagnose. If you change these values and find that you need to reset them to defaults, use the default settings listed in [Table 9-1](#).

The values listed in [Table 9-1](#) are to the power of 2. The access point computes Contention Window values with this equation:

$$CW = 2 ** X \text{ minus } 1$$

where X is the value from [Table 9-1](#).

**Table 9-1** Default QoS Radio Access Categories

Class of Service	Min Contention Window	Max Contention Window	Fixed Slot Time	Transmit Opportunity
Background	4	10	7	0
Best Effort	4	10	3	0
Video <100ms Latency	3	4	2	3008
Voice <100ms Latency	2	3	2	1504



### Note

In this release, clients are blocked from using an access category when you select **Enable** for Admission Control.

Using the Admission Control check boxes, you can control client use of the access categories. When you enable admission control for an access category, clients associated to the access point must complete the WMM admission control procedure before they can use that access category. However, access points do not support the admission control procedure in this release, so clients cannot use the access category when you enable Admission Control.

## Disabling IGMP Snooping Helper

When Internet Group Membership Protocol (IGMP) snooping is enabled on a switch and a client roams from one access point to another, the clients' multicast session is dropped. When the access points' IGMP snooping helper is enabled, the access point sends a general query to the wireless LAN, prompting the client to send in an IGMP membership report. When the network infrastructure receives the host's IGMP membership report, it ensures delivery of that host's multicast data stream.

The IGMP snooping helper is enabled by default. To disable it, browse to the QoS Policies - Advanced page, select **Disable**, and click **Apply**.

## Sample Configuration Using the CLI

```
class-map match-all _class_WMM1
match ip precedence 1
class-map match-all _class_WMM0
match ip precedence 0
class-map match-all _class_WMM3
match ip precedence 3
class-map match-all _class_WMM2
match ip precedence 2
class-map match-all _class_WMM5
match ip precedence 5
class-map match-all _class_WMM4
match ip precedence 4
class-map match-all _class_WMM7
match ip precedence 7
class-map match-all _class_WMM6
match ip precedence 6

policy-map WMM
class _class_WMM0
set cos 0
class _class_WMM1
set cos 1
class _class_WMM2
set cos 2
class _class_WMM3
set cos 3
class _class_WMM4
set cos 4
class _class_WMM5
set cos 5
class _class_WMM6
set cos 6
class _class_WMM7
set cos 7
```



## Channel Settings

This appendix lists the radio channels supported by Cisco access products in the regulatory domains of the world.

### IEEE 802.11b (2.4-GHz Band)

The channel identifiers, channel center frequencies, and regulatory domains of each IEEE 802.11b 22-MHz-wide channel are shown in [Table A-1](#).

**Table A-1** Channels for IEEE 802.11b

Channel Identifier	Center Frequency (MHz)	Regulatory Domains		
		Americas (-A)	EMEA (-E)	Japan (-J)
1	2412	X	X	X
2	2417	X	X	X
3	2422	X	X	X
4	2427	X	X	X
5	2432	X	X	X
6	2437	X	X	X
7	2442	X	X	X
8	2447	X	X	X
9	2452	X	X	X
10	2457	X	X	X
11	2462	X	X	X
12	2467	-	X	X
13	2472	-	X	X
14	2484	-	-	-

**Note**

Mexico is included in the Americas (-A) regulatory domain; however, channels 1 through 8 are for indoor use only while channels 9 through 11 can be used indoors and outdoors. Users are responsible for ensuring that the channel set configuration is in compliance with the regulatory standards of Mexico.

## IEEE 802.11g (2.4-GHz Band)

The channel identifiers, channel center frequencies, and regulatory domains of each IEEE 802.11g 22-MHz-wide channel are shown in [Table A-2](#).

**Table A-2** Channels for IEEE 802.11g

Channel Identifier	Center Frequency (MHz)	Regulatory Domains					
		Americas (-A)		EMEA (-E)		Japan (-J)	
		CCK	OFDM	CCK	OFDM	CCK	OFDM
1	2412	X	X	X	X	X	X
2	2417	X	X	X	X	X	X
3	2422	X	X	X	X	X	X
4	2427	X	X	X	X	X	X
5	2432	X	X	X	X	X	X
6	2437	X	X	X	X	X	X
7	2442	X	X	X	X	X	X
8	2447	X	X	X	X	X	X
9	2452	X	X	X	X	X	X
10	2457	X	X	X	X	X	X
11	2462	X	X	X	X	X	X
12	2467	-	-	X	X	X	X
13	2472	-	-	X	X	X	X
14	2484	-	-	-	-	-	-

## IEEE 802.11a (5-GHz Band)

The channel identifiers, channel center frequencies, and regulatory domains of each IEEE 802.11a 20-MHz-wide channel are shown in [Table A-3](#).

**Table A-3** 5-GHz Radio Band

Channel Identifier	Center Frequency (MHz)	Regulatory Domains			
		North America (-A)	ETSI	Japan (-P)	China
36	5180	X	X	X	
40	5200	X	X	X	

Table A-3 5-GHz Radio Band (continued)

Channel Identifier	Center Frequency (MHz)	Regulatory Domains			
		North America (-A)	ETSI	Japan (-P)	China
44	5220	X	X	X	
48	5240	X	X	X	
52	5260	X	X	X	
56	5280	X	X	X	
60	5300	X	X	X	
64	5320	X	X	X	
100	5500	–	X	–	
104	5520	–	X	–	
108	5540	–	X	–	
112	5560	–	X	–	
116	5580	–	X	–	
120	5600	–	X	–	
124	5620	–	X	–	
128	5640	–	X	–	
132	5660	–	X	–	
136	5680	–	X	–	
140	5700	–	X	–	
149	5745	X	–	–	X
153	5765	X	–	–	X
157	5785	X	–	–	X
161	5805	X	–	–	X

**Note**

All channel sets are restricted to indoor usage except the Americas (-A), which allows for indoor and outdoor use on channels 52 through 64 in the United States.





## Protocol Filters

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The tables in this appendix list some of the protocols that you can filter on the access point. The tables include:

- Table A-1, [Ethernet Protocols](#)
- Table A-2, [IP Protocols](#)
- Table A-3, [IP Port Protocols](#)

In each table, the Protocol column lists the protocol name, the Additional Identifier column lists other names for the same protocol, and the ISO Designator column lists the numeric designator for each protocol.

**Table B-1**      **Ethertype Protocols**

<b>Protocol</b>	<b>Additional Identifier</b>	<b>ISO Designator</b>
ARP	—	0x0806
RARP	—	0x8035
IP	—	0x0800
Berkeley Trailer Negotiation	—	0x1000
LAN Test	—	0x0708
X.25 Level3	X.25	0x0805
Banyan	—	0x0BAD
CDP	—	0x2000
DEC XNS	XNS	0x6000
DEC MOP Dump/Load	—	0x6001
DEC MOP	MOP	0x6002
DEC LAT	LAT	0x6004
Ethertalk	—	0x809B
Appletalk ARP	Appletalk AARP	0x80F3
IPX 802.2	—	0x00E0
IPX 802.3	—	0x00FF
Novell IPX (old)	—	0x8137
Novell IPX (new)	IPX	0x8138
EAPOL (old)	—	0x8180
EAPOL (new)	—	0x888E
Telxon TXP	TXP	0x8729
Aironet DDP	DDP	0x872D
Enet Config Test	—	0x9000
NetBUI	—	0xF0F0

**Table B-2** *IP Protocols*

<b>Protocol</b>	<b>Additional Identifier</b>	<b>ISO Designator</b>
dummy	—	0
Internet Control Message Protocol	ICMP	1
Internet Group Management Protocol	IGMP	2
Transmission Control Protocol	TCP	6
Exterior Gateway Protocol	EGP	8
PUP	—	12
CHAOS	—	16
User Datagram Protocol	UDP	17
XNS-IDP	IDP	22
ISO-TP4	TP4	29
ISO-CNLP	CNLP	80
Banyan VINES	VINES	83
Encapsulation Header	encap_hdr	98
Spectralink Voice Protocol	SVP Spectralink	119
raw	—	255

**Table B-3 IP Port Protocols**

<b>Protocol</b>	<b>Additional Identifier</b>	<b>ISO Designator</b>
TCP port service multiplexer	tcpmux	1
echo	—	7
discard (9)	—	9
systat (11)	—	11
daytime (13)	—	13
netstat (15)	—	15
Quote of the Day	qotd quote	17
Message Send Protocol	msp	18
ttytst source	chargen	19
FTP Data	ftp-data	20
FTP Control (21)	ftp	21
Secure Shell (22)	ssh	22
Telnet	—	23
Simple Mail Transport Protocol	SMTP mail	25
time	timserver	37
Resource Location Protocol	RLP	39
IEN 116 Name Server	name	42
whois	nickname 43	43
Domain Name Server	DNS domain	53
MTP	—	57
BOOTP Server	—	67
BOOTP Client	—	68
TFTP	—	69
gopher	—	70
rje	netrjs	77
finger	—	79
Hypertext Transport Protocol	HTTP www	80
ttylink	link	87
Kerberos v5	Kerberos krb5	88
supdup	—	95
hostname	hostnames	101

**Table B-3** *IP Port Protocols (continued)*

<b>Protocol</b>	<b>Additional Identifier</b>	<b>ISO Designator</b>
TSAP	iso-tsap	102
CSO Name Server	cso-ns csnet-ns	105
Remote Telnet	rtelnet	107
Postoffice v2	POP2 POP v2	109
Postoffice v3	POP3 POP v3	110
Sun RPC	sunrpc	111
tap ident authentication	auth	113
sftp	—	115
uucp-path	—	117
Network News Transfer Protocol	Network News readnews nntp	119
USENET News Transfer Protocol	Network News readnews nntp	119
Network Time Protocol	nntp	123
NETBIOS Name Service	netbios-ns	137
NETBIOS Datagram Service	netbios-dgm	138
NETBIOS Session Service	netbios-ssn	139
Interim Mail Access Protocol v2	Interim Mail Access Protocol IMAP2	143
Simple Network Management Protocol	SNMP	161
SNMP Traps	snmp-trap	162
ISO CMIP Management Over IP	CMIP Management Over IP cmip-man CMOT	163
ISO CMIP Agent Over IP	cmip-agent	164
X Display Manager Control Protocol	xdmcp	177
NeXTStep Window Server	NeXTStep	178
Border Gateway Protocol	BGP	179
Prospero	—	191
Internet Relay Chap	IRC	194

**Table B-3** IP Port Protocols (continued)

<b>Protocol</b>	<b>Additional Identifier</b>	<b>ISO Designator</b>
SNMP Unix Multiplexer	smux	199
AppleTalk Routing	at-rtmp	201
AppleTalk name binding	at-nbp	202
AppleTalk echo	at-echo	204
AppleTalk Zone Information	at-zis	206
NISO Z39.50 database	z3950	210
IPX	—	213
Interactive Mail Access Protocol v3	imap3	220
Unix Listserv	ulistserv	372
syslog	—	514
Unix spooler	spooler	515
talk	—	517
ntalk	—	518
route	RIP	520
timeserver	timed	525
newdate	tempo	526
courier	RPC	530
conference	chat	531
netnews	—	532
netwall	wall	533
UUCP Daemon	UUCP uucpd	540
Kerberos rlogin	klogin	543
Kerberos rsh	kshell	544
rfs_server	remotefs	556
Kerberos kadmin	kerberos-adm	749
network dictionary	webster	765
SUP server	supfilesrv	871
swat for SAMBA	swat	901
SUP debugging	supfiledbg	1127
ingreslock	—	1524
Prospero non-privileged	prospero-np	1525
RADIUS	—	1812
Concurrent Versions System	CVS	2401
Cisco IAPP	—	2887
Radio Free Ethernet	RFE	5002



## Supported MIBs

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This appendix lists the Simple Network Management Protocol (SNMP) Management Information Bases (MIBs) that the access point supports for this software release. The Cisco IOS SNMP agent supports both SNMPv1 and SNMPv2. This appendix contains these sections:

- [MIB List, page C-1](#)
- [Using FTP to Access the MIB Files, page C-2](#)

### MIB List

- IEEE802dot11-MIB
- Q-BRIDGE-MIB
- P-BRIDGE-MIB
- CISCO-DOT11-IF-MIB
- CISCO-WLAN-VLAN-MIB
- CISCO-IETF-DOT11-QOS-MIB
- CISCO-IETF-DOT11-QOS-EXT-MIB
- CISCO-DOT11-ASSOCIATION-MIB
- CISCO-DOT11-QOS-MIB
- CISCO-DOT11-SSID-SECURITY-MIB
- CISCO-L2-DEV-MONITORING-MIB
- CISCO-IP-PROTOCOL-FILTER-MIB
- CISCO-SYSLOG-EVENT-EXT-MIB
- CISCO-TBRIDGE-DEV-IF-MIB
- BRIDGE-MIB
- CISCO-CDP-MIB
- CISCO-CONFIG-COPY-MIB
- CISCO-CONFIG-MAN-MIB
- CISCO-FLASH-MIB
- CISCO-IMAGE-MIB

- CISCO-MEMORY-POOL-MIB
- CISCO-PROCESS-MIB
- CISCO-PRODUCTS-MIB
- CISCO-SMI-MIB
- CISCO-TC-MIB
- CISCO-SYSLOG-MIB
- ENTITY-MIB
- IF-MIB
- OLD-CISCO-CHASSIS-MIB
- OLD-CISCO-SYS-MIB
- OLD-CISCO-SYSTEM-MIB
- OLD-CISCO-TS-MIB
- RFC1213-MIB
- RFC1398-MIB
- SNMPv2-MIB
- SNMPv2-SMI
- SNMPv2-TC

## Using FTP to Access the MIB Files

Follow these steps to obtain each MIB file by using FTP:

- 
- Step 1** Use FTP to access the server **ftp.cisco.com**.
  - Step 2** Log in with the username **anonymous**.
  - Step 3** Enter your e-mail username when prompted for the password.
  - Step 4** At the `ftp>` prompt, change directories to **/pub/mibs/v1** or **/pub/mibs/v2**.
  - Step 5** Use the **get *MIB\_filename*** command to obtain a copy of the MIB file.
- 

**Note**

You can also access information about MIBs on the Cisco web site:  
<http://www.cisco.com/public/sw-center/netmgmt/cmtk/mibs.shtml>

---



## Error and Event Messages

This appendix lists the CLI error and event messages.

### How to Read System Messages

System messages begin with a percent (%) and are structured as follows: The text in bold are required elements of the system message, the text in italics are optional elements of the system message.

**%FACILITY-SEVERITY-MNEMONIC: Message-text**

FACILITY is a code consisting of two or more uppercase letters that indicate the facility to which the message refers. A facility can be a hardware device, a protocol, or a module of the system software. You can see a complete list of mainline facility codes for Cisco IOS Release 12.3 on Cisco.com. Go to this URL:

<http://www.cisco.com/univercd/cc/td/doc/product/software/ios123/123sup/123sems/123semv1/emgovr1.htm>

SEVERITY is a single-digit code from 0 to 7 that reflects the severity of the condition. The lower the number, the more serious the situation. [Table D-1](#) lists the severity levels.

**Table D-1** Error Message Severity Levels

Level	Description
0 – emergency	System unusable
1 – alert	Immediate action needed
2 – critical	Critical condition
3 – error	Error condition
4 – warning	Warning condition
5 – notification	Normal but significant condition
6 – informational	Informational message only
7 – debugging	Appears during debugging only

MNEMONIC is a code that uniquely identifies the error message.

Variable information is indicated in brackets, for example [mac-address] indicates a the mac address of a device, [characters] indicates a character string, and [number] indicates a numeric value.

## Message Traceback Reports

Some messages describe internal errors and contain traceback reports. This information is very important and should be included when you report a problem to your technical support representative.

The following sample message includes traceback information:

```
-Process= "Exec", level= 0, pid= 17
-Traceback= 1A82 1AB4 6378 A072 1054 1860
```

## Association Management Messages

**Error Message** DOT11-3-BADSTATE: [mac-address] [chars] [chars] -> [chars]

**Explanation** 802.11 Association and management uses a table-driven state machine to keep track and transition an Association through various states. A state transition occurs when an Association receives one of many possible events. When this error occurs, it means that an Association received an event that it did not expect while in this state.

**Recommended Action** The system can continue but may lose the Association that generates this error. Copy the message exactly as it appears and report it to your technical service representative.

**Event Message** DOT11-6-ASSOC: Interface [interface], Station [char] [mac], SSID [ssid], Authentication Type [auth\_type], Key Management [key\_mgmt] Associated

**Explanation** A station associated to an access point.

**Recommended Action** None.

**Event Message** DOT11-6-ADD: Interface [interface], Station [char] [mac] Associated to parent [char] [mac]

**Explanation** A station associated to an access point.

**Recommended Action** None.

**Event Message** DOT11-6-DISASSOC: Interface [interface], Deauthenticating Station [mac] [char], Reason [explanation], SSID [ssid].

**Explanation** A station disassociated from an access point.

**Recommended Action** None.

**Error Message** DOT11-6-ROAMED: Station [mac-address] Roamed to [mac-address]

**Explanation** The indicated station roamed to the indicated new access point.

**Recommended Action** None.

**Error Message** DOT11-4-ENCRYPT\_MISMATCH: Possible encryption key mismatch between interface [interface] and station [mac-address]

**Explanation** The encryption setting of the indicated interface and indicated station may be mismatched.

**Recommended Action** Check the encryption configuration of this interface and the failing station to ensure that the configurations match.

## 802.11 Subsystem Messages

**Event Message** DOT11-6-FREQ\_INUSE: Radio frequency [int] is in use

**Explanation** When scanning for an unused frequency, the unit recognized another radio using the displayed frequency.

**Recommended Action** None.

**Event Message** DOT11-6-FREQ\_USED: Radio frequency [int] selected

**Explanation** After scanning for an unused frequency, the unit selected the displayed frequency.

**Recommended Action** None.

**Error Message** DOT11-4-NO\_VALID\_INFRA\_SSID: No infrastructure SSID configured. [interface] not started

**Explanation** No infrastructure SSID was configured and the indicated interface was not started.

**Recommended Action** Add at least one infrastructure SSID to the radio configuration.

**Error Message** DOT11-4-VERSION\_UPGRADE: Interface [interface], upgrading radio firmware

**Explanation** When starting the indicated interface, the access point found the wrong firmware version. The radio will be loaded with the required version.

**Recommended Action** None.

**Error Message** DOT11-2-VERSION\_INVALID: Interface [interface], unable to find required radio version [hex].[hex] [number]

**Explanation** When trying to re-flash the radio firmware on the indicated interface, the access point recognized that the indicated radio firmware packaged with the Cisco IOS software had the incorrect version.

**Recommended Action** None.

**Error Message** DOT11-3-RADIO\_OVER\_TEMPERATURE: Interface [interface] Radio over temperature detected

**Explanation** The radio's internal temperature exceeds maximum limits on the indicated radio interface.

**Recommended Action** Take steps necessary to reduce the internal temperature. These steps will vary based on your specific installation.

**Error Message** DOT11-3-RADIO\_TEMPERATURE\_NORMAL: Interface [interface] radio temperature returned to normal

**Explanation** The radio's internal temperature has returned to normal limits on the indicated radio interface.

**Recommended Action** None.

**Error Message** DOT11-3-TX\_PWR\_OUT\_OF\_RANGE: Interface [interface] Radio transmit power out of range

**Explanation** The transmitter power level is outside the normal range on the indicated radio interface.

**Recommended Action** Remove unit from the network and service.

**Error Message** DOT11-3-RADIO\_RF\_LO: Interface [interface] Radio cannot lock RF freq

**Explanation** The radio phase lock loop (PLL) circuit is unable to lock the correct frequency on the indicated interface.

**Recommended Action** Remove unit from network and service.

**Error Message** DOT11-3-RADIO\_IF\_LO: Interface [interface] Radio cannot lock IF freq

**Explanation** The radio intermediate frequency (IF) PLL is unable to lock the correct frequency on the indicated interface.

**Recommended Action** Remove unit from network and service.

**Error Message** DOT11-6-FREQ\_SCAN: Interface [interface] Scanning frequencies for [number] seconds

**Explanation** Starting a scan for a least congested frequency on the interface indicated for a the time period indicated.

**Recommended Action** None.

**Error Message** DOT11-2-NO\_CHAN\_AVAIL: Interface [interface], no channel available

**Explanation** No frequency is available, likely because RADAR has been detected within the previous 30 minutes.

**Recommended Action** None.

**Error Message** DOT11-6-DFS\_SCAN\_COMPLETE: DFS scan complete on frequency [frequency] MHz

**Explanation** The device has completed its Dynamic Frequency Scan (DFS) frequency scanning process on the displayed frequency.

**Recommended Action** None.

**Error Message** DOT11-6-DFS\_SCAN\_START: DFS: Scanning frequency [frequency] MHz for [number] seconds

**Explanation** The device has begun its DFS scanning process.

**Recommended Action** None.

**Error Message** DOT11-6-DFS\_TRIGGERED: DFS: triggered on frequency [frequency] MHz

**Explanation** DFS has detected RADAR signals on the indicated frequency.

**Recommended Action** None. The channel will be placed on the non-occupancy list for 30 minutes and a new channel will be selected.

**Error Message** DOT11-4-DFS\_STORE\_FAIL: DFS: could not store the frequency statistics

**Explanation** A failure occurred writing the DFS statistics to flash.

**Recommended Action** None.

**Error Message** DOT11-4-NO\_SSID: No SSIDs configured, [characters] not started

**Explanation** All SSIDs were deleted from the configuration. At least one must be configured for the radio to run.

**Recommended Action** Configure at least one SSID on the access point.

**Error Message** DOT11-4-NO\_SSID\_VLAN: No SSID with VLAN configured. [characters] not started

**Explanation** No SSID was configured for a VLAN. The indicated interface was not started.

**Recommended Action** At least one SSID must be configured per VLAN. Add at least one SSID for the VLAN on the indicated interface.

**Error Message** DOT11-4-NO\_MBSSID\_VLAN: No VLANs configured in MBSSID mode.  
[characters] not started

**Explanation** No VLAN configured in MBSSID mode. The indicated interface was not started.

**Recommended Action** Add at least one SSID with the VLAN on the indicated interface configuration.

**Error Message** DOT11-4-NO\_MBSSID\_SHR\_AUTH: More than 1 SSID with shared authentication method in non-MBSSID mode. %

**Explanation** Not more than one SSID can have shared authentication method when MBSSID is not enabled.

**Recommended Action** Remove SSID from Dot22Radio radio interface or change authentication mode for SSIC to open configuration.

**Error Message** DOT11-4-FW\_LOAD\_DELAYED: Interface [interface], network filesystem not ready. Delaying firmware [characters] load

**Explanation** The network filesystem was not running or not ready when trying to flash new firmware into the indicated interface. Loading the identified firmware file has been delayed.

**Recommended Action** Make sure the network is up and ready before attempting to reflash the new firmware.

**Error Message** DOT11-2-FLASH\_UNKNOWN\_RADIO: Interface [interface] has an unknown radio

**Explanation** The radio type could not be determined when the user attempted to flash new firmware into the indicated interface.

**Recommended Action** Reboot the system and see if the firmware upgrade completes.

**Error Message** DOT11-4-UPLINK\_ESTABLISHED: Interface [interface] associated to AP [characters] [characters] [characters]

**Explanation** The indicated repeater has associated to the indicated root access point. Clients can now associate to the indicated repeater and traffic can pass.

**Recommended Action** None.

**Error Message** DOT11-2-UPLINK\_FAILED: Uplink to parent failed: [characters]

**Explanation** The connection to the parent access point failed for the displayed reason. The uplink will stop its connection attempts.

**Recommended Action** Try resetting the uplink interface. Contact Technical Support if the problem persists.

**Error Message** DOT11-4-CANT\_ASSOC: Interface [interface], cannot associate [characters]

**Explanation** The indicated interface device could not associate to an indicated parent access point.

**Recommended Action** Check the configuration of the parent access point and this unit to make sure there is a match.

**Error Message** DOT11-2-PROCESS\_INITIALIZATION\_FAILED: The background process for the radio could not be started: [characters]

**Explanation** The initialization process used by the indicated interface failed for some reason, possibly a transient error.

**Recommended Action** Perform a reload of the access point. If this fails to rectify the problem, perform a power cycle. If this still fails, try downgrading the access point firmware to the previous version.

**Error Message** DOT11-2-RADIO\_HW\_RESET: Radio subsystem is undergoing hardware reset to recover from problem

**Explanation** An unrecoverable error occurred that could not be resolved by a soft reset.

**Recommended Action** None.

**Error Message** DOT11-4-MAXRETRIES: Packet to client [chars] [mac] reached max retries [int], remove the client

**Explanation** A packet sent to the client has not been successfully delivered many times, and the max retries limit has been reached. The client is deleted from the association table.

**Recommended Action** Force re authentication from the client to reassociate to the router.

**Error Message** DOT11-4-RM\_INCAPABLE: Interface [interface]

**Explanation** Indicated interface does not support the radio management feature.

**Recommended Action** None.

**Error Message** DOT11-4-RM\_INCORRECT\_INTERFACE: Invalid interface, either not existing or non-radio

**Explanation** A radio management request discovered that the interface either does not exist or is not a radio interface.

**Recommended Action** None.

**Error Message** DOT11-3-POWERS\_INVALID: Interface [interface], no valid power levels available

**Explanation** The radio driver found no valid power level settings.

**Recommended Action** Investigate and correct the power source and settings.

**Error Message** DOT11-4-RADIO\_INVALID\_FREQ: Operating frequency [frequency] invalid - performing a channel scan

**Explanation** The indicated frequency is invalid for operation. A channel scan is being performed to select a valid frequency.

**Recommended Action** None.

**Error Message** DOT11-2-RADIO\_INITIALIZATION\_ERROR: The radio subsystem could not be initialized [characters]

**Explanation** A critical error was detected while attempting to initialize the radio subsystem.

**Recommended Action** Reload the system.

**Error Message** DOT11-4-UPLINK\_NO\_ID\_PWD: Interface [interface], no username/password supplied for uplink authentication

**Explanation** The user failed to enter a username and/or password.

**Recommended Action** Enter the username and/or password and try again.

**Error Message** DOT11-4-NO\_IE\_CFG: No IEs configured for [characters] [ssid index]

**Explanation** When attempting to apply a beacon or probe response to the radio, the beacon or probe was undefined on the indicated SSID index.

**Recommended Action** Check the IE configuration.

**Error Message** DOT11-4-FLASHING\_RADIO: Interface [interface], flashing radio firmware [characters]

**Explanation** The indicated interface radio has been stopped to load the indicated new firmware.

**Recommended Action** None.

**Error Message** DOT11-4-LOADING\_RADIO: Interface [interface], loading the radio firmware [characters]

**Explanation** The indicated interface radio has been stopped to load new indicated firmware.

**Recommended Action** None.

**Error Message** DOT11-2-NO\_FIRMWARE: Interface [interface], no radio firmware file [characters] was found."

**Explanation** When trying to flash new firmware, the file for the radio was not found in the Flash file system.

**Recommended Action** The wrong image has been loaded into the unit. Locate the correct image based on the type of radio used.

**Error Message** DOT11-2-BAD\_FIRMWARE: Interface [interface], radio firmware file [characters] is invalid."

**Explanation** When trying to Flash new firmware into the indicated interface the indicated radio firmware file was found to be invalid.

**Recommended Action** Make sure the correct firmware image file is located in the place where the unit expects to find it.

**Error Message** DOT11-2-RADIO\_FAILED: Interface [interface] failed - [chars]

**Explanation** The radio driver found a severe error and is shutting down.

**Recommended Action** Shut/no shut the interface. If that fails, reboot router.

**Error Message** DOT11-4-FLASH\_RADIO\_DONE: Interface [interface], flashing radio firmware completed

**Explanation** The indicated interface radio firmware flash is complete, and the radio will be restarted with the new firmware.

**Recommended Action** None.

**Error Message** DOT11-4-UPLINK\_DOWN: Interface [interface], parent lost: [characters]

**Explanation** The connection to the parent access point on the indicated interface was lost for the reason indicated. The unit will try to find a new parent access point.

**Recommended Action** None.

**Error Message** DOT11-4-CANT\_ASSOC: Cannot associate: [characters]

**Explanation** The unit could not establish a connection to a parent access point for the displayed reason.

**Recommended Action** Verify that the basic configuration settings (SSID, WEP, and others) of the parent access point and this unit match.

**Error Message** DOT11-4-BRIDGE\_LOOP: Bridge loop detected between WGB [mac-address] and device [mac-address]

**Explanation** The indicated workgroup bridge reported the address of one of its indicated Ethernet clients and the access point already had that address marked as being somewhere else on the network.

**Recommended Action** Click **Refresh** on the Associations page on the access point GUI, or enter the clear `dot11 statistics` command on the CLI.

**Error Message** DOT11-4-ANTENNA\_INVALID: Interface [interface], current antenna position not supported, radio disabled

**Explanation** The Indicated AIR-RM21A radio module does not support the high-gain position for the external antenna (the high-gain position is folded flat against the access point). The access point automatically disables the radio when the antenna is in the high-gain position.

**Recommended Action** Fold the antenna on the AIR-RM21A radio module so that it is oriented 90 degrees to the body of the access point.

**Error Message** DOT11-3-RF\_LOOPBACK\_FAILURE: Interface [interface] Radio failed to pass RF loopback test

**Explanation** Radio loopback test failed for the interface indicated.

**Recommended Action** None.

**Error Message** DOT11-3-RF\_LOOPBACK\_FREQ\_FAILURE: Interface [interface] failed to pass RF loopback test

**Explanation** Radio loopback test failed at a given frequency for the indicated interface.

**Recommended Action** None.

**Error Message** DOT11-7-AUTH\_FAILED: Station [mac-address] Authentication failed

**Explanation** The indicated station failed authentication.

**Recommended Action** Verify that the user entered the correct username and password, and verify that the authentication server is online.

**Error Message** DOT11-4-TKIP\_MIC\_FAILURE: Received TKIP Michael MIC failure report from the station [mac-address] on the packet (TSC=0x%11x) encrypted and protected by [key] key."

**Explanation** TKIP Michael MIC failure was detected from the indicated station on a unicast frame decrypted locally with the indicated pairwise key.

**Recommended Action** A failure of the Michael MIC in a packet usually indicates an active attack on your network. Search for and remove potential rogue devices from your wireless LAN.

**Error Message** DOT11-4-TKIP\_MIC\_FAILURE\_REPORT: Received TKIP Michael MIC failure report from the station [mac-address] on the packet (TSC=0x0) encrypted and protected by [key] key

**Explanation** The access point received an EAPOL-key from the indicated station notifying the access point that TKIP Michael MIC failed on a packet transmitted by this access point.

**Recommended Action** None.

**Error Message** DOT11-3-TKIP\_MIC\_FAILURE\_REPEATED: Two TKIP Michael MIC failures were detected within [number] seconds on [interface] interface. The interface will be put on MIC failure hold state for next [number] seconds

**Explanation** Two TKIP Michael MIC failures were detected within the indicated time on the indicated interface. Because this usually indicates an active attack on your network, the interface will be put on hold for the indicated time. During this hold time, stations using TKIP ciphers are disassociated and cannot reassociate until the hold time ends. At the end of the hold time, the interface operates normally.

**Recommended Action** MIC failures usually indicate an active attack on your network. Search for and remove potential rogue devices from your wireless LAN. If this is a false alarm and the interface should not be on hold this long, use the **countermeasure tkip hold-time** command to adjust the hold time.

**Error Message** SOAP-3-WGB\_CLIENT\_VLAN: Workgroup Bridge Ethernet client VLAN not configured

**Explanation** No VLAN is configured for client devices attached to the workgroup bridge.

**Recommended Action** Configure a VLAN to accommodate client devices attached to the workgroup bridge.

**Error Message** SOAP-3-ERROR: Reported on line [number] in file [characters]. [characters]

**Explanation** An internal error occurred on the indicated line number in the indicated filename in the controller ASIC.

**Recommended Action** None

**Error Message** IF-4-MISPLACED\_VLAN\_TAG: Detected a misplaced VLAN tag on source [interface]. Dropping packet

**Explanation** Received an 802.1Q VLAN tag which could not be parsed correctly. The received packet was encapsulated or de encapsulated incorrectly.

**Recommended Action**

# Local Authenticator Messages

**Error Message** RADSRV-4-NAS\_UNKNOWN: Unknown authenticator: [ip-address]

**Explanation** The local RADIUS server received an authentication request but does not recognize the IP address of the network access server (NAS) that forwarded the request.

**Recommended Action** Make sure that every access point on your wireless LAN is configured as a NAS on your local RADIUS server.

**Error Message** RADSRV-4-NAS\_KEYMIS: NAS shared key mismatch.

**Explanation** The local RADIUS server received an authentication request but the message signature indicates that the shared key text does not match.

**Recommended Action** Correct the shared key configuration on either the NAS or on the local RADIUS server.

**Error Message** RADSRV-4-BLOCKED: Client blocked due to repeated failed authentications

**Explanation** A user failed authentication the number of times configured to trigger a block, and the account been disabled.

**Recommended Action** Use the **clear radius local-server user *username*** privileged EXEC command to unblock the user, or allow the block on the user to expire by the configured lockout time.



- 802.11** The IEEE standard that specifies carrier sense media access control and physical layer specifications for 1- and 2-megabit-per-second (Mbps) wireless LANs operating in the 2.4-GHz band.
- 802.11a** The IEEE standard that specifies carrier sense media access control and physical layer specifications for wireless LANs operating in the 5-GHz frequency band.
- 802.11b** The IEEE standard that specifies carrier sense media access control and physical layer specifications for 5.5- and 11-Mbps wireless LANs operating in the 2.4-GHz frequency band.
- 802.11g** The IEEE standard that specifies carrier sense media across control and physical layer specifications for 6, 9, 12, 18, 24, 36, 48, and 54 Mbps LANs operating in the 2.4-GHz frequency band.
- 802.3af** The IEEE standard that specifies a mechanism for Power over Ethernet (PoE). The standard provides the capability to deliver both power and data over standard Ethernet cabling.

## A

- access point** A wireless LAN data transceiver that uses radio waves to connect a wired network with wireless stations.
- ad hoc network** A wireless network composed of stations without Access Points.
- antenna gain** The gain of an antenna is a measure of the 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.
- associated** A station is configured properly to allow it to wirelessly communicate with an Access Point.

## B

- backoff time** The random length of time that a station waits before sending a packet on the LAN. Backoff time is a multiple of slot time, so a decrease in slot time ultimately decreases the backoff time, which increases throughput.

<b>beacon</b>	A wireless LAN packet that signals the availability and presence of the wireless device. Beacon packets are sent by access points and base stations; however, client radio cards send beacons when operating in computer to computer (Ad Hoc) mode.
<b>BOOTP</b>	Boot Protocol. A protocol used for the static assignment of IP addresses to devices on the network.
<b>BPSK</b>	A modulation technique used by IEEE 802.11b-compliant wireless LANs for transmission at 1 Mbps.
<b>broadcast packet</b>	A single data message (packet) sent to all addresses on the same subnet.
<b>C</b>	
<b>CCK</b>	Complementary code keying. A modulation technique used by IEEE 802.11b-compliant wireless LANs for transmission at 5.5 and 11 Mbps.
<b>cell</b>	The area of radio range or coverage in which the wireless devices can communicate with the base station. The size of the cell depends upon the speed of the transmission, the type of antenna used, and the physical environment, as well as other factors.
<b>client</b>	A radio device that uses the services of an Access Point to communicate wirelessly with other devices on a local area network.
<b>CSMA</b>	Carrier sense multiple access. A wireless LAN media access method specified by the IEEE 802.11 specification.
<b>D</b>	
<b>data rates</b>	The range of data transmission rates supported by a device. Data rates are measured in megabits per second (Mbps).
<b>dBi</b>	A ratio of decibels to an isotropic antenna that is commonly used to measure antenna gain. The greater the dBi value, the higher the gain, and the more acute the angle of coverage.
<b>DHCP</b>	Dynamic host configuration protocol. A protocol available with many operating systems that automatically issues IP addresses within a specified range to devices on the network. The device retains the assigned address for a specific administrator-defined period.
<b>dipole</b>	A type of low-gain (2.2-dBi) antenna consisting of two (often internal) elements.
<b>domain name</b>	The text name that refers to a grouping of networks or network resources based on organization-type or geography; for example: name.com—commercial; name.edu—educational; name.gov—government; ISPname.net—network provider (such as an ISP); name.ar—Argentina; name.au—Australia; and so on.

<b>DNS</b>	Domain Name System server. A server that translates text names into IP addresses. The server maintains a database of host alphanumeric names and their corresponding IP addresses.
<b>DSSS</b>	Direct sequence spread spectrum. A type of spread spectrum radio transmission that spreads its signal continuously over a wide frequency band.
<b>E</b>	
<b>EAP</b>	Extensible Authentication Protocol. An optional IEEE 802.1x security feature ideal for organizations with a large user base and access to an EAP-enabled Remote Authentication Dial-In User Service (RADIUS) server.
<b>Ethernet</b>	The most widely used wired local area network. Ethernet uses carrier sense multiple access (CSMA) to allow computers to share a network and operates at 10, 100, or 1000 Mbps, depending on the physical layer used.
<b>F</b>	
<b>file server</b>	A repository for files so that a local area network can share files, mail, and programs.
<b>firmware</b>	Software that is programmed on a memory chip.
<b>G</b>	
<b>gateway</b>	A device that connects two otherwise incompatible networks together.
<b>GHz</b>	Gigahertz. One billion cycles per second. A unit of measure for frequency.
<b>I</b>	
<b>IEEE</b>	Institute of Electrical and Electronic Engineers. A professional society serving electrical engineers through its publications, conferences, and standards development activities. The body responsible for the Ethernet 802.3 and wireless LAN 802.11 specifications.
<b>infrastructure</b>	The wired Ethernet network.
<b>IP address</b>	The Internet Protocol (IP) address of a station.
<b>IP subnet mask</b>	The number used to identify the IP subnetwork, indicating whether the IP address can be recognized on the LAN or if it must be reached through a gateway. This number is expressed in a form similar to an IP address; for example: 255.255.255.0.
<b>isotropic</b>	An antenna that radiates its signal in a spherical pattern.

**M**

- MAC** Media Access Control address. A unique 48-bit number used in Ethernet data packets to identify an Ethernet device, such as an access point or your client adapter.
- modulation** Any of several techniques for combining user information with a transmitter's carrier signal.
- multipath** The echoes created as a radio signal bounces off of physical objects.
- multicast packet** A single data message (packet) sent to multiple addresses.

**O**

- omni-directional** This typically refers to a primarily circular antenna radiation pattern.
- Orthogonal Frequency Division Multiplex (OFDM)** A modulation technique used by IEEE 802.11a-compliant wireless LANs for transmission at 6, 9, 12, 18, 24, 36, 48, and 54 Mbps.

**P**

- packet** A basic message unit for communication across a network. A packet usually includes routing information, data, and sometimes error detection information.

**Q**

- Quadruple Phase Shift Keying** A modulation technique used by IEEE 802.11b-compliant wireless LANs for transmission at 2 Mbps.

**R**

- range** A linear measure of the distance that a transmitter can send a signal.
- receiver sensitivity** A measurement of the weakest signal a receiver can receive and still correctly translate it into data.
- RF** Radio frequency. A generic term for radio-based technology.

<b>roaming</b>	A feature of some Access Points that allows users to move through a facility while maintaining an unbroken connection to the LAN.
<b>RP-TNC</b>	Reverse Polarity Threaded Neill Concelman connector. Part 15.203 of the FCC rules covering spread spectrum devices limits the types of antennas that may be used with transmission equipment. In compliance with this rule, Cisco, like all other wireless LAN providers, equips its radios and antennas with a unique connector to prevent attachment of non-approved antennas to radios.
<b>S</b>	
<b>slot time</b>	The amount of time a device waits after a collision before retransmitting a packet. Short slot times decrease the backoff time, which increases throughput.
<b>spread spectrum</b>	A radio transmission technology that spreads the user information over a much wider bandwidth than otherwise required in order to gain benefits such as improved interference tolerance and unlicensed operation.
<b>SSID</b>	Service Set Identifier (also referred to as Radio Network Name). A unique identifier used to identify a radio network and which stations must use to be able to communicate with each other or to an access point. The SSID can be any alphanumeric entry up to a maximum of 32 characters.
<b>T</b>	
<b>transmit power</b>	The power level of radio transmission.
<b>U</b>	
<b>UNII</b>	Unlicensed National Information Infrastructure—regulations for UNII devices operating in the 5.15 to 5.35 GHz and 5.725 to 5.825 GHz frequency bands.
<b>UNII-1</b>	Regulations for UNII devices operating in the 5.15 to 5.25 GHz frequency band.
<b>UNII-2</b>	Regulations for UNII devices operating in the 5.25 to 5.35 GHz frequency band.
<b>UNII-3</b>	Regulations for UNII devices operating in the 5.725 to 5.825 GHz frequency band.
<b>unicast packet</b>	A single data message (packet) sent to a specific IP address.
<b>W</b>	
<b>WEP</b>	Wired Equivalent Privacy. An optional security mechanism defined within the 802.11 standard designed to make the link integrity of wireless devices equal to that of a cable.

<b>WMM</b>	Wireless MultiMedia.
<b>workstation</b>	A computing device with an installed client adapter.
<b>WPA</b>	Wi-Fi Protected Access (WPA) is a standards-based, interoperable security enhancement that strongly increases the level of data protection and access control for existing and future wireless LAN systems. It is derived from and will be forward-compatible with the upcoming IEEE 802.11i standard. WPA leverages TKIP (Temporal Key Integrity Protocol) for data protection and 802.1X for authenticated key management.



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